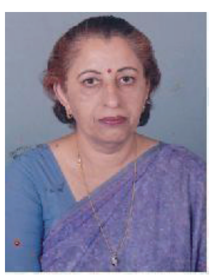
Across the globe vast areas that in the past supported natural forests have either been deforested or have degraded. Data shows that nearly 30 percent of the world's potential forest cover has been completely cleared and a further 20 percent has been degraded. But the silver lining is that still more than two billion hectares of deforested and degraded forest landscapes worldwide have the potential to be restored on sustainable basis. Land is one of the most precious natural resource on which all human activities are based. Changes in land use and land cover are therefore being increasingly recognized as critical factors influencing global change. While land cover and land use are often assumed to be identical, they are rather quite different. Land cover may be defined as the biophysical earth surface, while land use is often shaped by human, socioeconomic and political influences on the land. Last few decades have witnessed enhanced pace of landscape alteration in India. Developmental activities as well as anthropogenic causes have fragmented natural landscapes leading to deteriorating bird and animal habitats and alterations of biodiversity.



Prafulla Soni

Prafulla Soni M.Sc. Ph.D.is Retd.Scientist & Head Ecology and Environment Division Forest Research Institute, Dehradun(India). Presently Advisor Restoration ecology & Biodiversity Conservation. A Forest Ecologist with 43 years of Research, Teaching and Execution of field projects in restoration of derelict mined/degraded landscapes.

978-3-659-15849-0

Landscape Restoration Researches

Soni, Singh (Eds.)

Prafulla Soni (Ed.)
Lal Singh (Ed.)

Landscape Fragmentation and Restoration Researches in India

Restoration and Management Practices in India

LAP LAMBERT Academic Publishing

Prafulla Soni, Lal Singh (Eds.)

Landscape Fragmentation and Restoration Researches in India

Prafulla Soni, Lal Singh (Eds.)

Landscape Fragmentation and Restoration Researches in India

Restoration and Management Practices in India

LAP LAMBERT Academic Publishing

Impressum / Imprint
Bibliografische Information der Deutschen Nationalbibliothek: Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://dnb.d-nb.de abrufbar.

Bibliographic information published by the Deutsche Nationalbibliothek: The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at http://dnb.d-nb.de.

Coverbild / Cover image: www.ingimage.com

Verlag / Publisher:
LAP LAMBERT Academic Publishing
ist ein Imprint der / is a trademark of
AV Akademikerverlag GmbH & Co. KG
Heinrich-Böcking-Str. 6-8, 66121 Saarbrücken, Deutschland / Germany
Email: info@lap-publishing.com

Herstellung in Deutschland (siehe letzte Seite) /
Printed in the U.S.A. / U.K. by (see last page)
ISBN: 978-3-659-15849-0

CONTENTS

Landscape Fragmentation, Biodiversity Loss, Restoration and Management

Ecological Blueprint of Plantation in Mining Sectors: an Implication in Biodiversity Conservation and Climate Change

Anshumali

Department of Environmental Science and Engineering

Indian School of Mines

Dhnabd-826004, Jharkhand

Abstract

For the sustainable development of Indian economy, large scale mining activities have been taking place in the tropical deciduous forests of eastern, central and southern India for last two decades. The afforestation and reforestation of mined out areas to enhance the secondary succession, leguminous and exotic species have been selected for the restoration without considering their *in situ* relative frequency, density, dominance and diversity indices. The major problem associated with leguminous plants is their occurrence (<14 %) in tropical deciduous forests with poor regeneration capacity. The mountain slopes are dominated by dicot plants with simple leaves (non-leguminous plants) while the dry flat surfaces on mountain/plateau (away from seasonal water channels) are dominated by dicot plants with compound leaves (leguminous/non-leguminous plants). These are seldom used for restoration of OB dumps. Not only this, even after accumulation of organic matter and increased essential nutrients in mine spoils by using leguminous trees, restoration activities further ignore plantation of dominant native plants as per their microclimate. In view of these, an Integrated Vegetation Cover Development Programme (IVCDP) is required to address the following bottlenecks in the sustainable mining practices:

- Scientific investigation of dominance of dicot plants with simple

leaves (non- leguminous) on the mountain slopes and dicot plants with compound leaves (leguminous and non-leguminous) on the dry flat surfaces of mountain/plateau/uplands (away from seasonal water channels)

- Data generation on diversity loss due to mining industries
- CO_2 sequestration by tropical deciduous forests
- Socio-economic viability of current management practices

Keywords: Sustainable Development, Tropical Deciduous Forests, Mine Spoils.

Introduction

Understanding the diversity of nature in various forms is a fundamental goal of ecological research (Lubchenco et al.,1991) and is also essential for understanding the ecosystem function and stability (Ehrlich & Wilson 1991; Holdgate 1996; Tilman 2000). In India, tropical forests account for ca. 46% of the total forest land (Singh and Singh, 1988), however, because of high anthropogenic pressures and habitat destruction in the past several decades, the dry deciduous forest cover in most parts of central India is being converted into dry deciduous scrub, dry savanna and dry grasslands which are progressively species poor with decreased species richness and heterogeneity. Further, in-depth studies of these forests with respect to classification, mapping, change detection study of vegetation using satellite images (i.e. deforestation, fragmentation and degradation), phytosociology of plant communities (composition, regeneration and diversity patterns), phenology relationship between leaf traits and vegetation response to a broad range of environmental factors etc., using large-scale permanent inventory plots revealed sever impact of anthropogenic activities on diversity loss particularly tree species.Based on the baseline data generated and published on various aspects of tropical deciduous forests of Vindhyan region, this review has been carried out to (i) assess the dominance of dicot plants with simple leaves (non-leguminous) on the mountain slopes and dicot plants with compound leaves (leguminous and non- leguminous) on the dry flat surfaces of mountain/plateau/uplands (away from seasonal water channels) (ii) assess the leguminous and non-leguminous species loss due to habitat destruction.

Plant Diversity Assessment

The detailed information about the Vindhyan forests is given elsewhere (Jha et al., 2005; Sagar and Singh, 2005). Forest fragmentation and its impact on species diversity using remote sensing and GIS reveals a substantial portion of the dry tropical landscape are undergoing simplification or homogenization in terms of species richness and vegetation cover as a result of increasing large scale anthropogenic pressure in the form of mining, thermal power generation, cement industry, sporadic illegal tree felling, widespread lopping and extraction of non-timber forest resources etc. (Jha et al., 2005; Singh et al. 1991).

The total number of adult plant species belong to Fabaceae is 17 % (Table 1). However, the significant regeneration capacity is shown only by 4 % mainly *Acacia catechu* and *Hardwickia binata*. The rest 83 % belong to the non-leguminous trees species. The communities most vulnerable to alien invasive plants are Acacia- Terminalia, Terminalia-Shorea and Hardwickia-Acacia (Raghubanshi and Tripathi,2009). Raizada et al. (2009) studied the response of selected native dry tropical and alien invasive species to CO_2 enrichment and found increased net assimilation rate (NAR) as well as relative growth rate (RGR) under elevated CO_2 in all species but the magnitude was higher in the case of invasive species. These indicate that the leguminous trees can be replaced by non-leguminous invasive plants like *Lantana camara*, *Parthenium hysterophorus* and *Ocimum basilicum* at a great extent in near future.

Adaptation Strategies

Leaf traits are often cited as the principal traits to relate plant resource use,biomass and ecosystem functioning (Westoby, 1998; Weiher, 1999; Craine et al.,2001; Vendramini et al., 2002). Pandey et al (2009) studied the leaf traits of eight common plant species (non-leguminous) found in Vindhyan dry tropical region to understand their adaptation strategies (Table 2). The simple leaves of non-leguminous plants are short-lived but productive due to high leaf area, leaf weight, specific leaf area (SLA), and chlorophyll content. Sagar and Singh (2003) showed the percent of species and importance values were larger for medium or less deciduous trait categories (non-legumes) than for highly deciduous traits (legumes), representing a trade-off between water loss and period of dry matter synthesis. The non-legumes are also characterized by low height:diameter ratio (Table 3) i.e. large investment in diameter compared to height growth, therefore the H:D ratio is positively correlated with relative growth rate. Thus non-leguminous plants with simple leaves growing on moist slopes achieve a greater CO_2 sequestration and hence fast growth in resource- rich environment. Singh et al. (2000) found similar response to nutrient enrichment for non-leguminous species planted on mine spoils. Generally, the trees that allocate comparatively less resources to stem per unit of height growth are assumed to grow taller than those that allocate more (King, 1981; Lawton, 1984).

Further, gradient analysis along decreasing moisture and/or nutrient availability indicate absence of leguminous plants on slopes due to poor regeneration capacity and phenotypic plasticity while non-leguminous plants can grow well on slopes and flat surfaces i.e.,highphenotypic plasticity. On slopes, non-leguminous Plants show high density-dependent mortality, which may be associated with high regeneration capacity. This infer poor resistance and resilience of leguminous and non-leguminous plants with compound leaves along gradients of decreasing moisture/ nutrient availability, and vulnerable to change in climate and anthropogenic disturbances.

Table 1.Summary of adult plant species* present in Vindhyan forests (Sagar and Singh, 2005).

Botanical Name	Family	Leaf Type
Buchanania lanzan	Anacardiaceae	Simple
Lannea coromandelica	(3)	Compound
Semecarpus anacardium		Simple
Miliusa tomentosa	Annonaceae	Simple
Holarrhena antidysenterica	Apocynaceae	Simple
Stereospermum suaveolens	Bignoniaceae	Compound
Bombax ceiba	Bombacaceae	Compound
Boswellia serrata	Burseraceae	Compound
Cassine glauca	Celastraceae	Simple
Anogeissus latifolia		Simple
Terminalia bellirica	Combretaceae	Simple
Terminalia chebula	(4)	Simple
Terminalia tomentosa		Simple
Cochlospermum religiosum	Cochlospermace	Simple

	ae	
Shorea robusta	Dipterocarpaceae	Simple
Eriolaena hookeriana	Dombeyoideae	Simple
Eriolaena quinqueolocularis	(2)	Simple
Diospyros melanoxylon	Ebenaceae	Simple
Antidesma ghaesembilla		Simple
Phyllanthus emblica	Euphorbiaceae	Simple
Bridelia retusa	(3)	Simple
Acacia catechu		Compounds
Albizia odoratissima		Compound
Bauhinia racemosa		Simple
Butea monosperma		Compound
Cassia fistula	Fabaceae (10)	Compound
Dalbergia sissoo		Compound
Hardwickia binata		Compound
Mimosa himalayana		Compound
Ougenia oojeinsis		Compound
Pterocarpus marsupium		Compound
Casearia elliptica	Flacourtiaceae	Compound
Flacourtia indica	(2)	Simple
Lagerstroemia parviflora	Lythraceae	Simple
Soymida febrifuga	Meliaceae	Compound
Ficus benghalensis	Moraceae	Simple
Nyctanthes arbortristis	Oleaceae (2)	Simple
Scherebera swietenoides		Simple
Zizyphus glaberrima	Rhamnaceae (2)	Simple

Zizyphus nummularia		Simple
Adina cordifolia		Simple
Gardenia latifolia		Simple
Gardenia turgida	Rubiaceae (6)	Simple
Hymenodictyon excelsum		Simple
Mitragyna parvifolia		Simple
Randia uliginosa		Simple
Aegle marmelos	Rutaceae (2)	Compound
Chloroxylon swietenia		Compound
Schleichera oleosa	Sapindaceae	compound
Sterculia urens	Sterculiaceae	Simple
Grewia serrulata	Tiliaceae	Simple
Holoptelia integrifolia	Ulmaceae	Simple
Tectona grandis	Verbenaceae	Simple

*Sspecies without botanical name are excluded from the original list.

Table 2. Mean leaf area, leaf weight, specific leaf area and chlorophyll content of eight species of Vindhyan forests (Pandey *et al*., 2009).

Speci es	*L/N	Leaf Type	Leaf are (c m^2	Le af	Spec ific leaf	Chlor ophy
Shorea robusta	NL	Simple	118.33	1.09	108.86	1.07
Buchanania lanzan	NL	Simple	107.39	1.031	108.27	1.04
Diospyros melanoxylon	NL	Simple	61.48	0.70	88.15	1.26
Lagerstroemia parviflora	NL	Simple	26.51	0.30	89.67	0.82
Lannea coromandelica	NL	Compound	49.13	0.31	168.92	0.90
Terminalia tomentosa	NL	Simple	143.05	1.38	118.42	0.73
Holarrhena antidysenterica	NL	Simple	26.39	0.26	114.90	0.72
Lantana camara	NL	Simple	29.77	0.11	269.35	0.74

Table 3. Height (H): Diameter (D) ratio of five plant seedlings of tropical deciduous forests in Jharia Coalfield, Jharkhand.

Plant species	***A. indica***	***E. officinalis***	***D. strictus***	***F. religiosa***
L/NL	NL	NL	NL	NL
Leaf	Compound	Simple	Simple	Simple
H:D ratio	69.82 ±6.485	181.17 ±14.48	155.94 ±9.41	52.1075 ±9.405

*L/NL = Leguminous/Non-leguminous

Impact of Human Disturbance and High Altitude

In situ seed germination and seedling establishment of non-leguminous species with simple leaves are not successful at those sites where leguminous plants prefer to grow, vice-versa. This leads to classification of leguminous trees as a rare species which prefer to grow in isolation and also contribute poor species richness, evenness and α-diversity. These characteristics reveal their patchy distribution and weak phenological plasticity in intact forests and/or forest fragments.

Consequently, future population growth of leguminous trees and associated ecosystem structure and functions are at risk. Moreover, the impact of habitat destruction on the loss of leguminous plant species is higher than the non-leguminous plant species in all phenological stages (i.e. seedling, sapling and adult), as it has been found in the study carried out by Sagar et al. (2005) where nine leguminous species at Hathinala site (least disturbed) and four species each at Khatabaran (moderately disturbed) and Kota (highly disturbed) sites were present (Table 4).

Swamy et al (2000) carried out plant diversity assessment in

Veerapuli and Kalamalai Forest Reserve of Agastyamalai Hills in the Western Ghats where based on important value index number of leguminous species is only 4 % (Table 5).

Table 4. Summary of leguminous plant species present at five sites in Vindhyan forests (Sagar and Singh, 2005).

Plant Species	**Hathinala**	**Khatabaran**	**Majhauli**	**Bhawani Katariya**	**Kota site**
Acacia catechu	+	+	+	+	+
Albizia odoratissima	+				
Bauhinia racemosa	+	+	+		
Butea monosperma		+	+		
Cassia fistula	+	+	+		+
Dalbergia sissoo					+
Hardwickia binata	+			+	+
Mimosa himalayana	+				
Ougenia oojeinsis	+		+		
Pterocarpus marsupium	+		+	+	

In other words, suboptimal habitats supporting leguminous plants are fragile in nature and more prone to anthropogenic disturbances. This observation is supported by decadal increase (1988-1998) in forest fragments and restricted dominance of Hardwickia-Acacia community in <1.5 ha forest patches in Vindhyan region (Jha et al., 2005).

Similarly, Raghubanshi and Tripathi (2009) studied the impact of disturbance results in extensive mortality and failure of recruitment of legumes and non-legumes in Vindhyan forests.

Further, the number of leguminous species decreases with increase in altitude. This shows natural constraint on existence of leguminous trees and nitrogen fixation in high mountain areas though atmospheric oxygen is less, which perceived as a favorable condition for nitrogen fixation.

Table 5. Based on importance value index (IVI), Family-wise contribution of plant species (S) in Tropical forest ecosystems at Veerapuli and Kalamalai Forest Reserve of Agastyamalai Hills in the Western Ghats of Tamil Nadu, India (Swamy *et al*., 2000).

Families	Species	Family	Species
Anacardiaceae	5	Moraceae	2
Achariaceae	1	Myristicaceae	1
Anonaceae	1	Myrtaceae	4
Apocynaceae	3	Oleaceae	1
Bignoniaceae	1	Phyllanthaceae	4
Burseraceae	1	Podocarpaceae	1
Clusiaceae	2	Polygalaceae	1
Combretaceae	4	Putranjivaceae	1
Connaraceae	1	Rosaceae	1
Cornaceae	1	Rubiaceae	4
Cycadaceae	1	Salicaceae	2
Dilleniaceae	1	Sapindaceae	2
Dipterocarpaceae	3	Sapotaceae	1
Ebenaceae	2	Staphyleaceae	1
Euphorbiaceae	6	Stemonuraceae	1
Fabaceae	3	Symplocaceae	1
Lauraceae	8	Theaceae	1

Lecythidaceae	1	Others	6
Malvaceae	3	**Total**	**85**
Meliaceae	2		

This may be considered as evolutionary restricted diversity of leguminous species in lower elevations or foothills of mountain particularly dry regions where huge energy demand for N_2 fixation can be full-filled by CO_2 sequestration.

Mining and Leguminous Species

In natural forest of Vindhyan region, dominant leguminous and non-leguminous species prefer to grow in two different microclimates. But, this strategy is not adopted by mining industries to create microclimates suited for both legumes and non-legumes. Perhaps, the reason may be in design of overburden dumps, which only deal with stability guidelines for mine spoil dumping. Hence, researchers experiment mine spoils with only one option i.e. monoculture and/or mixed plantation using various spoil treatment methods for successful establishment of woody species (Jha and Singh, 1993; Rao et al., 2008; Singh, 2006; Singh, 2008). This is the reason that we do not have enough reclaimed mined out areas that can be used for comparative assessment of growth performance of native species. Therefore we need a comprehensively engineered design of overburden dump to save rare leguminous species on one hand and common non-legumes on another hand. This is most urgent requirement, because mining industries divert huge forest land into a deforested land, which is more severe than forest resource utilization by native people. Further, the authentic data about the plant diversity loss due to mining activities is yet to be documented. As per the guidelines of

Environmental Clearance (EC), mining industries in consultation with Central and State authorities insure socio-economic viability of restoration measures adopted for mined out areas. But in reality, all the efforts are futile due to lack of awareness and inculcated habit of ignorance about the conservation of natural resources

Thrust Research Areas

In light of above facts, an Integrated Vegetation Cover Development Programme (IVCDP) is suggested to address the following bottlenecks in the sustainable mining practices:

- Scientific investigation of dominance of dicot plants with simple leaves (non- leguminous) on the mountain slopes and dicot plants with compound leaves (leguminous and non-leguminous) on the dry flat surfaces of mountain/plateau/uplands (away from seasonal water channels). This study will help in design of overburden dump taking into account environmental significance of biotic and abiotic factors in in-situ/*ex-situ* plant diversity conservation.
- Establish relationship between carbon and nitrogen cycles considering natural and anthropogenic constraints in tropical deciduous forests.
- Data generation on plant diversity loss due to mining industries.
- Socio-economic viability of current management practices.

Conclusions

The diversity pattern of legumes and non-legume species in Vindhyan region and other parts of Indian subcontinent reveal their entirely different nature and response to type of disturbance. Generally, both dominant legumes and non-legumes do not grow in each other's habitat due to their unique phenological plasticity and regeneration capacity. Further, non-legumes carry out CO_2 fixation while leguminous species play dual role in deciduous forests i.e. CO_2 fixation and N_2 fixation. These characteristics emphasize conservation as per their requirement in forest region and mined out areas. Hence, the concept of IVCDP will be useful for the sustainable development of natural resources.

References

Craine, J.M., Frochle, J., Tilman, D.G., Wedin, D.A., Chapin, F.S., 2001. The relationships among root and leaf traits of 76 grassland species and relative abundance along fertility and disturbance gradients. *Oikos*, 93, 274–285.

Ehrlich, P.R., Wilson E.O.,1991. Biodiversity studies-science and policy. *Science*,253: 758-762.

Holdgate M., 1996. The ecological significance of biological diversity. *Ambio*, 25:409-416.

Jha A.K., Singh, J.S., 1993. Restoration of degraded land: an overview. pp. 1-9. In: J.S. Singh (ed.) *Restoration of Degraded Land: Concepts and Strategies*. Rastogi Publications, Meerut, India.

Jha C.S., Goparaju L., Tripathi A., Gharai B., Raghubanshi A.S., Singh J.S., 2005.Forest fragmentation and its impact on species diversity: an analysis using remote sensing and GIS. *Biodiversity and Conservation*, 14: 1681–1698.

King D.A., 1981. Tree dimensions: maximizing the rate of height growth in dense stands. *Oecologia*, 51: 351-356.

Lawton, R.O. 1984. Ecological constraints on wood density in a tropical montane rain forest. *American Journal of Botany*, 71: 261-267.

Lubchenco, J., Olson A.M., Brubaker L.B., Carpenter S.R., Holland M.M., Hubbell S.P., Levin S.A., Macmahon J.A., Matson P.A., Melillo

J.M., Mooney H.A., Peterson C.H., Pulliam H.R., Real L.A., Regal P.J., Risser P.G.,1991. The sustainable biosphere initiative: an ecological research agenda. *Ecology*, 72:371-412.

Pandey S.K., Singh H., Singh J.S., 2009. Species and site effects on leaf traits of woody vegetation in a dry tropical environment. *Current Science*, 96(8): 1109-1114.

Raghubanshi A.S., Tripathi A.,2009. Effect of disturbance, habitat fragmentation and alien invasive plants on floral diversity in dry tropical forests of Vindhyan highland: a review. *Tropical Ecology*, 50(1): 57-69.

Rao P.B., Kaur A., Tewari A., 2008. Drought resistance in seedlings of five important tree species in Tarai region of Uttarakhand. *Tropical Ecology* 49(1): 43-52.

Raizada P., Singh A., Raghubanshi A.S., 2009. Comparative response of seedlings of selected native dry tropical and alien invasive species to CO_2 enrichment. *Journal of Plant Ecology*, 2(2): 69–75.

Sagar R., Singh J.S., 2005. Structure, diversity, and regeneration of tropical dry deciduous forest of northern India. *Biodiversity and Conservation*, 14: 935–959.

Singh A., 2006. Growth and leaf nutrient status of companion species as influenced by neighbouring species in mixed plantations raised on mine spoil. *Tropical Ecology* 47(2): 259-269.

Singh A., 2008. Influence of tree canopy on dry matter yield of seedlings of *Leucaena leucocephala* on mine spoil in dry tropical environment. *Indian Journal of Forestry*, 31(2): 207-208.

Singh K.P., Singh J.S., 1988. Certain structural and functional aspects of dry tropical forests and savanna. *International Journal of Ecology*

Environmental Science,14: 31–45.

Singh J.S., Singh K.P., Agrawal M., 1991. Environmental degradation of the Obra- Renukoot-Singrauli area, India and its impact on natural and derived ecosystems. *Environmentalist*, 1:171–180.

Singh A., Jha A.K., Singh J.S.,2000. Effect of nutrient enrichment on native tropical trees planted on Singrauli Coalfields, India. *Restoration Ecology*, 8: 80-86.

Swamy P.S., Sundarapandian S.M., Chandrasekar P., Chandrasekaran S.,2000. Plant species diversity and tree population structure of a humid tropical forest in Tamil Nadu, India. *Biodiversity and Conservation*, 9: 1643–1669.

Tilman, D., 2000. Causes, consequences and ethics of biodiversity. *Nature,* 405: 208-211.

Vendramini, F., Diaz, S., Gurvich, D.E., Wilson, P.J., Thompson, K., Hodgson, J.G.,2002. Leaf traits as indicators of resource-use strategy in floras with succulent species. *New Phytol.* 154: 147–157.

stoby, M., (1998). A leaf height seed (LHS) plant ecology strategy scheme. *Plant Soil*,199: 213–227.

Weiher, E., 1999. The combined effects of scale and productivity on species richness.*Journal of Ecology*, 87: 1005–1011.

Sustainable Landscape Restoration for Jharia Coalfield- India

Biswajit Paul
Department of Environmental Science and Engineering,
Indian School of Mines, Dhanbad, Jharkhand, India

Abstract

Mining Industries are considered as an environmentally perilous development in the area. Mine restoration is planning to reclaim the mines after it is exhausted of its mineral resources, uneconomical or it is technically unsuitable for mining. The Jharia coalfield lying in eastern part of India have 49 overlapping coal seams of various thicknesses, unapproachable old mine working, devastating mine fire, numerous environmental problems and highly populated surface along with important infrastructures was chosen for the study. Here millions of tonnes of good metallurgical coal get devastated due to ravaging mine fire leading to uncontrolled high carbon dioxide emissions.

The workings of the Jharia Coalfield being more than two century old has brought in numerous environmental degradation as mentioned. More than four hundred private mines were operating to supply coal for industrial use during the British period in India. The mine planning to operate the coalfield as a whole was never conducted although Mine Closure planning or Reclamation Planning is a part of mine plan.

Geological study, seam orientation, geographical boundaries and method of working was studied by the author to establish a sustainable mine closure and restoration strategy for different areas/geological measures of the coalfields to combat the existing fire thus reducing emissions and safe evacuation of coal. The outcome of this paper will enable the mine officials to take appropriate steps to achieve sustainable

mine closer and post mining environmental management in the next two centuries.

Mine Restoration Planning of this coalfield will cover the post mining land use, safety and favorable environmental condition for the inhabitants of the coalfield.

Keywords: Coalfield, closure planning, degradation, restoration

Introduction

The Jharia coalfield (JCF) is one of the most important coalfield in India because of its reserves of prime coking coal. These prime coking coals are used for making coke for metallurgical purposes. There are some reserves of non-coking coal also which are used for the nearby power plants. The river Damodar traverses in the southern portion of the sickle shaped coalfield. The coal basin covers an area of 456sq.km. There are 49 overlapping coal seams in his coalfield of which 26 seams are local in nature while 23 seams are regional and found throughout the coalfield (Sengupta, 1980).

Location of the Coalfield

The Jharia Coalfield is situated in the eastern part of India in the state of Jharkhand. The coalfield is located mostly in Dhanbad district, in the state of Jharkhand. It is lying between latitude 23° 39' to 23° 48' N and longitude 86° 11' to 86° 27' E which is about 260km northwest of Kolkata. Figure 1 shows the location of the coalfield with some of the mines having problems of fire.

History of Mining

The existence of the coalfield was known from time immemorial. However (Heatly, 1842) the first reference about the occurrence of coal was made in 1777. The coalfield was surveyed several times during the mid-nineteenth century. The Geological Survey of India (GSI) finally in started a systematic investigation in 1866 (Hughes, 1866). Over the years the exploitation of this coalfield was also started by private owners due to growing demand by the railways. The coal production from this coalfield boosted during early twentieth century due to setting up of some steel plants, increase in railway networks and the world wars. There were more than 400 mines in the pre-nationalization period with the theory of 'more hole more coal'. Least importance was given to scientific mining, environment and safety. After nationalization (during 1971-73) several mines were amalgamated to about 100 mines and big mines were created to promote scientific mining for high production and conservation point of view.

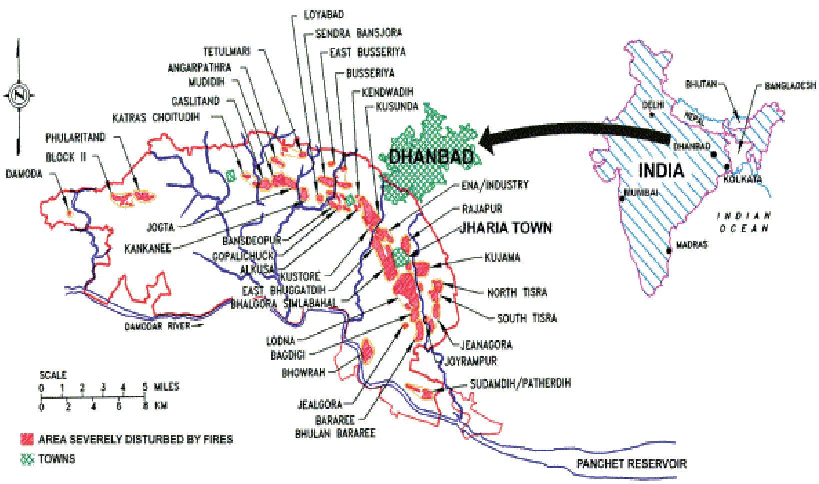


Figure 1. Jharia Coalfield and principal collieries affected by underground mine fires (Michalski et al., 1997).

Problems

Unscientific Mining

Mining in this coalfield was initially in the hands of private entrepreneurs, who had limited resources and lack of desire for scientific mining. The mining methods were comprised of both opencast as well as underground. The opencast mining areas were not backfilled, so large voids are still present in the form of abandoned mining areas. Having small leases the overburdens had been kept over the coal bearing areas hence have to be rehandled several times.

Subsidence

The thick seams were extracted by underground caving methods at shallow depth also. This process has damaged the surface land in the form of subsidence impacts and formation of pot holes or cracks damaging the surface infrastructure. Around 34.97 sq. km. area of the JCF is under subsidence and considered unstable. It is mentioned in JCF reconstruction program that about 70% of the underground production of coal would come by caving and balance 30% by stowing and thus about 101 sq. km. underground mining area would be affected by subsidence.

Mine Fire

Land subsidence has also enhanced spontaneous heating of coal seams leading to mine fires. This coalfield was engulfed with about 70 mine fires, spread over an area of 17.32 sq. km., blocking more than 636 million tonnes of coking coal and 1238 million tonnes of non-coking coal (www.envfor.nic.in).

Small Leases

The coal mining leases were distributed in more than 400 small mines operated by private owners as said earlier. However to promote scientific mining after nationalization M/s Bharat Coking Coal Limited (BCCL) the main lessee of JCF has amalgamated these large numbers of mines into about 100 mines for better administrative purpose, view of coal conservation and for technological advantages. Still larger mines have to be created for scientific mining purpose.

Settlements

The greatest hindrance to the scientific mining in JCF is the huge population settled over the mining blocks, which prevent the mine operators, to mine in a scientific methodical manner. Presently as per the Jharia Action Plan BCCL have to rehabilitate about 1,00,000 families away from the lease hold areas in the northern Metamorphic regions, in order to protect the coal blocks from raging mine fire, continue mining and close the exhausted mines in a sustainable manner.

Geological Formations

The general stratigraphic succession is given in Table 1. The plan of the geological formations of Jharia coalfield is presented in Figure 2.

Table 1 .Geological Succession – Jharia Coalfield (Chandra, 1992).

Age	Formation	Litho-type	Maximum Thickness
Jurassic or Tertiary Lower Jurassic		Dolerite dykes Mica Lamprophyre dykes & sills	
Upper Permian	Raniganj	Fine grained feldspathic sandstones, shales with coal seams.	800m
Middle Permian	Barren Measures	Buff coloured sand stones shales and carbonaceous shales	730m
Lower Permian	Barakar	Buff coloured coarse and medium grained feldspathic sandstones, grits, shales and coal seams	1250m
Upper Carboniferous	Talchir	Greenish shale and fine grained sandstones	245m
--------------------------------Unconformity------------------------------			
Archean		Metamorphics	

The cross-section of the coalfield at two sections are shown in Figure 3. The basement metamorphic rocks are overlain by Talchir Formation followed by the Barakar Formation, which is the main coal-bearing horizon (Chandra, 1992).This measure extends from extreme north to extreme south upto the southern fault and then vanishes. It also extends from extreme east to extreme west. Above the Barakar formation lays the Barren Measures which is bereft of coal seams except for a few lenses of coal. Overlying the Barren Measures lies the Raniganj Formation which is also coal bearing. This measure is placed in the south-west corner of JCF. This Raniganj measure is a full coalfield with all the features of a coal basin having different series of coal seams than that of the Barakar Measures.

Metamorphic Rocks -The coalfield is surrounded by metamorphic rocks made up of granites, granite-gneisses, quartzites, mica schists and amphibolites. Gneisses are the dominant rock type. In the north west part of the coalfield, at Dumra an outlier of metamorphic rock is exposed as shown in Figure 2. Otherwise the metamorphic rock occurs only at the base of the basin at different depths.

Talchir Formation-Rocks of Talchir Formation are of fluvio-glacial origin marked by a basal boulder bed resting on the pre-Cambrian basement. The formation is exposed almost continuous stretch around the northern crescent-shaped periphery of the basin. Toward the eastern and southeastern periphery and also at depth, the formation gradually vanishes toward the middle.

Barakar Formation-This Formation consisting of fluviatile deposits is the lowermost member in the Jharia coalfield. This is the most important formation containing coal seams and covers an area of about 210sq km.

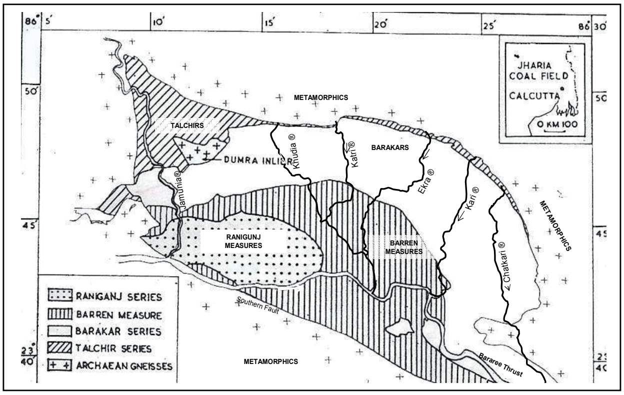


Figure 2. Geological formations of Jharia coalfield with drainage pattern (Chandra, 1992)

The Barakar Formation consists of coarse-grained sand-stones, conglomerates, shales, carbonaceous shales, silt-stones, fireclays and coal seams. Sengupta (1980) has recognized 49seams in the Jharia coalfield of which 26 seams are local and rest 23 seams are regionally available. The nomenclatures of these seams are I to XVIII. The thickness of this formation varies from 800 to 1250m.

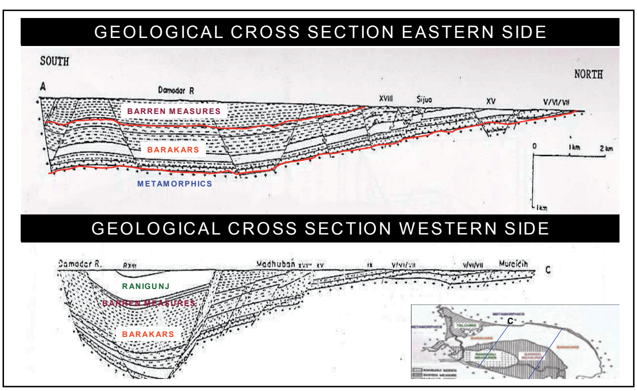


Figure 3. Geological sections at different sections

Barren Measures Formation-This formation is called Barren Measures because except for a few thin lenses of coal it is completely devoid of coal seams. The constituent rock types are coarse to pebbly sand-stones, sandy shales, carbonaceous shales and siderite bands. This formation is widely exposed covering a total thickness ranging from 600 to 730m.

Raniganj Formation-Overlying the Barren Measures the new Raniganj Formation occupies an oval basin covering an area of 58sq.km at the southwestern part of the basin. This is the uppermost coal bearing sequence of Jharia basin. There are ten local seams and three regional seams within this formation and are named as 0 to XII. These seams are different from that of the seams in the Barakar Measures.

Conceptual Mine Planning of the Coalfield

The author after investigation into the geological setting of the coal seams has found that mines lying in different formations should to be mined out by different methods. In the northern part of the coalfield, the coal seams are outcropping in the Barakar formations. These formations should be mined out by opencast methods as deep as the mine economics permit.

The deeper part of Barakar measures underlying the Barren measures needs to be mined out by underground mines. Therefore the mines in the Barren measure will form a different group of mines with deep underground workings.

The Raniganj formations will be mined out by opencast mines in the periphery and underground at the deeper central portions.

The planners of the coalfield has also planned in similar manner but due to the small mine leases, mine fires, legal problems, dense population as well as short term planning probably has led to unscientific mining of the property. It is high time that the planners should think of planning the mining operation of the entire coalfield instead of individual leases. Big blocks should be excavated right from the extreme north and should proceed toward south. The mines should be reclaimed or backfilled after de-coaling from the northern side only to prevent rehandling of OB dumps.

Mine Boundaries in the Barakar Measures

Large opencast mine have to be created by combining several mines. Therefore the mine boundaries have to be demarcated for long term plans. The Jharia coalfield has been traversed by several perennial streams namely the Jamunia, Khudia, Katri, Ekra, Kari and Chatkari streams. These streams are the main drainage system of the 456sq.km coalfield and flow from the north to the south to meet the river Damodar. The mine waters, washery effluents, domestic wastewaters are directed to these natural drains. As it is essential to maintain these natural drains, these streams may form natural boundaries of the big mines. The other boundaries may be the Metamorphics and the demarcation between the Barakar, Barren and Raniganj measures. For example the portion between the Jamunia and Khudia River lying in the Barakar formation only i.e., the Phularitand and Block II area in Figure 1 may form only one big mine. Figure 2 shows the streams and different measures to mark the boundaries of the big mines to be mined in similar methods. As lot of coal will be blocked under these streams, these may also be diverted through the de-coaled area temporarily by building artificial drain or canal like structure.

Mining the Barakar Measures

The geological cross section shows as the seams are outcropping in the northern side of the coalfield we should start the opencast mines from the extreme north and after de-coaling proceed toward the southern boundary as per the dip direction of the seams. The overburdens could be kept initially in the Metamorphic areas lying in the north of the coalfield.

As the mines proceeds toward the dip side backfilling with reclamation can be started from the northern side. This will minimize the re-handling of the overburden in different areas and facilitate faster rehabilitation in the de-coaled areas.

Mining the Barren Measures

The mines lying under the Barren Measure are suitable for underground only as the coal bearing Barakar measures are underlying it. Therefore these mines can carry on their operation till the opencast mines from the rise side (Barakar Measures) approaches these underground mines. Suitable precautions have to be taken as the opencast mines may get connected with the underground mines which may disturb the ventilation and may allow surface water into the mines causing inundation from the rise side.The connections between the opencast and the underground mines may also serve as coal transport networks from the deep mines to the exposed part of the seams in the opencast mines.

Mining the Raniganj Measures

The Raniganj Measures also can be mined out from the periphery as opencast mines and proceed toward the centre. Later on as these peripheral opencast mines reaches the un-economics depth towards the centre, underground mining may continue at the central deep portion. There are potential for coal bed methane extraction also in the eastern and south-eastern portion of the Raniganj Measures near the Bhatdih mines.

Closure and Restoration Plan of Jharia Coalfield

The Jharia Closure and restoration plan should be integrated with the mining plan of the coalfield. With the present rate of extraction of 30Mt per annum, the coalfield may last for another 200years considering 40% extraction of roughly 17000Mt of reserve. As the major opencast mines will be lying in the Barakar measure the restoration of the mines in this formation will be of utmost importance. The progressive mine closure and reclamation of this coalfield will also start from the northern boundary of the coalfield. The following areas need to be addressed in the mine closure and restoration plan of JCF.

Reclamation and Rehabilitation of the Mined-Out Land

The actual site of the pit will be restored by reclamation and rehabilitation of mined-out land for future use. The proposals should be supported with relevant plans and sections depicting the method of land restoration / reclamation / rehabilitation. Suitable plantation will be done to stabilize the land. The land will be allowed to consolidate for a few years before utilization for any infrastructure or construction purposes. The residual pits will be maintained with water suitable for use like pisciculture, lakes for tourism, migratory birds, picnic spots, etc. Necessary care will be taken to prevent any danger of the stored water to the adjacent underground mines or underneath seams.

The overburden dumps will be suitably terraced for stabilization and plantation will be done to prevent erosion and air pollution. Garland drainage and suitable sedimentation tanks will be constructed to accommodate the storm water. The garland drains and the sedimentation tanks will be cleaned before onset of every monsoon.

Care will be taken to prevent fire due to presence of carbonaceous materials in the overburden as well as in the mine fill. The mine opening will be suitably covered and stowed to prevent any future fire in the un-recovered coal pillars. The pits shall be suitably fenced, the shafts will be suitably covered to prevent any danger to man and animals.

The office building shall be used for the society. The railway tracks used for coal transportation may be used as city rails/metro rails. The mined out land may be handed over to the original owner, if found or may be auctioned with suitable planning and plotting.

Air Quality Management

The mining lands if not stabilized by vegetation, will be prone to air pollution due to presence of air borne materials. The overburden dumps as well as the backfilled areas should be suitably covered by plantation and weeding. Care will be taken to prevent fire due to presence of carbonaceous materials in the overburden as well as in the mine fill. The carbonaceous materials will be suitably packed and any contact with air will be prevented by making impermeable layers. Incombustible materials like ash may be mixed with the carbonaceous materials to prevent smoldering. The mine opening will be suitably closed, stowed and sealed to prevent any future fire in the remnant pillars. A regular air quality monitoring will be done to check the status of air pollution.

Water Quality Management

The existing surface and ground water bodies available in the lease areas will be protected and the measures for protection against erosion, sedimentation, siltation will be taken. Water treatment, diversion of water courses will be done if there are chances of contamination of ground water from leaching, acid mine drainage etc. Quantity and quality of surface water bodies should be monitored to meet the water quality conforming to the permissible limits. Regular hydrological study will be carried out in the area to monitor the water balance.

The residual mine pits, shafts and workings may be used as water reservoirs. The mine pumps and the water treatment plants should be maintained by the lease holders for a few years, to distribute water to the local people for domestic and agricultural purposes before handing them over to the local administration.

Waste Management

The type, quality and quantity of overburden, washery reject, pit head thermal power plant ash etc. available and their disposal practice should be addressed. If no utilizations of these waste materials are proposed, the manner in which these waste materials will be stabilized should be decided. The protective measures should be taken for prevention of siltation, erosion and airborne dust from these waste materials. If toxic and hazardous elements are present in the waste material, suitable protective measures like plantation, weeding and contouring should be taken to prevent their dispersion in the air environment, surrounding agricultural land and leaching in the surface and ground water.The mining wastes may be properly placed in the underground mine voids or surface exhausted pits after suitable toxicological and physical tests.

Risk Assessment and Disaster Management

The restoration plan should deal with action plan for high risk accidents like landslides, subsidence, flood, inundation or explosion in underground mines, fire, subsidence, seismic activities, tailing dam failure etc. Emergency plan should be proposed for quick evacuation and ameliorative measures to be taken. The capability of lessee to meet such eventualities and the assistance to be required from the local authority should also be described. The rehabilitated peoples over the mined out land should be well informed and well trained about the anticipated dangers of the old mining lands, old workings like outbreak of fire or subsidence.

Safety and Security

The mine shafts should be suitably covered and protected. The opencast mines connected to the underground mine working should be filled up properly with sealing of the connections to prevent fire, inundation as well as illegal mining. The slopes of the mine should be made stable by terracing, stone pitching and securing by fencing. Suitable plantation, weeding should be done in the slopes to prevent erosion. The areas likely to be subsided should be stowed properly. The public should be made aware about the unanticipated dangers of the area.

Disposal of Mining Machineries

As there will be high utilization of gigantic mining machines suitable disposal plans should be developed. The old and worn-out machines should be scheduled to be disposed and recycled. The tyres of the heavy machineries, belt conveyors etc should be properly recycled and disposed.The headgears, ropes, weigh bridges, workshops, railway siding tracks, pit head washeries should be dismantled and sent for useful purpose. The batteries should be disposed as per the rules enforced in the country.

Utilization of Office Buildings and Staff Quarters

The office building should be used for societal purpose during the post mining period and the residential buildings may be auctioned or donated to the local people. Suitable markets, schools, community centers, training centers should be developed in the abandoned lands to promote sustainability.

Economic Repercussions of Closure and Restoration of Mine and Manpower Retrenchments

Manpower retrenchment, compensation to be given, socio-economic repercussions and remedial measures, consequent to the closure of mines should be described, specifically stating the following:

- Number of local residents employed in the mine, status of the continuation of family occupation and scope of joining the occupation back in some other mining areas of the company.

- Compensation given or to be given to the employees connecting with sustenance of himself and their family members.
- Satellite occupations connected to the mining industry - number of persons engaged therein - continuance of such business after mine closes.
- Continued engagement of employees in the rehabilitated status of mining lease area and any other remnant activities.
- Envisaged repercussions on the expectation of the society around due to closure of mine.

Time Scheduling for Abandonment

The details of time schedule of all abandonment operations as proposed above should be addressed with time schedule. The manpower and other resources required for completion of proposed job should be described. The schedule of such operations should also be supplemented by PERT (Programme Evaluation & Review Technique), Bar chart etc.

Abandonment Cost

The closure and restoration cost has to be estimated based on the activities required for implementing the protective and rehabilitation measures including their maintenance and monitoring programme. The restoration cost should be considered as a part of mining operation rather than a separate environmental or social budget.

Conclusions

The inventors of the coalfield could not plan the mining methods for proper conservation, safety and environmental requirements. For this reason the present operators are facing difficulties due to the small mine leases, legal problems, dense population, mine fires and unscientific mining of the property. It is high time that we should think of planning the mining operation of the entire coalfield instead of individual small leases. Similarly the restoration of the entire coalfields have to be conceptualized and implemented along with the current mining operations so that sustainable development take place making the future generations secured from the unsafe mining and environmental adversities. The author of the paper has conceptualized the closure and restoration of the Jharia Coalfield in his own way of imagination.

Acknowledgements

The views expressed in the paper are personal. The present problems faced in the mining operations are due to absence of long term planning during the pre-nationalised period. Hence a closure plan of the entire JCF is required to be formulated so that the future anticipated problems can be eliminated and Jharia will be a better place to live. The author is thankful to Professor Gurdeep Singh, Head of the Department, Centre of Mining Environment, Environmental Science & Engineering Department, Indian School of Mines(ISM), Dhanbad for his inspiration and guidance. He also expresses his sincere gratitude to Professor T. Kumar for his kind acquiescence for this write-up.

References

Chandra, D. 1992) *Jharia Coalfield,* Geological Society of India, 1-42.

Heatly Tollemache, S.G.1842. Contributions towards a history of the development of the Mineral Resources of India, *J. Asiat. Soc, Beng,11*,811.

Huges, T.W.H., (1866). *Jharia Coalfield*, Mem.Geol.Surv.India, 5,334-336.

Master Plan for dealing with fire, subsidence and rehabilitation in the leasehold of BCCL, BCCL, 2008.

Michalski, S.R. Custer, E.S. and Munshi, P.L.1997. Investigation of the Jharia coalfield mine fires – India, Vision 2000, *14th Annual Meeting of the American Society for Surface Mining and Reclamation, Austin, Texas,* May 10-16,

Sengupta,N.1980. A revision of the geology of Jharia coalfield with particular reference to distribution of coal seam, *Ph.D. thesis*, Indian School of Mines, Dhanbad, 103pp.

Biodiversity Conservation through Removal of *Lantana camara*-an Invasive Species in Planted Ecosystem of Rajaji National Park Uttarakhand

H.B.Vasistha, Mridula Negi, S. Rasaily*,
Suryapal Singh Bhandari and S.K. Kamboj
Division of Ecology and Environment,Forest Research Institute, Dehradun
* Director, Rajaji National Park

Abstract

Invasion of alien species is a growing problem for the world, both ecological and economically. They can alter ecological relationships among native species and can affect ecosystem functions, economic value of ecosystem as well as human health. Biodiversity of different habitats in our country is largely affected by the invasion of various invasive species, *Lantana camara* native to South America is one of them. Rajaji National Park nestled in Shivalik ranges and extending in the district of Dehradun, Haridwar and Pauri of Uttarakhand, and characterized by the presence of distinct natural vegetation communities i.e. sal, mixed broad leaf, chir pine, scrubland, grassy pastures, riverine and planted ecosystems are largely invaded by *L. camara,* resulting in loss of biodiversity and food of wild animals. Eucalyptus which is planted in certain parts of Kansaro range of Rajaji National Park in the years 1996 and 1997 is heavily encroached by *L. camara*. To manage the plantation ecosystems, Lantana is being removed from these areas. In order to see the impact of invasion of *L. camara* particularly on plant diversity and species composition, a study has been carried out in Lantana invaded as well as Lantana removal sites in *Eucalyptus* plantations.

The present paper describes the species composition and plant

diversity as influenced by the invasion of *Lantana camara* in *Eucalyptus* plantation in Rajaji National Park.

Keywords: Invasion, Alien species, Ecosystem, Riverine, Shivalik Ranges.

Introduction

Invasion of alien species is a growing problem for the world, both ecological and economically. It is a high priority problem in the field of environmental management.Invasive species often alter the ecological relationship among native species and affect the ecosystem functions, their economic value as well as human health. Biodiversity of different forest ecosystem whether natural or manmade is largely affected by the various invasive species. Word wide an estimated 80% of endangered species could suffer losses due to competition with or predation by invasive species (Smith and Berg, 1988). Convention on

Biological Diversity (CBD) recognizes biological invasions as the second most important casual factor for the loss of biological diversity in natural ecosystem across the world (Love e*t al.,* 2009).The problem of invasion of alien species becomes more serious when it occurs in National Parks, Sanctuary and Biosphere reserve etc. Since spread of alien species disturbed the food chain of the ecosystem by reducing the habitat of wild animals and loss of biodiversity thereof. Rajaji national park which was established in the year 1983 with the aim to maintain the habitats of various wild animals such as Asian elephant, tiger, leopard, dear, samber etc. is facing an accentuated problem of invasion of *Lantana camara,* an exotic weed native to South America. The invasion resulted in loss of habitats and biodiversity, food of herbivores and free movement of wild animals in both natural and planted ecosystems of the park area. In order to ascertain the extent of loss of biodiversity and vegetation composition under planted ecosystems, a study has been carried out under

Eucalyptus plantation in Kansaro Range of Rajaj national park.

Study area

Rajaji National Park nestled in Shivalik ranges is extending in the district of Dehradun, Haridwar and Pauri Garhwal of Uttarakhand. It is spread over an area of 820.42sqkm., and situated at a longitude of 77^0 54’30” to 78^0 01’15” E and latitude of $29^0$56’40” to $30^0$20’N.The park area is characterized by the presence of both distinct natural vegetation communities i.e., Sal, mixed broad leaf, Chir pine, scrubland, grassy pastures, riverine and planted ecosystems of various species such as Teak (*Tectona grandis),Eucalyptus, Ailanthus excelsa* etc. High rainfall, humidity and high temperature have favored a rich tropical moist type of vegetation. The average rainfall is approximately 2000-2200 mm. May and June are the hottest months with temperature reaching upto 40- 41^0C and December to January are the coldest months with temperature below 2^0C. July and September are monsoon months with heavy rainfall. These natural and planted ecosystems are largely invaded by *L.camara*. To sustain the habitats of wild animals the park authority has initiated the removal of *L.camara* from the park area in a phase manner since 2006. The removal is being done by mechanical measures i.e., direct uprooting.

Methodology

To ascertain the impact of invasion of *L.camara,* the experimental sites were selected in Lantana invaded and three years old Lantana removal sites under 15 years old *Eucalyptus* plantations in Kansaro range of Rajaji national park. Vegetation survey was carried out using quadrat sampling methods (Misra,1968). Nested quadrats of size 10m x 10m, 3m x 3m and 1m x 1m were laid randomly respectively for recording trees, shrubs and herbaceous vegetation (Khan, 1961). Saplings of trees and seedlings of trees and shrubs were also counted respectively in the quadrats of shrubs and herbaceous vegetation. The data were quantitatively analyzed for frequency, density, and their relative values and finally Importance Value Index (IVI) (Curtis and McIntosh, 1950; Curtis and Cottam, 1956; Phillips,1959). Species diversity index was also calculated using Shannon and Wiener (1963). The data were analyzed separately for Lantana invaded and Lantana removal sites.

$$\text{Density} = \frac{\text{Total number of individual species}}{\text{Total number of quadrats studied}}$$

$$\text{Frequency \%} = \frac{\text{Number of quadrats of occurrence of species}}{\text{Total number quadrats studied}} \times 100$$

Basal area of each species was calculated by measuring collar diameter of plants using Vernier Caliper.

Basal area = πr^2 where, $\pi = 3.14$ and r=radius of species

$$\text{Relative Frequency} = \frac{\text{Frequency of a species}}{\text{Frequency of all the species}} \times 100$$

$$\text{Relative Density} = \frac{\text{Density of a species}}{\text{Density of all the species}} \times 100$$

$$\text{Relative Dominance} = \frac{\text{Basal Area of a species}}{\text{Basal Area of all the species}} \times 100$$

Importance Value Index (IVI) =Relative Frequency + Relative Density + Relative Dominance

Results and Discussion

The data analyzed for ecological attributes i.e., frequency, density and dominance for Lantana invaded and Lantana removal sites are presented in Tables 1 and 2.

Floristic composition of tree vegetation

Since the study was carried out under 15 year old planted ecosystem, therefore no marked changes were expected in relation to the composition and ecological attributes of mature tree species in Lantana invaded and removal sites. *Butea monosperma* was the only native species which was recorded in the *Eucalyptus* planted area (Tables 1 and 2). The values for frequency percentage, density /ha and IVI for *Eucalyptus* were more or less similar in both these conditions. The slight differences in density value in these two conditions are attributed to the mortality of some individuals of *Eucalyptus* in Lantana invaded sites during 15 years of establishment.

A distinct change in composition of shrubs and saplings was recorded in Lantana invaded and removal sites (Table 1 and 2). In Lantana invaded sites there were five shrub species and five tree species in the form of saplings (Table 1), whereas in Lantana removal sites, the number of shrub species was 11 and saplings 10 in numbers (Table 2). In Lantana invaded site, the most frequent and dominant species was *L.camara* having 90% frequency and 192.68 IVI value. A big gap between IVI values of *L.camara* and other species was recorded, indicating the dominance of single invaded species. *Clerodendrum viscosum* and *Murraya koenigii* which is abundantly found in Sal and other vegetation communities in dry and moist deciduous forests of Doon valley have registered very low values of IVI as compared to *L.camara*. Under saplings, the most dominant species was *Mallotus philippensis* (IVI 24.38) followed by *Litsaea chinensis* (IVI 8.30).

Species i.e. *Cordia myxa, Syzygium cumini* and *Holarrhena antidysenterica* were having more or less similar IVI values ranging in between 4.16 to 4.19

Table 1.Floristic composition of Lantana invaded site in planted ecosystem of Eucalyptus

Species	Frequency (%)	Density /ha	R. Frequency	R. Density	R. Domin.	IVI
Trees						
Eucalyptus sp.	50.0	100	83.33	90.91	99.68	273.92
Butea monosperma	10.0	10	16.67	9.09	0.32	26.08
Shrubs						
Lantana camara	90.0	1,999.98	31.03	75.00	85.64	191.6
Clerodendrum viscosum	30.0	,222.22	10.34	7.64	3.82	21.81
Murraya koenigii	40.0	666.66	13.79	4.17	2.92	20.87
Solanum indicum	30.0	777.77	10.34	4.86	1.12	16.32
S.xanthoxylum	10.0	111.11	3.45	0.69	0.00	4.14
Saplings						
Mallotus philippensis	40.0	666.6	13.79	4.17	6.43	24.38
Litsaea chinensis	20.0	222.22	6.90	1.39	0.02	8.30
Cordia myxa	10.0	111.11	3.45	0.69	0.04	4.19
Syzygium cumini	10.0	111.11	3.45	0.69	0.02	4.16
Holarrhena antidysenterica	10.0	111.11	3.45	0.69	0.00	4.14
Herbs						
Cyperus monocephalus	30.0	7,000	21.43	67.96	33.68	123.07
Pepromia sp.	10.0	8,000	7.14	7.77	15.40	30.31
Oplismenus compositus	10.0	6,000	7.14	5.83	1.28	14.25
O. burmannii	10.0	3,000	7.14	2.91	0.52	10.58
Seedlings						
Murraya koenigii	30.0	7,000	21.43	6.80	40.48	68.70
Clerodendrum viscosum	30.0	7,000	21.43	6.80	6.60	34.83
Randia spinosa	10.0	1,000	7.14	0.97	1.56	9.67
Litsaea chinensis	10.0	,1000	7.14	0.97	0.48	8.59
Grand Total		40,000				

Table 2. Floristic composition of Lantana removal site in planted ecosystem of Eucalyptus

Species	Frequency	Density /ha	R. Frequency	R. Density	R. Dominance	IVI
Trees						
Eucalyptus sp.	60.0	130	85.71	92.86	99.19	**277.76**
Butea monosperma	10.0	10	14.29	7.14	0.81	**22.24**
Shrubs						
Clerodendrum	100.0	20,555.53	14.08	41.20	36.01	**91.30**
Pogostemon	70.0	14,777.76	9.86	29.62	19.02	**58.50**
Lantana camara	100.0	3,999.99	14.08	8.02	9.42	**31.53**
Murraya koenigii	80.0	3,444.44	11.27	6.90	12.03	**30.20**
Callicarpa macrophylla	20.0	333.33	2.82	0.67	0.12	**3.60**
Carissa opeca	20.0	333.33	2.82	0.67	0.06	**3.54**
Solanum indicum	10.0	555.55	1.41	1.11	0.59	**3.12**
Perilla frutescens	10.0	222.22	1.41	0.45	0.26	**2.12**
Flemengia chappar	10.0	111.11	1.41	0.22	0.25	**1.88**
Crotalaria sp.	10.0	111.11	1.41	0.22	0.04	**1.67**
Urena lobata	10.0	111.11	1.41	0.22	0.03	**1.66**
Saplings						
Holarrhena	70.0	1,999.99	9.86	4.01	13.90	**27.77**
Mallotus	80.0	1,222.22	11.27	2.45	2.29	**16.01**
Eucalyptus sp.	30.0	777.77	4.23	1.56	0.76	**6.55**
Cassia fistula	10.0	111.11	1.41	0.22	4.11	**5.74**
Randia spinosa	20.0	555.55	2.82	1.11	0.31	**4.24**
Ziziphus maurtiana	20.0	222.22	2.82	0.45	0.18	**3.44**
Ehretia laevis	10.0	111.11	1.41	0.22	0.48	**2.11**

Wrightia tomentosa	10.0	111.11	1.41	0.22	0.10	**1.73**
Phyllanthus emblica	10.0	111.11	1.41	0.22	0.02	**1.66**
Premna latifolia	10.0	111.11	1.41	0.22	0.01	**1.65**
Herbs						
Chloris dolichostachya	30.0	6,43,000	4.11	67.68	17.39	**89.19**
Impereta cylindrica	20.0	65,000	2.74	6.84	20.32	**29.91**
Ageratum conyzoides	70.0	40,000	9.59	4.21	12.51	**26.31**
Cyperus eria	30.0	40,000	4.11	4.21	15.62	**23.94**
Cassia tora	60.0	44,000	8.22	4.63	9.33	**22.18**
Achyranthes aspera	50.0	7,000	6.85	0.74	0.01	**7.59**
Commelina	20.0	8,000	2.74	0.84	1.70	**5.28**
Capillipedium	10.0	1,000	1.37	1.79	1.49	**4.65**
Rungia pectinata	20.0	4,000	2.74	0.42	0.28	**3.44**
Oxalis corniculata	10.0	2,000	1.37	0.21	0.78	**2.36**
Oplismenus	10.0	3,000	1.37	0.32	0.26	**1.95**
O. compositus	10.0	2,000	1.37	0.21	0.11	**1.69**
Seedlings						
Sida cordata	70.0	24,000	9.59	2.53	1.66	**13.78**
Clerodendrum	50.0	8,000	6.85	0.84	4.58	**12.27**
Ichnocarpus frutescens	30.0	8,000	4.11	0.84	6.31	**11.26**
Holarrhena	40.0	5,000	5.48	0.53	1.56	**7.57**
Pogostemon	40.0	8,000	5.48	0.84	0.70	**7.02**
Randia spinosa	20.0	3,000	2.74	0.32	1.43	**4.49**
Murraya koenigii	20.0	4,000	2.74	0.42	0.52	**3.68**
Litsaea chinensis	10.0	1,000	1.37	0.11	1.73	**3.21**
Mitragyna parviflora	10.0	1,000	1.37	0.11	0.48	**1.95**
Mimosa sp	10.0	1,000	1.37	0.11	0.31	**1.79**
Lantana camara	10.0	1,000	1.37	0.11	0.13	**1.61**
Wrightia tomentosa	10.0	1,000	1.37	0.11	0.07	**1.54**
Phyllanthus emblica	10.0	1,000	1.37	0.11	0.07	**1.54**
Urena lobata	10.0	1,000	1.37	0.11	0.07	**1.54**
Eucalyptus sp.	10.0	1,000	1.37	0.11	0.05	**1.53**
Asparagas racemosa	10.0	1,000	1.37	0.11	0.04	**1.51**

Cissampelos pareira	10.0	1,000	1.37	0.11	0.02	**1.49**
Grand Total		**8,66,000**				

Floristic composition of shrub vegetation

In contrary to the Lantana invaded site, Lantana removal sites have accommodated more number of species under shrub layer i.e.11 as shrub species and 10 tree species in the form of saplings, which clearly indicates the impact of removal of Lantana on regeneration of number of native species (Table 2).In addition, the gaps between IVI values of species are narrowed in Lantana removal sites than Lantana invaded sites indicating evenly distribution of individuals among species.

Clerodendrum viscosum (IVI 91.30) was most dominant species followed by *Pogostemon benghalense* (IVI 58.50) in Lantana removal sites. Similar to the shrub species, the number of saplings was also higher in Lantana removal site indicating the germination and establishment of various other native tree species. *Holarrhena antidysenterica* and *Mallotus philippensis* were recorded as dominant tree species in the form of saplings and also common in both these conditions. *Ehretia laevis* a common species in Doon valley forest has shown its presence only after the removal of Lantana from plantation area. A significant change in lowering of dominance of *Lantana camara* and enhancement of dominance of *Clerodendrum viscosum, Pogostemon benghalense* and *Murraya koenigii* was observed after removal of Lantana from park area.

The IVI value of *L.camara* has sharply reduced from invaded site to removal site, whereas the IVI value of other three species has increased as a result of removal of Lantana from park area. This has indicated a positive sign in enhancement of diversity of native species and growth after removal of Lantan*a* from the area.

Floristic composition of herbaceous vegetation

Similar to the shrub vegetation, the number of herbaceous vegetation comprising herbs, grasses and seedlings were also recorded higher in Lantana removal site than invaded site (Table 1 and 2). In Lantana removal site there were 12 herbs and grasses and 17 trees and shrubs in the form of seedlings, whereas in Lantana invaded sites there were only four herbs and grasses and four trees and shrubs in the form of seedlings. Among 12 herbaceous species six each were grasses and herbs and among 17 seedlings, 7 were of tree species and rest was shrub species in Lantana removal site.

The most dominant species in Lantana removal site was *Chloris dolichostachya* (IVI 89.19) and in Lantana invaded site the most dominant species was *Cyperus monocephalus*(IVI 123.07). The appearance of *C. dolichostachya* in Lantana removal site has shown a positive significant impact on conservation of food resources of wild animals. *C. dolichostachya* being a grass species is greatly browsed by herbivores. Among seedlings, 7 species were of tree seedling and 10 were of shrubs seedlings in Lantana removal sites. In Lantana invaded site there were only 2 tree species in the form of seedlings. The larger number of seedlings under Lantana removal sites again indicating positive impact on regeneration of native tree species.

Richness and species Diversity (H')

Herbaceous and shrubby vegetation are the two components of ecosystem which registered immediate changes in event of any disturbances or management practices. After removal of Lantana from *Eucalyptus* plantations, the species richness and diversity of herbaceous and shrub layer increased even within a short period of time i.e, three years of removal of Lantana.

Table 3. Species richness and diversity Index (H') of Lantana invaded and Lantana removal sites in planted ecosystem of *Eucalyptus*

	Lantana invaded site		Lantana removal site	
	Specie s richne	Diversity Index (H')	Specie s richnes	Diversity Index(H')
Tree layer	2	0.30	2	0.25
Shrub layer	10	1.02	21	1.72
Herbaceous layer	8	1.18	29	1.46

Kumar and Rohatgi (1999) also found that is some areas, competition by Lantana results in a reduction of biodiversity. Lantana leaves and their leachats exert allelopathic in vitro and to a lesser extent in soil on seed germination, root elongation and plant growth of many species (Cusado 1995, Sahid and Sugan 1993). Gentle and Duggin (1998) and Day *et al.* (2003) also reported suppressive effect of Lantana on a wide range of native species. A decline in plant species richness with increasing level of Lantana infestation in dry rainforest also reported by Fensham *et al.* (1994). Alcova (1987) showed a large (at least 70%) decline in inferred recruitment (number of native tree and shrub species) in Lantana infested areas of *Eucalyptus* woodland compared to Lantana free areas.

The reduction in the dominance of *L.camara,* regeneration of number of native trees and shrub species, higher species richness and diversity of herbaceous and shrubby layer and re-colonization and establishment of a grass species like *C. dolichostachya* as a result of removal of Lantana altogether showing a positive impact in the management of habitats of wild animals in the park area.

On the basis of analysis carried out it is recommended that there should be total removal of Lantana from the park area.

References

Alcova PA 1987. The effects of the presence of *Lantana camara* on local bird populations in Brisbane Forest Park. Project report NO T (AS) 99. Queensland University of Technology, Brisbane

Curtis J.T. And Cottam G. 1956**.** *Plant Ecology Work Book, Laboratory Field Reference Manual.*Burgess Pub. (Minnesota Co.) 193pp.

Curtis J.T. And McIntosh R.P. 1950. The interrelationship of certain analytic and synthetic phytosociological characters. *Ecology* ,31:434-445.

Cusado, C.M. 1995. Allelopathic effects of *Lantana camara* (Verbenaceae) on morning glory (*Ipomoea tricolor)*. *Rhodora*, 97: 264-274.

Day. M.D., Wiley, C.J., Playford, J., Zalucki, M.P. 2003. *Lantana:* Current management status and future protects. Australian Center for International Agricultural Research: Canberra.

Fensham, R.J., Fairfax R.J, Cannell, R.J. 1994. The invasion of *Lantana camara* L. in Forty Mile Scrub National Park, North Queensland. *Australian Journal of Ecology,* 19: 297-305.

Gentle C.B. and Duggin, J.A. 1998. Interference of *Choricarpia leptopetala* by *Lantana camara* with nutrient enrichment in mesic forest on the Central Cost of NSW. *Plant Ecology* 136: 205-211

Khan, M.A.W. 1961. Method of studying forest types. *Proc. X Silva Conference*. F.R.I.

Kumar, S and Rohatgi, N. 1999. The role of invasive weeds in changing floristic diversity. *Annals of Forestry ,*7(I): 147-150.

Love A., Babu, S. and Babu, C.R. 2009. Management of *Lantana,* an invasive alien weed in forest ecosystem of India. *Current Science* ,19(10): 1421-1429.

Misra R. 1968. *Ecology Work Book*. Oxford and I.B.H. Publishers, New Delhi

Phillips E.A. 1959. Methods of Vegetation Study. Henry Holt & Co. Inc.

Sahid, I.B. and Sugau, J.B. 1993. Alleopathic effect of *Lantana camara* and siam weeds (*Chromolaena odorata)* on selected crops. *Weed Science,* 41(2): 303-308.

Shannon, C.E. and Wiener, W.1963**.** The Mathematical Theory of Communication. Univ. Illinois Press, Urbana.

Smith, I.P. and Jr. K. Berg 1988. *Inventory of Rare and Endangered Vascular plants of California*.Sacramento, California: California Native plant Society.

Loss of Habitat of Endangered House-Sparrow (*Passer domesticus indicus*, Jardine and Selby, 1831) in Saharanpur District of Western U.P. and Suggestions for its Conservation

S.C. Dhiman, Harender Singh, Salman Ansari*

Entomology Research Lab,Dept.of Zoology,M.S. (P.G.) College, Saharanpur-247001

*C.C.S. University, Meerut-250004

Abstract

The house-sparrow *(Passer domesticus indicus)* is native to all the Indian states and found up to 4000m in Himalayas. It is clearly tied to human activity and usually absent from extensive woodlands, forests, grasslands and deserts. It is a small bird having clear cut sexual dimorphism, male has black throat while female has brown colour with eye strips. In last 30 years, it has undergone a drastic decline from most of the part of India. Hence, it is included in the IUCN red list. Surveys conducted of different areas of Saharanpur district of U.P. have revealed that it occurs in less number in the rural and urban areas. Its population has been recorded comparatively more from Ghad areas such as Behat, Mirjapur, Biharigarh where houses having thatched roof still exists. Its food mainly includes seed of cereals, pulses, wild grasses and some insects. The change in agriculture practices, shifting of monoculture crop planting, indiscriminate use of pesticide and insecticide, loss of nesting places due to urbanization, concrete houses, industrialization, increase in predators, poorer breeding success, tighter hygiene regulations, competition for food, introduction of unleaded petrol, lack of holes, nooks and crannies in houses, modern farming methods and absence of insects which are needed by newborn sparrow etc..

The common house sparrow *(Passer domesticus indicus)* once seen

widely everywhere in Saharanpur district of U.P. has now shown remarkable decline in its population in Saharanpur proper, Deoband and Nakur. However, in adjacent villages of Nakur and Behat, its population has been seen comparatively more. The present study aims at finding reasons and consequences of changing and declining in population pattern of house-sparrow in Saharanpur district of U.P.. To conserve this little and homely bird to whom most children and adults are aquivanted, some means are suggested which includes, climate changes, to provide nesting sites, food resources, plantation of plant bushes and hedgerows within the ground perimeter, environmental and house-sparrow conservation programmes in villages, erection of cell-phone towers away from rural areas as well as urban dwellings and minimize mushrooming of these towers , formation of sparrow club in metropolitan cities and building of sparrow shelters in houses, gardens and foam lands, feeding of sparrow by giving healthy seeds as pious Hindus do far pigeons and control of air-pollution in big cities.

Keywords: *Passer domesticus indicus*, loss of habitat, ghad, disappearance, conservation, IUCN.

Introduction

There are so many different species of birds that have inhabited the earth before the arrival of *Homo sapiens*. According to the book of Dr. Oliver Austen's "Book of the World", fossils records reach at a peak of approx. 11,500 species during the Pleistocene period, about 250,000 years ago. Since then they are declining to our world countable near about 9,000 living species. Out of all, approx. 100 unique species of birds have become extinct during the past decades, even today the threatened comes with 1,000 or above species**.** The House sparrow, *Passer domesticus indicus*, a member of family Passeridae and considered to be relative to the Weaver Finch Family. These birds are ubiquitous and sedentary birds and don't travel more than one or two kilometers in search of food. But it is a very unfortunate to say that coming generation may not be able to see the little bird if the present situation is going on.

It is small song bird, males and females can be differentiated distinctly .The average size is 14-16 cm and 26-32 gm in weight. It is a small bird, beak thick, short legs, chest unstreaked and always prefer to stay near human populations . hey prefer to make nest in small holes in buildings, thatched roofs and even street lamps . The house sparrow, *Passer domesticus indicus* has undergone a drastic decline in the past 30-40 years. It is included in the red list of IUCN (International Union for the Conservation of Nature) and highly concerned of 'Conservation ICU (Intensive Care Unit). The Royal Society for Protection of Birds (RSPB) UK recently added the house sparrow to its Red list due to rapidly declining bird populations, which pose global conservation concern. India encompasses almost all the hot and humid evergreen forests, providing habitats for various species up to about 4000m in the Himalayas. *Passer domesticus indicus* is abundant in temperate climate. The house sparrow survives for around 3 years in the open and upto 13 years in captivity and eats seeds, live-stock feed, weed and insects (Lowther and Clink, 1992). The first introduction of the house sparrow was conducted by the Brooklyn Institute in 1851. House sparrow is a summer visitor (March-October) to higher elevation in Baluchistan and in the Himalayas, Pakistan, Bangladesh, Sri-lanka, Andaman Islands and Nepal, Ranges from Arabia to Burma, South Africa, Zanzibar, Comoro and Mascarene Islands. Nest is made up of an untidy bulky collection of straw, fibres, cotton strings, lined with feather. Egg, 3-6 usually 4, pale greenish white blotched and spotted with brown and ashy grey (Ali and Ripley, 1974 and 1983) **.** In

Netherlands, this species is even considered an endangered species (BBC News, 2008) and population has dropped in half since the 1980s. The British Trust of Ornithology (bto,1982)estimated that the sparrow population in London had decline by 71% in b/w 1994-2004. A study by a conservation biologist. In India during last 30 years, dramatic decline of sparrow populations occurred across, almost all the rural and urban areas of India.

Hence, present investigation has been taken in Saharanpur city proper and Ghad areas of West Uttar Pradesh to ascertain the loss of habitat of the house-sparrow *Passer domesticus indicus* and measures to be taken to enhance population of this endangered bird.

Material and Methods

Surveys were conducted of different areas of District Saharanpur including rural and urban areas for three consequents years 2007-2009. These surveys were made during different season's viz., summer, autumn and winter. Number of Birds in each area was recorded and their feeding and nesting habit was also observed. A questioner was prepared and given to the selected villagers and urban peoples to fill up it. The data generated from the questionnaire were pooled and observations were recorded. Binocular was also used for careful observations and photographs of the birds were taken by Sony digital camera.

Results and Discussion

Saharanpur district attained the status as Saharanpur division in 1997 of Uttar Pardesh. The total area is 3860 square Kilometers (Figure 1.).

All seasons are available here and the district is in a rectangular shape and lies between $29^o34'$ 45" and $30^o21'30"$north latitude and $77^o9'$ $78^o14'45"$ east longitude.

Figure 1. Map showing location of Saharnpur

Surveys conducted of different areas of Saharanpur district of U.P. have revealed that *Passer domesticus indicus* occurence in less number in the urban areas such as Saharanpur proper (Questionnaire 1), Deoband, Nakur, Sarsawa and Chilkana. However, in Chutmalpur, Biharigarh and Nagal areas, its population was comparatively more (Questionnaire 2). In Behat and Nakur, these have been observed, nesting in old crumpling buildings and thatched and mud houses. In big buildings, made of concrete, these were not seen nesting. In Rural areas of ghad and adjacent to Yamuna river comparatively more population was observed, feeding on cereals, seed of grasses and insects.

Breeding period was seen during summer from April to September. The data generated from questioner distributed among the people indicated their presence only in those areas where still some nesting places or natural habitat for the bird still there.The population of these birds declined many folds during last 20 years causing reduction in number.

There are several reasons for declining the population of *Passer domesticus indicus* in this region. Among them the main are:

1. Loss of habitat due to construction of concrete and brisk houses,

due to which nesting places, is not available for the bird.

2. In the past time people had the habit to reduce the moisture content of seed grains (wheat, maize, oat, barley) by spreading in open on the ground which served easy food for these birds but now a day's good storing facilities for grains and flour supply by mills directly to the shops and consumers.

3. Mushrooming of mobile towers and electrification in almost all areas which generates electromagnetic radiations affecting the population of birds.

4. The absence of the kitchen gardens and non-availability of insect larvae such as *Helicorerpa armigera, Agrotes, Chilo* etc. usually found in beans, cereals and legume crops is the possible reasons for the sparrow's decline in numbers.

5. An urban air pollutant, which contains nearly 3,000 different elements and compounds, has a wide ranging toxic effect. The major components of these fine particles are sulfates, carbonaceous materials, nitrates, and trace elements. Organic carbon is suspected to be mutagenic and carcinogenic, while Elemental carbon is linked to a range of adverse environmental effects, including interference in the lung clearance mechanism. The presence of these pollutants in the urban atmosphere is also considered as a limiting factor for the healthy breeding of sparrows.

6.Organic farming and the increased use of chemical pesticides and fertilizers to improve yield, are leading the bird to a state of being more endangered.

7. Reducing areas of badly maintained buildings. The decline is due to lack of holes for nesting in modern houses and cutting of hedges from gardens. Old spacious buildings are being replaced by match-box flats.

8. Hedges being replaced by wrought iron fences may be the probable cause for decline the number of house-sparrow in urban areas.

9. Increased predation by owls and cats and competition of food by other species, including pigeons, crows and mynahs may be the probable cause of decline the number of house-sparrow in rural and urban areas of Saharanpur district.

10. Introduction of unleaded petrol, believed to be eco-friendly, had harmful byproducts. The fuel uses Methyl Tertiary Butyl Ether (MTBE) as an anti- knocking agent. Along with byproducts of combustion, this kills small insects. The insecticidal nature of the byproducts makes the food for those birds feeding on insects scarce is may be the probable cause of the disappearance of the house- sparrow in rural and urban areas of Saharanpur district of western Uttar Pradesh.

11. Indiscriminate use of insecticides or pesticides which kill the insects and their larvae on large scale as well as acts as toxins for birds.

Suggestions for Management

Following recommendations are being suggested for management of *Passer domesticus indicus* population so that these may not entirely disappear from this region like vulture, white kite, horn-owls etc.:

1. To provide nesting site
2. To provide food resources
3. Plantation of plant bushes and hedge rows within the ground perimeter
4. Environmental and house-sparrow conservation related programmes in rural and urban areas.
5. Erection of cell-phone towers away from rural and urban areas or minimize the mushrooming of these towers
6. Formation of sparrow club in metropolitan cities
7. Building of shelters for sparrows in houses, garden and farm lands.

8. Control of air-pollution in the urban areas as well as in rural areas.
9. Provide small pots having water and seed grain to keep up on the roof top.
10. To give feed to the birds like pious Hindus do for pigeons in metropolitan cities.
11. Conservation of endangered birds should be made a part of the syllabus of school and colleges.

The common house-sparrow, *Passer domesticus indicus* are ubiquitous in nature (excluding the poles) (Joshi, 2009) . It likes areas that have been modified by humans, farms, residential and urban areas. It forms monogamous pairs for each breeding season. It makes nest between February and May, from dried vegetation, feathers, strings and paper (Joshi, 2009) . It has been observed nesting in the holes of tree trunks in some parts of the Saharanpur district. Eggs are laid at many times in the nesting period. After the eggs are hatched, both males and females feed the young. House sparrows tend to forage for food on the ground, using a hopping movement. House-sparrow aggressively protects a small territory just around their nesting site (Dandapat, 2010). They usually stay in the same region all year round, but maybe partially migratory in some areas (Banerjee, 2010). The same has been observed in Saharanpur district. Hose-sparrows eat various kinds of seed supplemented by some insects. Rural birds tend to eat more waste seed from animal dung and from fields, while urban birds tend to eat more commercial bird seed and weed seed (Chakrobarty,2010). Besides all seeds, it also feed upon insects, terrestrial non-insect arthropods (Including grasshoppers, spiders, bettles, caterpillars, butterflies, mothes etc.) (Lowther and Clink, 1992). House-sparrows are native to Europe. Asia and North Africa and have been introduced to North America, South America, South Africa, Australia and

New Zealand. They were introduced to North America n 1851, when 100 birds were released in Brokley, New York. Vocalizations are varied, but loud "cheeps" are most common. The common preys on House-sparrow are hawks, owls, domestic cats, dogs and black rat snakes (Dandapat, Banerjee and Chakrobarty,2010).

House-sparrows are monogamous, farming long term pair bonds. They have multiple broods, but it is rare that more than two of these will be successful (Gulati,2005). Mating display begin by male selecting a nest site and remains as it advertisement calling, a quite chirrup, repeat at a rate of 1 call every 1-2 sec, sometimes accompanied by wing shivering and tail raising, if female approaches and shows interest in the nest, male becomes excited, jumping about in stiffly held posture, wing held out slightly and drooped head held high with black throat feathers erected (Hatch, 2007) . Its breeding season is chiefly March-June in the northern area, continuing till September- October in central India and throughout the year in southern India (Monika, 2005) . House-sparrows lays 5-6 eggs, profusely dusted, speckled or blotched with black –brown on a blue tinted or creamy white ground (Monika, 2005). The incubation period of all the birds varies around 10-12 days (Hatch and Westneat, 2007). Clutch size usually 4-5 eggs and range 1-8. Male and female incubate the egg for a period of 10-13 days (Walters, 1994). Both adults feed the young and maintain the nest; on rare occasions other adults will also assist with chicks (Ali and Repley, 1974) . The young fledge after 14-17 days, remaining dependent on their parents for an additional 10 days (Ali and Repley, 1984) .The preliminary analysis of population dynamics of *Passer domesticus indicus* have been conducted at Saharanpur proper and Ghad region of West Uttar Pradesh, which indicated the presence of bird in those areas more which are having still some habitat for the birds.

Acknowledgements

The Authors are thankful to the people of rural areas of Saharanpur district, farmers,students and even women who cooperated with full heart during the period of present study. Thanks are also due to NGOs and students of M.S. (P.G.) College, Saharanpur who cooperated for population count of the bird in Saharanpur proper and adjacent areas.

References

Ali, S. 2002. *The Book of Indian Birds*. 13th edition, revised.

Ali, S. and Ripley, S.D. 1974. Flowerparkers to Buntings in: *Handbook of the birds of India and Pakistan.* Vol. **10**.. Oxford University Press.

Ali, S. and Ripley, S.D. 1983. 106 plates depicting all the birds by Dick. J. in: *A pictorial guide to the bird of Indian sub continent*. The Bombay Natural History Society. Oxford University Press.

Baker, M. 1995. Environmental Component of Latitudinal Clutch-size Variation in House-Sparrows (Passer domesticus). *The Auk* **112 (1):** 249-252.

BBC News (2008).Sparrow death mars record attempt. BBC News Channel.Retrieved July 20, 2008, http://news.bbc.co.uk/1/hi/world/europe/4450958.stm

Brunn, Bertel, Chandler S.R., and Herbert S.Z. 1983. *Birds of North America: AGuide to field identification*. Expanded, Revised Edition. Golden Press, New York.

BTO Breeding birds in the under countryside (2002) http://www.bto.org/birdtrends/werhousep.html.

Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, A.C.Stewart and M.C.E. McNall, 2001. *The Birds of British Columbia, Volume 4: Passerines (Wood-Warblers through Old*

World Sparrow). UBC Press, Vancouver, BC.

Carson, R. 1962: Silent Spring, pg 100-101.

Chapman, F.M. 1966. *Hand Book of Birds of Eastern North America*. Dover Publications, Inc. New York. 581 Pp.

Dandapat A., Dipak Banerjee and Dibyendhu Chakrobarty, 2010.The case of the Disappearing House Sparrow (Passer domesticus indicus). *Review, National Dairy Research Institute, Karnal, Haryana, India.* Vol.3 (2), 97-100. Veterinary World.

Dongre S.D. and R. G. Verma, 2009. Effect of Cell Phone Radiation on Gauriya Sparrows *Passer Domesticus*. *Shodh, Samiksha aur Mulyankan (International Research Journal)*-ISSN-0974-2832 Vol. II, Issue-7, p51-52.

Dr. Bigu J., 1973. National Research Center of Canada. Extract From Ltr-CS-113. Forbush, E.H. 1955. *A Natural History of American Birds of Eastern and Central North America,* Bramhall House, New York, 554 Pp.

Ford, P. 2002: Europe the case of the missing Sparrows. *The Christian Science Monitor* Dec 27, 2002 edition.

Goyal Monika 2005. Preliminary Survey of House sparrow (Passer domesticus) in three different areas of Haridwar, Uttaranchal. *M.sc. Thesis*, Gurukul kangri University, Haridwar, India.

Greenoak, F. 1979. *All the Birds of the air*. Book Club Associates, London. Gulati V.2005. House sparrow on verge of extinction. Tribune News Service. Chandigarh, India.Retrieved September 20, 2005, http://www.Tribuneindia.com/2005/20050920/cth1.htm#11.

Hatch Marget I. and Westneat David F. 2007.Age related patterns of reproductive success in house-sparrow *Passer domesticus*. *Journal of Avian Biology* 38:603-611.

Imhof, T.A. 1962. *Alabama Birds.* State of Alabama, Department of Conservation, Game and Fish Division, University of Alabama Press. 591 Pp.

Joris, Everaet, Dirk Banwen, 2007: Electromagnetic Biology and medicine Pages 63-72.

Lowery, G.H., Jr. 1960. *Louisiana Birds*. Louisiana Wildlife and Fisheries Commission, Louisiana State University Press. 567 Pp.

Lowther P E and Clink C L 1992 *The Birds of North America* (Editor: A Poole, P Stettenhein, and F Gill). No. 12, The Academy Of Natural Science, Philadelphia, PA and the American Ornithologists Union, Washington, DC.

Martin schram, 2008: Scripps Howard News Service.

Menon, M. and R. Mohanraj, 2010. Vanishing Sparrows- Possibly A Synergistic Effect. *Tiger Paper*, Vol. **37(1).**

Parmar B. 2008. Where are all the sparrows gone? Retrieved June 09, 2008, from http://indiwo.in.com/india/features/harmony-in-life/where-are-all-the-sparrows- gone/40681/0.

"Passer domesticus" (On-line), Animal Diversity Web. Accessed October 02, 2007 athttp://animaldiversity.ummz.umich.edu/site/accounts/information/Passer_d omesticus.html

Royal Society for the Protection of Birds (RSPB).
http://www.rspb.org.uk/birds/guide/h/housesparrow/index.asp.

Scott Weidensaul and R. Robinson. 2004. Natural Inquires. *National Wildlife Federation* Vol 42(3).

Sprunt,A.Jr. and E.B.Chamberlin.1970. *South Carolina Bird Life.* University of South Carolina Press, Columbia, 655 Pp.

Tanner,J.A. and Sierra,Romero,1973.Department of Anatomy,Queen

University, Kingston Canada Extract from LTR-CS-89.

Tanner,J.A.,1969.National Research Center of Canada. Extract fom Ltr-Cs-18. Vijayan, V.S. 2003. Where Have all the Sparrows gone*? Down To Earth. (Cross Currents).*

Youth, H. 2003. State of World, Watching Birds Disappear. Word *Watch Institute*, pg 15.

Analysis of Soil Moisture Variability in Relation to Natural Regeneration in watershed forested with Sal (*Shorea robusta*).

J.V. Tyagi,Rakesh Kumar and R.D.Singh

National Institute of Hydrology

Jal Vigyan Bhawan, Roorkee- 247667, Uttarakhand, India

Abstract

Soil moisture is regarded as one of the important factors that affect the natural regeneration of *Sal* (S*horea robusta*) species. Both, soil moisture and natural regeneration vary spatially depending on the overhead canopy density. The present study was carried out to assess the soil moisture variation under different micro- environments due to overhead canopy of varying density and analyze its relationship with the natural regeneration of s*al*. Experimental plots of 40m X 40m size were demarcated under different overhead canopy densities in a small *Sal* forested watershed in the foot hills of Himalayas in Nainital District of Uttarakhand State. The plots were monitored on long term basis for soil moisture and natural regeneration of *Sal*. The weekly soil moisture observations were taken at 25, 50 and 100 cm depths and the regeneration surveys were conducted on annual basis. The analysis of regeneration data revealed that the natural regeneration was highest under C1 (up to 0.30) canopy followed by C2 (0.30-0.50), and C3 (0.50-0.70) canopies. The C3 canopy rather showed the dying back of *Sal* shoots over 4 years of study. The monthly average soil moisture storage was found highest under C3 canopy and lowest in C1 canopy both at 100 cm and 50 cm depths. It is indicative of higher withdrawal of soil moisture under C1 canopy. At 25 cm depth, the soil moisture regime in three canopies was found to interchange with time which is probably due to the fact that the depletion of soil moisture at 25 cm depth is

affected more by evaporation than transpiration. The highest R^2 value of linear regression between average incremental score of plot regeneration and average soil moisture content was obtained as 0.156 for the average soil moisture content at 100 cm depth during the period November to June. The results of the study indicated that the natural regeneration in C2 and C3 canopy is not limited by soil moisture.

Keywords: Natural regeneration, Sal, canopy density, soil moisture.

Introduction

Forests are the essence of environment and constitute an essential life support providing food, fiber, fodder, fuel, and medicines. They also play a vital role in moderating the climate, altering the seasonal and annual water yield, checking soil erosion and preserving biodiversity. *Shorea robusta* or *sal* is an important timber- yielding plant known for its heavy, hard and tough wood, and is one of the major forest types in South Asia. Its geographic range extends from the southern slopes and lower foothills of the Himalayas to plains, river slopes and valleys in Nepal, Bangladesh, India, Bhutan and South China (Gautam & Devoe, 2006; Sapkota, 2009). In India, *sal* forest is widely distributed in tropical regions and covers about 10.57 m ha (Rathore, 2000), which is about 13.3% of the total forest area in the country. In the Himalayan foothill belt, it extends up to the Assam valley (including Meghalaya and Tripura) in the east to foothills of north-west Bengal, Uttar Pradesh, Uttarakhand, and Kangra region of Himachal Pradesh.

The natural regeneration which generally takes place through seeds has been the main source of the sustained *sal* forests. Of late, these forests have, however, been found to face some problems with the result that their perpetuity has become a matter of worry to all concerned. Several studies on regeneration of *sal* have been carried out in the past and the factors like biotic (grazing and fire), seeding, canopy density, plant communities, competition of weeds, climate, nutrient requirements, growth of seedling along shade and moisture gradients, root growth and its penetrability have been studied (Champion, 1933; Davis, 1948; Pande, 1956; Soni, 1961; Seth, 1961; Rao and Singh, 1984; Saxena and Singh, 1984; Singh and Singh, 1984; Tewari 1982; Upreti *et al.,* 1985). However, the information on variation in soil moisture and regeneration under different micro-environments formed due to varying overhead canopy density seems to be meager (Dabral, *et al.,* 1980). Hole (1914, 1921) and Boyce & Bakshi (1959) observed that poor soil aeration and inadequate soil moisture are mainly responsible for unsatisfactory *sal* regeneration. Seth and Bhatnagar (1960) found positive correlation between soil moisture content and good regeneration. Srivastava (1972) reported that the maximum height growth, foliage development and uptake of potassium and phosphorus of *sal* was at 37% moisture, i.e at 85% of water holding capacity, but it did not withstand water logging condition because of bad soil aeration.

Gautam *et al.* (2007) reported that the correlation of *sal* with soil moisture was positive ($r = 0.127$ and $p < 0.01$) at seedling stage, positive but not significant at sapling stage and negative ($r = -0.102$ and $p < 0.05$) in the mature stage. Chauhan *et al.* (2008) carried out a multiple regression between seedling density of *sal* and six soil parameters (soil moisture, soil organic carbon, pH, nitrogen, phosphorous and potassium) and reported the coefficient of determination (R^2) as 0.042 and 0.222 in natural and planted forest respectively. Sapkota (2009) found that seedling regeneration of *sal* differed significantly between the gap and intact vegetation environments. The seedling density was higher in the gaps than in the intact vegetation. Since the soil moisture varies under different canopy densities (Jetten,1994; Dam, 2001), there is a need to study the relationship between natural regeneration and soil moisture under varying micro-environmental conditions. In the present work, an attempt has been made to analyze the soil moisture variation under different canopy densities at 25, 50 and 100 cm depths and correlate the soil moisture levels with natural regeneration.

Study Area

A *sal* forested watershed of about 16.40 ha, located between latitudes 29º 20′29" to 29º 20′ 57" N and longitudes 79º 18′ 26" to 79º 18′ 37" E, was selected in Musabangar village of Kaladhungi Tehsil in Nainital district, Uttarakhand, India. The watershed was fenced by a barbed wire to protect it from grazing by villagers' animals and browsing by wild animals like pigs, deer and porcupines which cause a great disturbance to the natural regeneration. The normal annual rainfall of Nainital district is about 1528 mm, of which about 80% occur in monsoon months of July to September. The entire study watershed is covered under *sal* forest of varying canopy density. The elevation in the watershed varies from 562 m at the upstream to 526 m at the outlet. The slope of the watershed though varies from flat to about 72%, the major area (approx. 80%) falls under slope range of 5 to 25%. Soil samples were collected from 27 locations and analyzed for grain size distribution in the laboratory using mechanical sieve shakers and laser based particle size analyzer. The analysis revealed that the watershed chiefly consists of silt loam with medium to coarse gravel. The canopy density survey of the watershed was conducted by the Department of Forests of Uttarakhand State under three canopy density classes of C1, C2 and C3,representing respectively the areas where canopy density has reduced to (0-0.30), (0.30-0.50), and (0.50-0.70).

Data Collection and Analysis

In order to study the variation in soil moisture storage and regeneration response of *sal* under different canopy densities, a series of twenty seven experimental plots of 40m X 40m size was demarcated in the watershed under three density classes of C1,C2 and C3, with nine experimental plots in each canopy(Figure 1).The watershed rainfall was measured with an ordinary rain gauge (ORG) located near the watershed outlet. The soil moisture sensors of ‘Water Mark’ make were installed at 25, 50 and 100 cm depths in each of the experimental plots to monitor the soil water potential at different depths.An intensive data collection programme was initiated in the watershed towards the end of the year 2005. The soil water potential in all the sensors was monitored at weekly intervals and converted to volumetric soil moisture content using the soil-moisture retention curves developed for respective sites and depths. Few of these sensors were either damaged by wild pigs or malfunctioned after some time and therefore these were discarded for further observations.The temporal variation of soil moisture along with corresponding rainfall was plotted for all the sites as illustrated in Figure 2 for one of the sites. The soil moisture variation was found to respond well to the rainfall and the evapotranspiration. The soil moisture values at 25 cm depth were found to increase quickly with occurrence of rainfall and also depleted at a faster rate as compared to those at 50 cm and 100 cm depths. It is obvious that a longer time is required for percolation of water to greater depths. Also, the evaporation from soil mostly takes place up to 20-30 cm depth and therefore the soil moisture is depleted quickly in this layer. Though the soil moisture at all three depths is observed at highest level during rainy months of July to September(monsoon season),it sustains for longer duration at 100 cm depth as there is no evaporation from this depth. The soil moisture starts depleting during dry months (non-monsoon season) and reaches its lowest value at all three depths.

It was observed from the temporal plots of soil moisture that winter rains of low magnitude and prolonged duration caused rise in soil moisture generally up to 50 cm depth but the isolated rainfalls of high magnitude were found to contribute to the soil moisture up to 100 cm depth.

The effect of isolated storms at 25 and 50 cm depth, however, might not have been captured as the observations were taken at weekly intervals and soil moisture in upper layers must have depleted due to evaporation.The regeneration survey for *sal* species in the experimental plots was conducted by the Department of Forests during the months of January/February in the years 2006, 2007, 2008, 2009, and 2010.

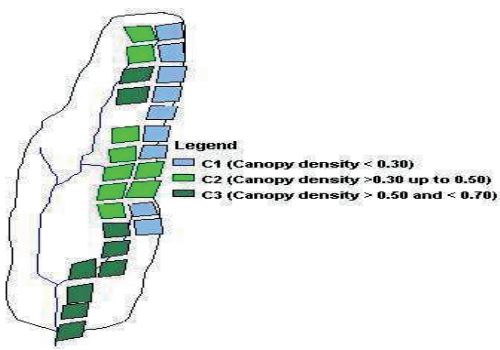


Figure 1. Layout of experimental plots

For the survey purpose, the regenerated plants/shoots were classified into five categories depending on their height/health and a weight was assigned to the plant as given in Table 1.

Table 1. Categories of regeneration survey

Categories	Description	Weight
E	Established shoot of sal which has attained a height of 2.50 m and a diameter of 10 cm	5
W	Woody shoot of sal which has not attained the height of 'E' but would establish being healthy with good growth	4
U+	Whippy shoot *('Lachila')* with a height of more than 50 cm but is not yet fully established	2
S+	Sub-whippy shoot (*'Chhoti Lachili'*) with a height of less than 50 cm	0.5
R	A new shoot germinated in the year of counting	0

Table 2.Year wise plot regeneration score, incremental score and average incremental score under C1, C2 and C3 canopy densities

Canopy density	Plot no.	Year wise plot score of regeneration					Incremental score during 2006 - 2010
		2006	2007	2008	2009	2010	
C1	1	10338	10833	11661	11676	11907	1569
	2	7448	7921	8222	8281	8444	996
	3	13885	14248	15829	15840	16329	2444
	4	16862	17185	17791	17799	17938	1076
	5	6985	7435	7554	7607	7798	813
	6	9558	9663	10413	10455	10673	1115
Average incremental plot score over 4 years							**1335**
	1	2526	2585	2797	2805	2963	437
	2	8345	8448	8970	8984	9086	741

C2	3	6099	6252	6944	6978	7089	990
	4	4473	4554	4704	4790	4942	469
	5	6785	6890	7296	7312	7429	644
	6	5792	5895	6223	6265	6386	594
Average incremental plot score over 4 years							**646**
C3	1	5905	6068	4903	4907	4986	-919
	2	3178	3380	3264	3268	3332	154
	3	4710	4971	5100	5106	5168	458
	4	3888	4093	4019	4024	4117	229
	5	1987	2022	1927	1930	1970	-17
	6	8802	8898	7746	7750	7894	-908
Average incremental plot score over 4 years							**-167**

Regeneration Score under Different Canopy Densities

The year wise regeneration score of individual experimental plot was computed as the sum of the product of number of plants in various categories and their respective weights.

The incremental score over a period of four years (i.e. 2006-2010) for each plot was computed as the difference of scores of the years 2010 and 2006. The average incremental regeneration score for the canopy densities of C1, C2 and C3 was calculated by taking mean of the incremental scores of all the plots lying under respective canopy densities.

The computed year wise scores and incremental scores of individual

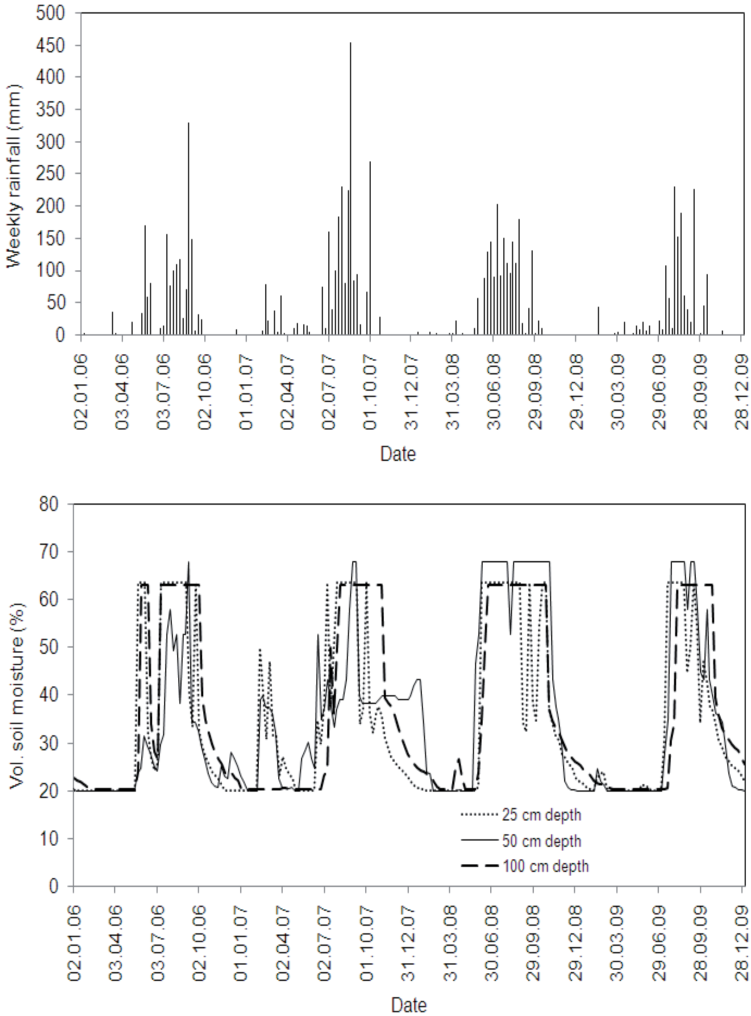


Figure 2. Illustration of temporal variations of soil moisture storage in a sample plot

The C3 canopy.The computed year wise scores and incremental scores of plots, and the average incremental scores under C1, C2 and C3 canopies are given in Table 2. It can be observed from Table 2 that the incremental score is highest under C1 canopy (1335), followed by C2 (646) at 25 cm. for .Individual plots, and scores under C1, C2 and C3 canopies are given in Table 2. It can be observed from the average incremental Table 2 that the incremental score is highest under C1 canopy (1335), followed by C2 (646). The C3 canopy rather shows the dying back with a regeneration score of -167 over 4 years of study.

Variation of Soil Moisture under Different Canopy Densities

The monthly average soil moisture at 25, 50 and 100 cm depth in each experimental plot was computed by averaging the weekly values of four years of observation (i.e. Jan. 2006 to Dec. 2010).

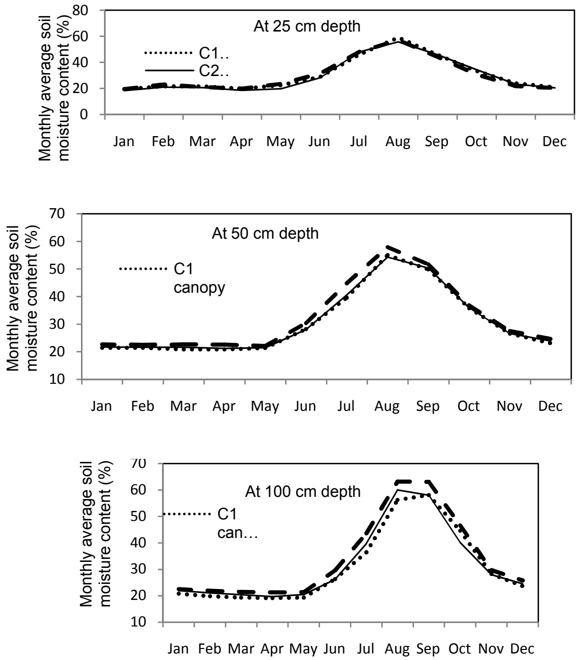


Figure 3. Monthly average of soil moisture content under three canopy densities at 25, 50, and 100 cm depths.

The monthly average soil moisture storage is found highest under C3 canopy and lowest in C1 canopy both at 100 cm and 50 cm depths. It is indicative of higher withdrawal of soil moisture under C1 canopy. At 25 cm depth, the soil moisture regime in three canopies is found to interchange with time. This is probably due to the fact that the depletion of soil moisture at 25 cm depth is affected more by evaporation than transpiration. Also, the replenishment and depletion of soil moisture due to rainfall and evapotranspiration respectively is faster at 25 cm depth that at deeper depths.

Correlation between Soil Moisture and Regeneration

The regeneration in *sal* is affected by dying back. Therefore to minimize its effect in any individual year, an incremental score was computed over 4 years of study period for each plot (Table 2).

In order to examine the bearing of soil moisture on regeneration, the average soil moisture values over 4 years (corresponding to the period of incremental score) were determined at each of the three depths during the periods: (i) January to December, (ii) November to June, and (iii) January to June. The duration of January- December included the periods of highest moisture (July to October), lowest moisture (January to June) and moderate moisture (November to December). Since the soil moisture during July to October should pose no scarcity for regeneration, this period was excluded from the duration at (ii). The duration at (iii) represented only dry period.

The average incremental regeneration score and the average soil moisture content of the experimental plots were plotted against each other for each of the above durations and depths and a straight best fit line was drawn (Figure 4, 5 and 6).

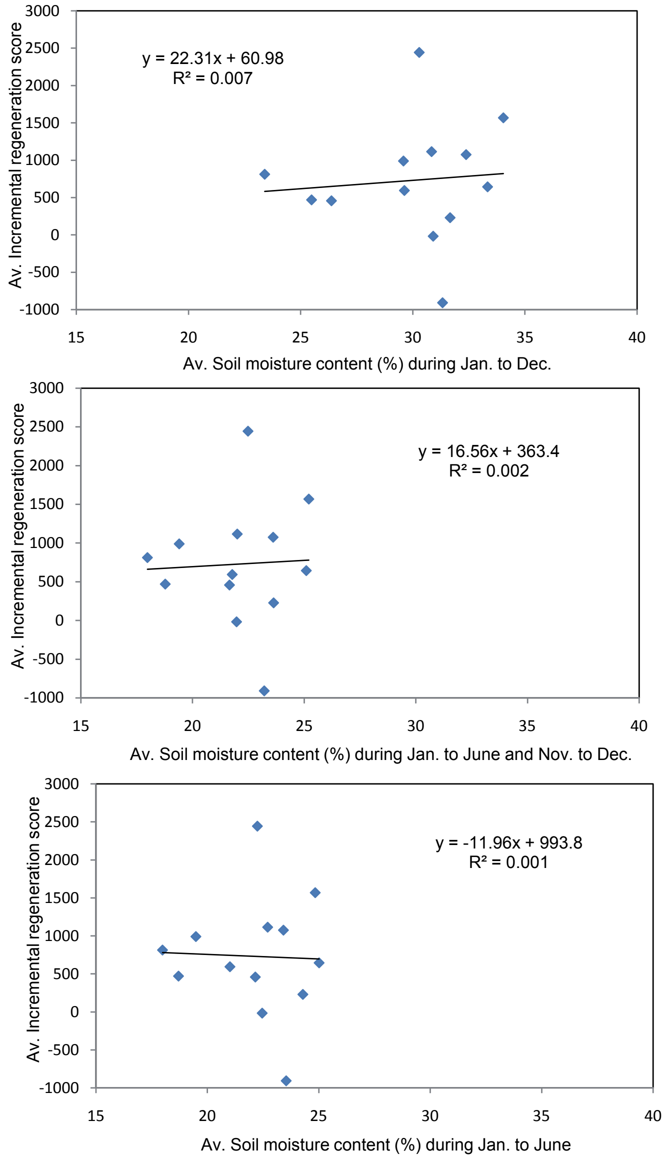
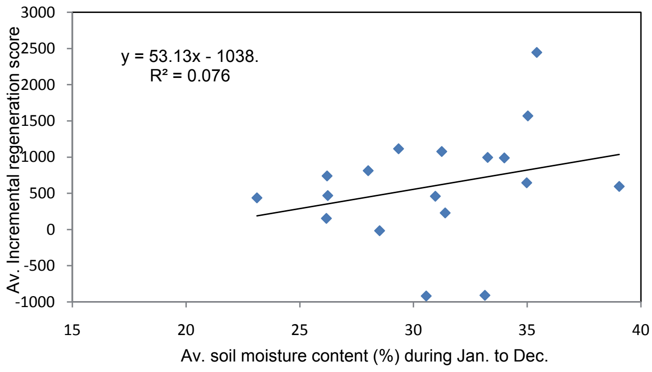
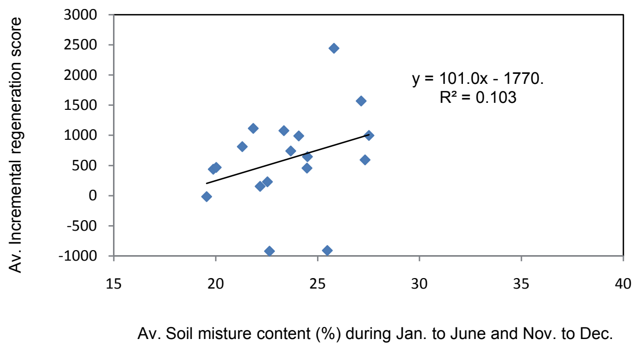


Figure 4. Plot of average incremental regeneration score and average soil moisture content at 25 cm depth





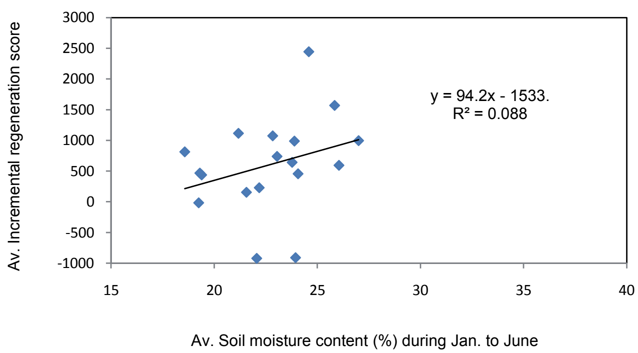


Figure 5.Plot of average incremental regeneration score and average soil moisture content at 50 cm depth

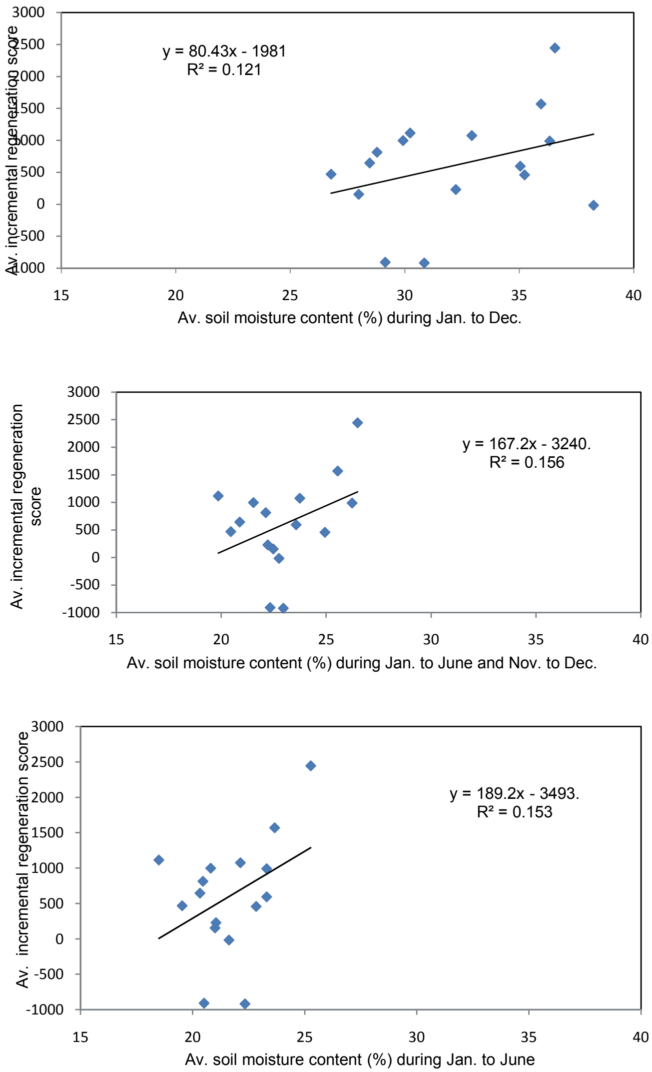


Figure 6. Plot of average incremental regeneration score and average soil moisture content at 100 cm depth

The regression equation and coefficient of determination (R^2) were also computed for each of these lines. The results of the regression analysis revealed that a very poor but positive correlation existed between regeneration and soil moisture at 25 cm depth during the period (Jan. to Dec.) and almost no correlation existed during the periods (Nov. to June) and (Jan. to June). The regeneration was found to be positively correlated with soil moisture both at 50 and 100 cm depths. The value of R^2 was obtained as 0.076, 0.103, and 0.088 for soil moisture at 50 cm depth during the periods (Jan. to Dec.), (Nov. to June), and (Jan. to June) respectively; and 0.121, 0.156, and 0.153 for soil moisture at 100 cm depth during respectively periods. These R^2 values are found consistent with the values reported by others, for example, Gautam *et al.* (2007) reported r = 0.127 between *sal* seedling and soil moisture; Chauhan *et al.* (2008) reported multiple regression R^2 between *sal* seedling density and six soil parameters (soil moisture, soil organic carbon, pH, nitrogen, phosphorous and potassium) as 0.042 in natural forests, and 0.222 in planted forests. In the present study, the higher values of R^2 as 0.156 and 0.103 at 100 cm and 50 cm depth respectively indicate that the regeneration is better correlated with soil moisture during dry months especially at 50 to 100 cm depth than that at 25 cm depth. These results also indicate that the natural regeneration in C2 and C3 canopy is not limited by the soil moisture. This inference can be supported by the Figure 4 which shows that despite lowest levels of monthly average soil moisture under C1 canopy at 100 cm depth, the incremental regeneration score is highest under C1 canopy (Table 2).

Conclusions

Following conclusions were drawn from the results of the study:

1. The natural regeneration was found highest under C1 (up to-0.30) canopy followed by C2 (0.30-0.50), and C3 (0.50-0.70) canopies. The C3 canopy rather showed dying back with a regeneration score of -167 over 4 years of study.
2. The monthly average soil moisture storage was found highest under C3 canopy and lowest in C1 canopy both at 100 cm and 50 cm depths. It is indicative of higher withdrawal of soil moisture under C1 canopy. At 25 cm depth, the soil moisture regime in three canopies was found to interchange with time.
3. The R^2 values of linear regression between average incremental score of plot regeneration and average soil moisture content were obtained as 0.156 and 0.103 for the average soil moisture content at 100 cm and 50 cm depth respectively during the period November to June. No correlation was found with soil moisture at 25 cm depth. This indicated that the regeneration is affected by the soil moisture content of dry months especially at 50 to 100 cm depth than that at 25 cm depth.
4. The results also indicated that the natural regeneration in C2 and C3 canopy is not limited by soil moisture.

Acknowledgements

The project team is extremely thankful to the officers and staff of Department of Forests, Govt. of Uttarakhand, India for providing logistics during field visits and sparing their valuable time for discussion.

References

Boyce, J.S. and Bakshi, B.K. 1959. Dying of sal. *Indian Forester,* 85(10): 585-588.

Champion, H.G. 1933. Regeneration and management of sal (*shorea robusta*). *Indian Forest Records*(Old series),*Silviculture* 19(3). Manage Publications, Delhi.

Chauhan, D.S., Dhanai, C.S., Singh, B., Chauhan, S.,Todaria, N.P. and Khalid. M.A.2008. Regeneration and tree diversity in natural and planted forests in a Terai - Bhabhar forest in Katarniaghat Wildlife Sanctuary, India. *Tropical Ecology,*49(1): 53-67, 2008.

Dabral, B.G., Pant, S.P., and Pharasi, S.C. 1980. Microclimate of a regenerating sal forest in West Dehradun. *2nd Forestry Conference*, Dehradun.

Dam, O.V. 2001. Forest filled with gaps - Effects of gap size on water and nutrient cycling in tropical rain forest. *Tropenbos-Guyana Series 10,* Tropenbos- Guyana Programme, Georgetown, Guyana.

Davis, P.W. 1948. Sal natural regeneration in United provinces. *Indian Forester,*74(2).

Gautam, K.H. and Devoe, N.N. 2006. Ecological and anthropogenic niches of sal (*Shorea robusta* Gaertn. f.) forest and prospects for multiple-product forest management - A review. *Forestry,* 79: 81-101.

Gautam, M.K., Tripathi, A.K., Manhas, R.K. 2007. Indicator species for the natural regeneration of *Shorea robusta* Gaertn. f. (sal). *Current Science,* 93(10).

Hole, R.S. 1914. Ecology of sal (*shorea robusta*). *Indian Forest. Records,* 5(4): 87-102.

Hole, R.S. 1921. Regeneration of sal (*shorea robusta*) forests – A study in economic ecology. *Ind. Forest Rec.* (Old series), *Silviculture,* 8(2). Manager of Publications, Delhi.

Jetten, V.G. 1994. Modelling the effects of logging on the water balance of a tropical rain forest - A study in Guyana. *Ph.D.Thesis.* Dept. Of Physical Geography, University of Utrecht. Tropenbos Series 6, The Tropenbos Foundation, Wageningen, the Netherlands.

Pande, D.C. 1956. Natural regeneration of sal in Uttar Pradesh – some recent experimental evidence. *Proc. IX Silvi. Conf.,* Dehradun.

Rao, P.B. and Singh, S.P. 1984. Population dynamics of a foothill sal (*Shorea robusta Gaertn. F.*) forests in Kumaon Himalaya. *Oecol. Plantarum*, 6:147-152.

Rathore,C.S.2000.Sal borer problem in Indian sal forests. *http://www.iifm.ac.in/databank/problems/salborer.html* Retrieved on 10th August, 2009.

Sapkota, I.P. 2009. Species diversity, regeneration and early growth of sal forests in Nepal: responses to inherent disturbance regimes. *Ph.D. Thesis,* Swedish University of Agricultural sciences, Alnarp.

Saxena, A.K. and Singh, J.S. 1984. Tree population structure of certain Himalayan forest - annotation and implications of concerning future composition. *Vegetation,*58: 61-69.

Seth, S.K. and Bhatnagar, H.P. 1960.Inter-relation between mineral constituents of foliage, soil properties, site quality and regeneration status in some *Shorea robusta* forests.*Indian forester* 86 (10): 590-601.

Seth, S.K. 1961. The problem of sal regeneration in Uttar Pradesh. *Proc. VIII Silvi.Conf.,* Dehradun.

Singh, J.S. and Singh, S.P. 1984. An integrated ecological study of eastern Kumaon Himalaya with emphasis on natural resources. Final technical report, DST, Govt. of India, New Delhi.

Soni, R.C. 1961. Recent trends in sal natural regeneration techniques with particular reference to B3 type sal. *Proc. X Silvi. Conf.,* Dehradun.

Srivastava, P.B.L. 1972. Competitive potential of sal seedlings. *Indian Forester*,98(8),Dehradun.

Tewari, J.C. 1982. Vegetation analysis along altitudinal gradients around Nainital. *Ph.D. Thesis,* Kumaon University, Nainital.

Upreti, N., Tewari, J.C., and Singh, S.P. 1985. The Oak forests of the Kumaon Himalaya (India): composition, diversity and regeneration. *Mountain Res. Development,* 5:163-174.

Forest Landscape Restoration For Planetary Van Vihar Project(PVVP)at Deotsidh in Hamirpur District, Himachal Pradesh

Sanjay Sood & Sandeep Bhimta
State Forest Department,Hamirpur, H.P.

Abstract

Importance of various trees has been emphasized in our puranas,Vedas and upnishads. In the past, people preserved. Sacred groves (Navgrah Vatika, Nakshtra Vatika etc.)considering such trees to be incarnation of Gods. There is vast scope of planting such tropical plant species (of religious as well as medicinal significance) over degraded forest landscapes with the twin objectives of mitigating the degradation as well as to enhance the aesthetic environment of the site.Planetary Van Vihar project (PVVP) at Deotsidh ,district Hamirpur, Himachal Pradesh is an attempt in this direction to plan and design a model based on our religious texts and beliefs for the purpose of conservation as well as to cater to the multiple needs of the society.

Keywords : Restoration , tropical , aesthetic, religious

Introduction

The Vedas and Puranas are the words of God which He revealed to people through sages and through incarnations. There has been a very intimate and practical relationship between plants and various Nakshatras and planets. Many plants of astrological importance also have the power to heal certain ailments.The Planetary Van Vihar Project (PVVP) at Deotsidh, district Hamirpur, Himachal Pradesh is an attempt in this direction to plan and design a model based on our religious texts and beliefs for the purpose of conservation and to cater to the multifarious needs of the society.

Location

The site is around 300 mtrs from Sh. Baba Balak Nathji's temple at Deotsidh, at an altitude of 830 mtrs above MSL in district Hamirpur, Himachal Pradesh. Soil of the area is sandy loam in nature and neutral in reaction.

Climate

The climate of the area is tropical characterized by rainfall (monsoon) from July to September. Droughts are frequent both in the pre and post monsoon periods and frost of moderate intensity in December and January is common. The temperatures during May-June are the highest (36° C) whereas Dec.-Jan are the coldest months when the temperatures are as low as 10° C.

Conceptual Plan for restoration

Besides conservation aspects ,attraction and pleasantness are the other special features of the project.Models like Navgrah vatika (consonance of nine planets),Shiv Panchayat Vatika and a sale counter for sale of plants of astrological species (as per the Sun & Moon sign) have been incorporated as a part of multi dimensional approach towards environmental consciousness.Deciduous plant species intermixed with evergreens used for the plantation purpose is a sure bet against the impacts of harsh winters.The summarized conceptual plan is elaborated as under:

A) For Relaxation ,attraction and pleasure

a) The frontal area

b) The sprawling lawn

c) The Navgrah vat d) Shiv Panchayatna

B)For conservation and economic viability

a) Plant Conservation Area (PCA)

1. Provision of Navgrah Vatika plants to ward off evil effects of planets.

2. Provision of Shiv Panchayat Vatika for religious purpose.
3. Topiaries

b) Provision of nursery of medicinal & planetary plants.

c) Availability of Navgrah and medicinal & planetary plants for the visitors.(sale counter)

d) Provision of Trekking & relaxation measures in the landscape.

Important Features of the Project

The Planetary Van Vihar Project (PVVP) required considerable planning and thought. It was finally conceived and started in June 2010. Some of the important components of the conceptual plan are as listed below:

Conservation Measures

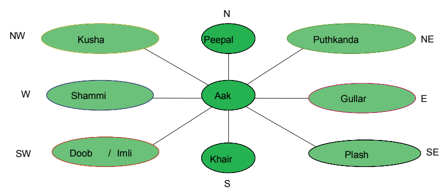
a) Planetary contented plants in the landscape by introducing Navgrah Vatika & Shiv Panchayat Van.

Plant species for Navgrah Vatika: Aak *(Calotropis)* for Sun,Plash *(Butea monosperma)* for Moon, Puthkanda *(Achyranthes aspera)* for Mercury , Gular *(Ficus glomerata)* for Venus , Shammi *(Prosopis cineraria)* for Saturn, Doob grass *(Cynodon dactylon)* for Rahu, Kusha *(Demostachya bipinnata)* for Ketu , Peepal *(Ficus religiosa)* for Jupiter , Khair *(Acacia catechu)* for Mars.These plants species are to be planted in a specific pattern as depicted below:

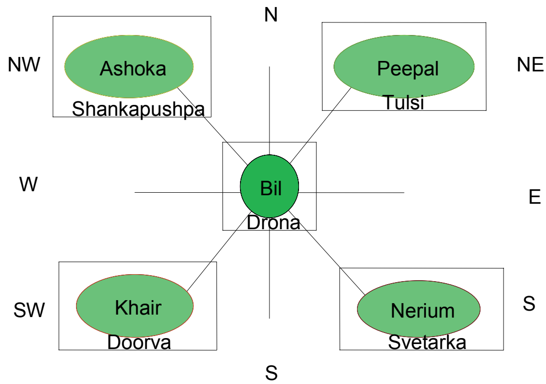
S.No.	Name of Planet	Local Name	Botanical Name
1	Ketu	Kush/Daab	*Desmostachya bipinnata*
2	Guru	Peepal	*Ficus religiosa*
3	Budh	Apamarg	*Achyranthes aspera*
4	Shani	Shami, Khejri	*Prosopis cineraria*
5	Ravi	Shweth Aak	*Calotropis procera*

6	Shukra	Gular	*Ficus glomerata*
7	Rahu	Doob Grass	*Cynodon dactylon*
8	Mangal	Khair	*Acacia catechu*
9	Chandra	Phalash/Dhak	*Butea monosperma*

Plant species for Shiva Panchayat : Bilva *(Aegele marmelos)*+ Drona *(Leucas cepheloites)* for lord Shiva, Ashwatha (*Ficus religiosa*)+ Tulsi *(Ocimum sanctum)* for Vishnu, *karaveera(Nerium odorum)+ Svetarka (Calotropis procera)* for Sun , Khadira *(Acacia catechu)+ doorva (Cynodon dactylon)* for lord Ganesha , Ashoka *(Saraca indica)+ shankapushpa (Clitoria ternatea)* for Goddess Ambika.These plants species have a composite behavior and are to be planted in a specific pattern representing various Gods / Godesses.



Navgrah Plantation Scheme



Shiva Panchayat Plantation Scheme

Pits of 60cm x 60cm x 60cm have been provided for tree planting whereas the pit size for shrubs has been kept at 45cmx45cmx45cm.The plants for Navgrah Vatika and Shiva Panchayat Van were arranged from the nearby forest nursery. Besides, plants of economic & aesthetic importance have also been provided for the stabilization of the forest landscape. The Navgrah Vatika is laid out in a 9m x 9 m plot where planetary plants have been planted in specific directions. The Shiv Panchayat Vatika has similarly been laid out in a 10mx10m plot. b) Life size Topiaries (meshed wire structures depicting the shape) of various deities have been introduced as a novel concept. These topiaries(20 in no.'s) of Lord Shiva ,Lord Baba Balak Nath ji,Godess Durga , Navgrah Planets besides various animal forms have been twined by plant creepers for better aesthetic look.

c)Water conservation measures have been affected by way of collecting reservoirs for control of surface and runoff water.

;c)Biodiversity index of the area has been enhanced by proper planning and implementation.

D) Social /Ecological / Economic Measures The Van Vihar Vatika has been designed for the purpose of spiritual contentment and relaxation to the visitors/trekkers/environmentalists vested with a zeal of love towards nature.Besides, it shall serve as an mini botanical garden of the local species for the purpose of educating school and college children.Plants have both an ecological & economic importance as listed below: d) Soil conservation has been affected by providing check walls and small stone structures, contouring of slopes, provision of jute matting and various vegetative methods.Efforts have been made to use only local and waste material for the purpose so as to cut down the costs.

B) Landscape Measures Proper landscaping of the site has been ensured by adopting the following measures:

a) Gentle gradient and garland drainage systems have been provided;b) Segmentation of the total area has been ensured;c) Provision of concrete structure and jute carpeting on the slopes;d) Plants planted in attractive layout designs to give aesthetic and harmonious look;g) The overall design planned to bolster positive energy and a sense of relaxation.

C) Biological Enrichment Measures a)Existing vegetation has been preserved but for eradication of some obnoxious weeds such as lantana. Only the plant species which are conducive to the site have been planted;b) Slopes stabilization has been affected by contouring and planting of *Aloe vera ,Duranta,Jasmine,Iresene,Cuphea* besides grasses like selection-1 strain of *Cynodon dactylon*

S.no.	Botanical Name	Local Name	Uses
1	*Desmostachya bipinnata*	Kush/Daab	Medicinal
2	*Ficus religiosa*	peepal	Medicinal

3	*Achyranthes aspera*	Apamarg	Medicinal
4	*Prosopia cineraria*	Shami, Khejri	Medicinal, wood
5	*Calotropis procera*	Shweth Aak	Medicinal, wood
6	*Ficus glomerata*	Gular	Medicinal, wood
7	*Cynodon dactylon*	Doob grass	Medicinal
8	*Acacia catechu*	Khair	Medicinal
9	*Butea monosperma*	Phalash/Dhak	Medicinal, wood
10	*Aegele marmelos*	Bilva	Medicinal, wood
11	*Leucas cepheloites*	Drona	Medicinal, wood
12	*Ocimum sanctum*	Tulsi	Medicinal
13	*Nerium odorum*	Karaveera	Medicinal
14	*Saraca indica*	Ashoka	Medicinal, aesthetic
15	*Clitoria ternatea*	Shankapushpa	Medicinal
16	*Jacaranda mimosifolia*	Nili Gulmohar	Wood, aesthetic
17	*Lagerstroemia indica*	Jarool	Wood, aesthetic
18	*Grevillea robusta*	Silver oak	Wood, aesthetic
19	*Nerium indicum*	Kaner	Medicinal, aesthetic
20	*Araucaria sp.*	Monkey	Aesthetic
21	*Populus sp*	Popular	Wood, aesthetic
22	*Tecoma grandiflora*	*Tecoma*	Aesthetic
23	*Juniper sp.*	Juniper	Aesthetic
24	*Jasminum humile*	Yellow jasmine	Medicinal, cosmetics & aesthetic
25	*Euonymus sp.*	Euonymus	Bio-fencing

26	*Duranta sp.*	Duranta	Bio-fencing & aesthetic
27	*Bougainvillea glabra*	Bougainvillea	Bio-fencing & aesthetic
28	*Hibiscus sp.*	Hibiscus	Medicinal & aesthetic
29	*Rosa indica*	Rose	Medicinal, cosmetics & aesthetic
30	*Schefflera sp.*	schefflera	Aesthetic
31	*Cycas revoluta*	Cycas palm	Aesthetic
32	*Phoenix sylvestris*	Wild date	Aesthetic
33	*Verbena sp.*	Verbena	Aesthetic
34	*Cuphea sp.*	Cuphea	Aesthetic
35	*Lavandula sp.*	Lavender	Medicinal, cosmetics &aesthetic
36	*Iresine sp.*	Iresine	Aesthetic

Vatika has been developed with the purpose of preserving the pristine surroundings in its natural form and shall also serve as a play area for the enjoyment and fun for children.

3)Restoration of the Landscape model : Indicators of success-

Since its development, the Van Vihar Vatika at Deotsidh has started yielding the desired results over the past few months. The indicators of success can be gauged by the following:

i)The steep slopes of the ecologically fragile area have started getting stabilized.The run off has decreased (as is ocularly visible) and the water flowing in adjacent crevices has become more transparent.

ii) The Vatika is supposed to be an educative plan guide of plants in relation to planets as mentioned in ancient scriptures and ayurvedic literature. Groups of daily student visitors to the site is itself a testimony to the increasing interest of people in this novel concept.

iii)) The local farming community has started taking keen interest in the cultivation of available commercial medicinal plants at the site for the purpose of supporting their livelihood.

iv) The restoration model at Deotsidh shall act as a focus for similar replicas in many other parts of the state and even beyond. It shall help encourage people to conserve nature by reviving their concern towards the religious and medicinal values of our plants.

References

"Miracles of Veda & Purana http://sanatandharma.tripod.com

Negi,S.S.1982 . Environment problems in the Himalayas.

Bioengineering Measures for Himalayan Landscapes Affected by Landslide –A Case Study

Ashish Rawat, Prafulla Soni* & H.B.Vasistha**

Louisberger,New Delhi

*Advisor Restoration ecology & Biodiversity Conservation

**Ecology & Environment Division

Forest Research Institute, Dehradun

Abstract

The Himalayan range of Garhwal Himalya is undergoing constant rupture in the thrust belt zone, due to which earthquake and landslide activity is triggered almost everywhere in the region. Landslides are one of the indicators of the geomorphological modifications taking place in this active and fragile terrain. Restoration is difficult on landslide surfaces because of the high degree of spatial and temporal heterogeneity in soil stability and fertility. Restoration efforts can be streamlined by using techniques that promote successional processes.Bioengineering is one such measure that effectively deal with landslides, hill slopes failure, and other related problems. It is an integrated approach that assists stabilization of hill slopes/landslide sites and im proves the site quality by improving soil nutrient status. The application of bioengineering is also vital for restoration of biodiversity in landslide damaged/degraded sites. Furthermore, this technique is a cost-effective solution, which uses locally available materials and allows the involvement of the local population in management and maintenance.

The present paper deals with the application of bioengineering and its importance in addressing landslides and other related problem in the Himalayan region with special reference to the catastrophic Varunavat landslide, occurred on September 24, 2003 in Uttarkashi district of

Garhwal Himalaya.

Keywords: Landslides, Bioengineering, Restoration, Varunavat, Himalaya

Introduction

Himalayas, one of the most fascinating, striking and astonishing mountain range in the world are geologically very weak, fragile and rugged in nature. The fragility and weak geology of Himalayas attribute several catastrophic disasters in the region, landslides are one of them. Landslides are a form of slope failure characterized by the rapid mass movement of soil and/or rock along a discrete shear surface (Varnes 1978). Landslides are one of the natural hazards that affect at least 15% of land area of our country exceeding 0.49 million km^2 (Sharda, 2008). The term *"landslide"* as presented by Varnes (1978) and Cruden and Varnes (1996) includes all types of gravity-induced mass movements, ranging from rock falls through slides/slumps, avalanches, and flows, and it includes both subaerial and submarine mass movements triggered mainly by precipitation (including snowmelt), seismic activity, and volcanic eruptions.

The Himalayas experience some of the highest rates of landslides in the world and the adverse geology, topography and land use are made more acute by the humid sub-tropical temperature zones. Rapid rock weathering and heavy rainfall are predominant features of this area and are responsible for inducing landslides and erosion. Bioengineering can be used to protect almost all slopes against erosion through slope protection and stabilization which dramatically reduces landslides and the devastation they cause.

Natural ecosystems have an inherent characteristic to recover after natural or man imposed damage. However, in view of frequent damage of natural ecosystems in various regions of Himalaya, technologies are required to hasten the process of recovery. Bioengineering is undoubtedly the most important factor in ameliorating the effects of severe ecological disturbance such as landslides.

Bioengineering as an Integrated Approach

Bioengineering entails the use of living plants and other auxiliary materials for stabilization of hill slopes, works as an integrated technique to protect slope against surface tension, to reduce the risk of planer sliding and to improve surface draining. Species having colonizing behaviour, fast growing nature and dense and deep root system with potential of adventitious root system and fast and simple propagation are needed to be selected for bioengineering application.

The skill of using vegetation in engineering is to combine it carefully with civil works to give the best results in terms of cost and effect. Bioengineering is relatively low in cost and the materials and skills are all available in rural areas. It takes some time for the materials to reach their maximum strength, but unlike civil engineering systems, they tend to become stronger over time.One of the main advantages of bioengineering approach to slope protection, viz. plants and the mechanical structures can function together in mutually reinforcing or complementary roles. The field studies (White, 1979) have shown that in many instances combined structural-vegetative slope protection systems are more cost-effective than the use of either vegetation or structure alone. Vegetative treatments alone are usually much less expensive than earth retaining structures or other geological protection systems. On the other hand, their effectiveness in terms of preventing soil loss or arresting slope movement under severe conditions may also be much lower.

Bioengineering application blend into the landscape, hence this application is environmentally viable but the geological structures do not visually intrude upon the landscape as much as the conventional earth retaining structures. Thus, opportunities arise to incorporate vegetation into structure itself. This is done by planting either in between structural members or upon the benches purposely designed into a structure.

Role of Vegetation in Landslide Stabilization

Vegetation is a regulatory factor towards the reconstruction of an ecosystem and landslide soils, as it improves the physical and biological diversity of disturbed sites. The role of vegetation is quite significant in prevention as well as stabilizing the landslides. Plant cover not only protects the surface from weathering due to direct impact of rain and winds but its intricate root system works as a cohesive in binding the loose soil and preventing it from erosion. Vegetation increases the soil infiltration capacity, helping to reduce the volume of runoff. Plants transpire considerable quantities of water, reducing soil moisture and increasing soil suction.

The vegetation acts as a barrier to the rainfall and significantly reduces the kinetic energy of raindrops and thus, reduces their power of erosion. The network of surface fibres produces a tensile mat effect and restrains the underlying strata. Plant roots bind the soil which increases the shear strength through a matrix of tensile fibres, resulting in increased resistance to deformation. The roots of plants penetrate deeply giving anchorage into firm strata, bonding the soil mantle to stable sub-soil or bedrock; and support to upslope material through buttressing and arching. The use of vegetation to manage erosion and protect slopes is relatively inexpensive, does not require heavy machinery on the slope, establishes wildlife habitat, and can improve the aesthetic quality of the property. Vegetation also encourages other plants and animals to live on the slope and therefore, bioengineering helps to improve the environment as well as providing useful products, such as, firewood and fruit.

Bradshaw (1987) envisaged the importance of achieving a stable and self- sustaining vegetative cover. Vegetation is a regulatory factor towards the reconstruction of an ecosystem and landslide soils, as it improves the physical and biological diversity of disturbed sites. Revegetation is supposed to be the best tool for stabilization of degraded habitats (Singh *et al.,* 2002), because vegetation not only provide long-term ecosystem stabilization and render potential ameliorative effects on soil quality, but also have potential value (Torbert *et al.,* 1993; Fisher, 1990; Ashby, 1987).

Plant Selection for Bioengineering Application

Selection of vegetation, for bioengineering of landslide sites depend upon many factors viz. site conditions, soil type, topography, aspect etc. but the vegetation selected for bioengineering of landslide habitats must adapt the site condition and fulfill the multitude of needs. For rehabilitation of any type of wasteland, the choice of species should be such that the demand for inputs is the least and attention needed is negligible. They should have deep and large root system and preferably be hardy, fast-growing and suckering (Sastry and Kavathekar, 1990). The native vegetation could be used in rehabilitation and restoration prorammes as they have fewer competitors than other species and the disturbances permits the germination and development of non-seeded species (Munshower, 1993). Leguminous species has been recognized as the suitable species for bioengineering of landslide because these species has the capability of fixing atmospheric nitrogen which not only improve the site condition but also make an invaluable contribution to the reestablishment of nitrogen cycle in the disturbed habitat (Cryderman and Sheltron, 1976; Biondini and Redente, 1986).

Vegetation can be selected and arranged on the slope to perform specific engineering functions. A mixture of plants, mainly fast growing shrubs and herbs should be introduced so as to give a range of rooting depths which create an irregular structure. This tends to prevent continuous shear planes from developing in the upper soil layers, discouraging shearing from taking place. The plants on the site should be a mixture of ages so that they do not all need to be replaced at the same time and to ensure that there will always be strong healthy plants protecting the slopes.

An ideal bioengineering vegetation community should be primary successional species with fast growing in nature and deep penetrating root system to bind the loose soil, high survival rate; good foliage cover, colonizing behaviour, giving the maximum anchorage effect. Shrubs with strong, woody roots which are shallower than the tree roots form an intermediate level and large clumping grasses with a dense network of fibrous roots close to the soil surface; provide a thick surface cover to prevent erosion.

Lessons of Bioengineering from Varunavat Landslide, Garhwal Himalaya-A Case Study

September 23rd, 2003 was not less than a doom day for Uttarkashi because Varunavat Parvat (longitudes 78°26’ E and latitudes 30°44’ N, elevation 1160-1790 m msl) which is sacred for thousands of local inhabitants, struck late in the night on September 23rd, 2003, immediately after the rainy season and left behind a classical example of devastation for scientists, geologists and researchers because at the foot of the Parvat lies the Uttarkashi township and it was under threat for a period of one month because of the hysterically debris slide (debris slide in the crown portion, and rockfall and rockslide in the middle part) from Varunavat Parvat.

The September, 2003, Varunavat landslide in Uttarkashi has affected a large area (about 18 ha) of Varunavat Parvat and damaged/uprooted about 2050 trees of chir pine (*Pinus roxburghii*), the dominating tree species of this region. Apart from this, about 450 trees of chir pine were slashed to transport heavy machinery used for geological treatment of Varunavat landslide area and about 600 trees were slashed down for various other purposes. The sum total of chir pine reduction was about 3,100 (Soni *et al.,* 2008).

Due to the catastrophic landslide, there was a huge loss to vegetation, which removed carbon from vegetation, hence total amount of carbon removed from vegetation was about 396.4 tonnes for chir pine and 0.25 tonns for shrubs. Regarding loss of biomass the total loss was assessed about 792.8 tonnes for chir pine and 0.50 tonnes for shrubs, while soil carbon loss in landslide areas was estimated about 404 tonnes. Economic loss due to depletion of biomass alone of chir pine has been assessed as rupees 43, 40 lakhs (Soni *et al.,* 2008).

About 13 species including 5 species of shrubs and 8 species of herbs and grasses has been disappeared from the Varunavat Landslide areas. Most of these species were ecologically and ethnobotanically important (Rawat *et al.,* 2007).

Bioengineering Measures at Varunavat Landslide Damaged Sites

Forest Research Institute, Dehradun and State Forest Department, Uttarakhand have undertaken a joint venture for the biological stabilization of Varunavat landslide using bioengineering technique in 2006-2007.

Three distinct sites within the landslide disturbed zone were identified for taking up rehabilitation measures using bioengineering application. These sites were:

1. Crown Area of Varunavat Parvat (Mahidanda Block III)
2. Middle Portion of Varunavat Parvat (Mahidanda Block II)
3. Dumping sites of Landslide debris I & II (Mahidanda Block I)

Since all the three sites are located adjacent to each other, hence the soil type, site conditions, requirement and methodology applied were almost same.In addition to the above sites, degraded natural forests adjoining to this landslide area have also been taken up for conservation of soil moisture and enhance biodiversity of the region.

Table 1. Species of common occurrence in and adjoining areas of Varunavat landslide area

Plant species	**Vernacular Name**	**Family**	**Habit**
Berberis asiatica	Chatori, Daruhaldi	Berberidaceae	Shrub
B. lycium	Kingora	Berberidaceae	Shrub
Colebrookea oppositifolia	Bambher, Bintalakri	Lamiaceae	Shrub
Geranium nepalense	Phori	Geraniaceae	Herb
G.wallichianum	Phori	Geraniaceae	Herb
Desmodium multiflorum	Koti-Kansar, Deota	Fabaceae	Under shrub
Eupatorium adenophorum	Bokhar	Asteraceae	Under shrub
Lespedeza sericea	Chinese lespedeza	Papilioneae	Under shrub
Malvastrum coromandelianum	broom weed, clock plant	Malvaceae	Herb
Rubus ellipticus	Hinsalu, Hinsar	Rosaceae	Shrub
Toona ciliata	Indian cedar, Tun	Meliaceae	Tree
[illegible]	[illegible]	[illegible]	Tree

Initially a combination of slope dressing, surface and subsurface drainage and provision of retaining structures (gabion wall, breast wall) were prepared out to check further mass movement and debris flow in the landslide damaged sites. Further, geo jutes were also spread out to arrest the loose soil. Space has been made in between the jeo-jute at a regular interval for germination of seeds and planting tufts of grasses and seedlings. The main advantage of the geo-jute is that it is easily biodegradable and can enhance the soil property after its decomposition.

In order to select the plant species for bioengineering measures in Varunavat landslide sites a reconnaissance survey of Varunavat Parvat and its adjoining villages has been conducted to note the ecologically and ethnobotanically important native plant species occurring in the area. After the survey a list of about 10 species of common occurrence, their botanical name, families and vernacular name has been recorded (Table 1.).

For further bioengineering trials in Varunavat landslide areas, the species of local occurrence with good soil binding capacity and fast growing nature have also been selected (Table 2).

Bioengineering Measures in Crown Area (Mahidanda Block III)

Bioengineering measures in crown area of Varunavat Parvat have been initially started with some primary successional as well as some economically important grass species.

Table 2. Species used in bioengineering measure in Varunavat landslide, their Mode of propagation and functional uses and services

Species	**Common Name**	**Mode of Propagation**	**Functional Uses & Services**
Albizia odoratissima	Bansa	Seed broadcasting, Seedling	Fodder, timber wood
Aesculus indica	Pangar	Seedlings	wood used as timber
Alnus nepalensis	Utis, Uttis	Seed	Wood of

		broadcasting, Seedlings	Timber, Fodder, Restoration of degraded lands
Cedrus deodara	Deodar, Devdar	Seedlings, Planting	Leaves used in Ayurvedic medicine, wood of timber, essential oil from wood
Prunus padus	Padam	Seedling, Planting	Fruits used for making jam and preserves, young leaves used for vegetable, stabilization of hill slopes.
Quercus leucotrichophora	Baanj, Oak	Seed broadcasting, Seedlings	Seeds are astringent and diuretic. Used for furniture and agricultural implements, recommended for stabilization of soil in inner and outer hills
Toona ciliata	Tun	Seed broadcasting	The flowers contain a red colouring matter and also a sulphur-coloured dye. The wood has

			a variety of uses.
Trema politoria	Khagshi	Seed broadcasting	The leaves and fruit are reported to be eaten. The bark yields a black dye. Wood Used in manufacturing panel products, poles and drumsticks.
Agave sisalana	Rambaansa	Bulbils	Leaf yields a fibre; used for twines, ship-cordage. This plant is extremely drought-resistant; recommended for growing on wastelands, landslide areas, and mine-spoils.
Buddleja asiatica	Dudhiya	Seed broadcasting	The plant has been used as an abortifacient and also in the treatment of skin complaints. Recommended for stabilizing the hill slopes and reclamation of degraded lands
Coriaria	Masuda	Seed	Fruit used as a

nepalensis		Broadcasting	beverage. The leaves contain 20% tannin. This species is a good soil binder is used for reclamation of degraded lands, hillslopes and mined spoils
Debregeasia hypoleuca	Sansaru	Seed broadcasting Seedlings	Fruit are sweet but insipid and mucilaginous. About the size of a pea. Used as flavouring. Recommended for reclamation of mined spoils and degraded lands.
Mimosa himalayana	Alay, Alaru	Seed broadcasting	Fuel Wood, bark are also used as a tonic and for diarrhea, It can be used on the steep banks of water reservoirs as an erosion-control measure.
Rubus ellipticus	Hinsalu, Hinsar	Seed broadcasting	Fruit, sweet with a pleasant blend of acidity. . The plant is grown to deter soil erosion and is good for soil conservation.
Rumex hastatus	Almoda, Amoda	Seeds	Plants contains quite high levels of oxalic acid,

			the oxalic acid content will be reduced if the plant is cooked. Recommended for stabilization of hillslopes and degraded habitats.
Vitex negundo	Simalu	Seedlings, Cutting	This species is widely used in Chinese herbal medicine; it is the second most important treatment for chronic, bronchitis. This species is very useful to control soil-erosion, and for afforestation of forest-lands affected by floods; it is also suitable for control of landslide and streambanks.
Woodfordia fruticosa	Dhaula, Dhaturgi	Seedlings	The flowers are acrid, astringent, styptic, depurative, uterine sedative, constipating, antibacterial, and corrective of urinary pigments, febrifuge and alexeteric. It can

			be planted for afforestation of landslips and denuded hilltops. Useful as soil-improver and efficient nurse to many other species
Arundinaria falcata	Ringal	Seedlings	Young shoots are cooked. The canes are used for making hats, baskets, rods etc. The plant is very effective soil stabilizer and used to stabilize the hill slopes and landslide areas.
Arundo donax	Narkat	clumps	The rhizome can be dried and ground into a powder to make bread, usually in conjunction with cereal flours. The plant can be grown as a windbreak screen. If it cuts down, the culms branch and in this form the plants can be used as a hedge.
Chrysopogon fulvus	Golda Grass	clumps	Highly valuable and nutritious fodder and can be converted

			into hay. Grass can form a constituent for pulp with other grasses. It can be grown for reclaiming and stabilizing hillslopes, stream banks and prevent water erosion; tufts used to prevent erosion of newly erected bunds.
Cymbopogon citrates	Lemon grass	Clumps	It is an aromatic tropical grass and has a lemon flavor. It can be planted for reclamation of degraded lands.
Cymbopogon martini	Palmarosa Grass	Clumps	Palmarosa oil calms the mind, yet has an uplifting effect, while clearing muddled thinking. Its utility in afforestation is highly important; also grows on soil with poor drainage
Cymbopogon nardus	Java Grass	Clumps	It is the source of the commercial citronella oil,

			used in perfumery and as an insect repellent. It has soil-binding capacity and can be used in reclaiming soils prone to erosion and can be improved.
Panicum maximum	Ginni Grass	Clumps	It is considered as a suitable plant to stop soil erosion on slopes (it has dense root mats) while providing valuable fodder.
Pennisetum purpureum	Napier Grass	root cuttings or stem pieces	This grass is commonly used as a fodder. It makes good hay if cut when young but is too coarse if cut late in its annual growth cycle.
Phragmites australis	Dambu	Rhizome	Useful for pulp, for rayon, paper and pens, hatching, wicker- work etc. Rhizome, root and young shoots are edible. Its young leaves are used as fodder, its long roots helps in binding the

			soil and preventing erosion
Stylosanthes hamata	Caribbean stylo	Seeds	A highly palatable pasture-legume available throughout the year. Recommended and suitable for semi arid tracts and dry pockets. This species is ideal for reclaiming hillslopes, degraded areas and wasteland

These species were Napier grass (*Pennisetum purpureum*), Java Grass (*Cymbopogon nardus*), Lemon grass (*Cymbopogon citratus*), Golda Grass (*Chrysopogon fulvus*) and Palmarosa Grass (*Cymbopogon martinii*). In addition seeds of *Dodonaea viscosa* and *Bauhinia varigata* have been spread out in this area. Bioengineering application through the use of these primary and soil conserving species will accelerate the site conditions.

Bioengineering Measures in Middle Portion of Varunavat Parvat (Mahidanda Block II)

To ease the process of rehabilitation, the sloppy area was first converted into benches and these benches were then covered by geo-jute to protect the soil erosion and conserving the soil moisture. Seed broadcasting of *Rumex hasatus, Crotalaria* sp., *Rosa* sp., *Trema politoria, Bauhinia variegata*, *Mimosa himalayana* and *Dodonaea viscosa* was done. Grasses such as *Pennisetum purpureum, Cymbopogon citratus, Cymbopogon martinii, Cymbopogon nardus, Panicum maximum* were also planted in these benches. In addition cutting of *Debregeasia hypoleuca, Vitex negundo* were also planted in the sites. Seedling planting of *Alnus nepalensis* was also done in this area.

Bioengineering Measures in Dumping Sites I & II (Mahidanda Block I)

These are the areas where debris were taken from Varunavat landslide area and dumped it in adjoining forest area. Dumping areas are known as loose, fragile, unstable and very much prone to soil erosion and sliding. The leading step towards bioengineering is to bind and stabilize the loose and unstable soil in its place and check the soil erosion by making trench at a regular interval. In order to cover these loose and fragile slopes seed broad casting of colonizing and nitrogen fixing plant species were done. These species were *Rumex hasatus, Crotalaria* sp*., Stylosanthes hamata, Dodonaea viscosa, Rosa* sp*., Trema politoria, Bauhinia variegata Alnus nepalensis* to bind the soil through the network of roots. The tufts of grasses such as *Pennisetum purpureum, Cymbopogon citratus, Cymbopogon martinii, Cymbopogon nardus, Phragmites australis* and *Stylosanthes hamata* were also planted in trenches. Apart from these grass species some species like *Agave sislana* supplemented with planting of *Alnus nepalensis* and seeding of *Dodonea viscosa*. Cuttings of *Vitex negundo* and *Erythrina* sp. have also been planted in trenches and benches. Besides, all these species seeds of *Dodonaea viscosa* has also been spread out in these sites.

Rehabilitation measures in degraded forest adjoining to the landslide areas (Mahidanda Block I)

Forest area adjoining to the landslide sites (Mahidanda Block I) comprise the reserved forest area of Varunavat Parvat. In this area mixture of species comprising *Albizia odoratissima, Aesculus indica, Alnus nepalensis*, *Cedrus deodara*, *Prunus padus*, *Quercus leucotrichophora*, *Toona ciliata* have been planted out and between these species the tufts of *Arundinaria falcate* (Ringal) and *Pennisetum purpureum* (Napier grass), *Panicum maximum* (Ginni grass) has been planted in trenches (size 3.00x0.30x0.20) to produce green fodder for local inhabitants .

All these species used in this process of bioengineering measures have successfully been established and developed a good foliage cover and remification of root networks. Now in addition to these planted species a number of other native and associated species have also started colonizing and the process of succession have now started in these degraded ecosystems.

Conclusions

The successful stabilization of Varunavat Landslide using bioengineering application exhibited the need of such advance technologies to hasten the recovery process in disturbed areas. The application of bioengineering needs a prior a proper investigation of landslides because it is not possible to design an effective mitigation system without proper understanding of the slope problems. Many development schemes implemented without carrying proper geological and geotechnical investigation due to shortage of money or time or due to other constraints. In order to avoid or minimize the landslide hazard, a proper geological and geotechnical investigation is essential prior to implementation of any development scheme. First of all, proper investigation method of landslide should be selected according to the need, which will save time and money too. A landslide calamity may be avoided or at least minimized by applying appropriate remedial measures or set or remedial measures at the initial stage of development scheme. Bioengineering is a suitable technique to protect slopes against surface erosion, reduce the risk of planer sliding and improve surface drainage. It is a technique that can be applied nearly everywhere in the world, provided that suitable plants and auxiliary materials are available on site. Implementation of bioengineering application creates a living and complex system which is very sensitive to environmental impacts. The success of this system depends on the growth performance of plants. The length and quantity of shoots and roots is an excellent indicator for biomass development, factor which indicates their suitability in terms of soil and climate for the area.

References

Ashby, W.C. 1987. Forests. In: Jordan, W.R, Gilpin, M.E. and Aber, J.D. (eds.) *Restoration Ecology: A Synthetic Approach to Ecological Research.* Cambridge University Press. Cambridge, UK.

Biondini, M.E. and Redente, E.F. 1986. Interactive effect of stimulus and stress on plant community diversity in reclaimed lands. *Reclamation and Revegetation Research*, 4:211-222.

Cruden, D.M. and Varnes, D.J. 1996. Landslides types and processes. In: Turner AK, Shuster RL (eds.) *Landslides: Investigation and mitigation*. National Academy of Sciences, Washington, DC, pp 36–71.

Cryderman, J.M. and Sheltron, S.G. 1976.Cation exchange capacity, Ca, Mg and pH changes in iron tailings as affected by vegetation.*Research Note no . 20 Ford Forestry Centre, Michigan Technological University*,10 p.

Fisher, R.F. 1990. Amelioration of soils by trees. In: Gessel, S.P, Lacate, D.S, Weetman, G.F. and Powers, R.F. (eds.), *Sustained Productivity of Forest Soils. Proc. North American For. Soils Conf, 7th Vancouver, B.C*, July, 24-28, 1988, Univ. British Columbia,Faculty of For. Publ. Vancouver, B.C. 525p.

Munshower, F.F. 1993. In. *Practical Handbook of Disturbed Land Revegetation*. Lewis Publishers. London (UK).

Sastry, T. C. S. and Kavathekar, K.Y. 1990. (Ed.). *Plants for Reclamation of Wastelands.*Publication and Information Directorate, Council of Scientific & Industrial Research, Hillside Road, New Delhi, India.

Sharda, Y.P. 2008. Landslides in India. *Glimpses of Geoscience Research in India.* 98-101pp.

Singh, A.N., Raghubanshi, A.S. and Singh, J.S. 2002. Plantation as a tool for mine spoil restoration. *Current Science*, 82(12): 1436-1441.

Varnes, D.J. 1978. Slope movement types and processes. *In: Schuster, R.L. and Krizek, R.J.* (eds.), *Landslides: Analysis and Control*, Nat‟l. Res. Council, Wash, D.C,Transp. Res. Bd. Spec. Rept.176,11-33 pp.

White, P.S. 1979. Pattern, process, and natural disturbance in vegetation. *Botanical Review*,45: 229-299.

Bradshaw, A. D. (1987). The reclamation of derelict land and the ecology of ecosystem. In W. R. Jordan, M. E. Gilpin, and J. D. Aber (eds.), *Restoratio ecology:A SyntheticAapproach to Ecological Research*. Cambridge, UK: Cambridge University Press.

Torbert, J. L., Burger, J. A. and Daniels, W. L. (1993). Pine growth variation associated with overburden rock type on a reclaimed surface mine in Virginia.

Rawat, A., Soni P. and Vasistha, H.B. (2007). Ecological Studies In Varunavat Landslide of Uttarkashi District of Garhwal Himalaya And Role of Native Plant Species For Its Biostabilization. In. IInd Uttarakhand Science Congress 15-17, Nov. Uttarakhand Academy of Administration, Nainital. *Journal of Environmental Quality*, (19): 88–92.

Soni P., Vasistha, H.B. and Rawat, A. (2008). Natural resources depletion and their ecological and economical valuation in Varunavat landslide of Uttarkashi district, Garhwal Himalaya. *Landslide Management: Present Scenario & Future Directions*, C.B.RI. Roorkee.278-283 pp.

Soil Nutrient Status in Age Series of Restored Rock Phosphate Mined Sites and Natural Forest - A Comparative Study

Shikha Uniyal Gairola and Prafulla Soni*

NOIDA,U.P.India

* Advisor Restoration ecology &

Biodiversity Conservation,Panditwari,Phase II-Dehradun

Abstract

Mining of minerals in the Himalayan region is important not only for the local and national economy but also for the development of industry as well, but the extraction of these minerals is bringing about superimposition of natural fertile soil by inactive and infertile materials. Present study has been carried out in an eco-restored rock phosphate mine at Maldeota Dehradun where ecorestoration measures were undertaken in 15 hectare mine spoil area in the year 1982. The study shows that after 23 years of restoration the soil nutrients in the restored areas have exceeded the adjoining natural forest. Total nitrogen, available phosphorous, exchangeable potassium and organic matter were found maximum in the restored site in comparison to the natural forest.

Keywords: Eco-restored, Rock phosphate, mine spoil, nutrients, natural forest

Introduction

Surface mining operations have the potential to destroy the flora and fauna,and contaminate the soil, air and water in the surrounding areas (Safaya, 1979; Dhar and Thakur, 1995). In India nearly 7,365 active mining leases are spread over an area of 7,30,230 hectares and idle mining leases (which are not operational due to one reason or the other) cover an area of 2,13,150 hectares. The total leased out area is thus 9, 43,380 hectares (Soni *et al*., 1995). Mine spoils pose adverse conditions for soil microbes and plant growth, due to their low organic matter,other essential nutrients and unfavourable soil chemistry, poor structure - either coarse or compact, and high isolation from vegetation (Meyer, 1973 and Harthill and Mckell, 1979). Poor microbial population inhibits nutrient transformation the establishment of the plant growth and the process of ecological succession (Singh *et al*., 1996). Consequently the natural recovery is a slow process and takes several years for the creation of self-sustaining ecosystem. The effect of soil disturbances are markedly adverse because many beneficial soil characteristics may require from hundreds to tens of thousands of years to develop through pedogenic processes in order to reach a steady state resulting in maximum productivity (Jha and Singh, 1992). This is of great concern to both the public and government agencies because of their local impacts on ecosystems.

Himalayas are very rich in mineral resources like marble, limestone, gypsum, dolomite and rock phosphate but the fact that these hills have very low carrying capacity is generally overlooked. While, mining of these minerals in the Himalayan region is important not only for the local and national economy but also for the development of industry as well, but the extraction of these minerals has resulted in loss of top fertile soil and inactive and infertile materials have been brought to surface. Ecological restoration of these derelict mined lands has been taken up and this has resulted in improvement of soil nutrient status. Present study describes the soil nutrient status in an age series (23, 22, 21and 20 years) of mined areas. Comparison of the nutrient status of mined areas has been done with the soil of natural forest in the adjoining areas.

Study Area

The Dun is a characteristic geomorphological entity of the

Himalayas and is significant for the natural resources particularly the minerals, soil, forest and water.The mineral wealth in the region is found in the form of high grade limestone, marble, gypsum, dolomite and rock phosphate. Mining of rock phosphate was initiated in this area by Pyrites Phosphate and Chemicals Ltd. (PPCL), a government of India undertaking, in the year 1960. The mining was done by both underground and open cast methods. Though mining of these valuable minerals has saved lot of foreign exchange for the country but it had defaced this picturesque valley leading to many ecological and socioeconomic problems.

Present study has been undertaken in restored area of rock phosphate mine at Maldeota in Doon Valley that has an elevation ranging from 650m to about 1050m above mean sea level. It is situated in the north east of Dehradun at a distance of about 18km on the west bank of perennial river Bandal. Mining in this area was done by Pyrites, Phosphate & Chemical Limited (A Govt. of India Undertaking) since 1970. The area affected by open cast mining was about 15 hectares till 1982 when ecorestoration was initiated. Ecological restoration of this mine site has been done by using integrated technical and biological measures. (Soni and Vasistha,1985). A comparative study of soil has been done between a 23 years old restored site (site1),22 years old restored site (site 2), 21 years old restored site (site3) and 20 years old restored site (site 4). For comparison an adjoining natural forest (site 5) soil have also been analyzed.

Methodology

The study was undertaken in the year 2005-07. The oil/minespoil samples were collected from all the sites in October 2005-06 and October 2006-07. The data presented are the mean values of the data collected for two years. In each site, five replicates of 1x1 meter quadrats were laid and soil samples were taken from these quadrats from 0-30 cm depth and then brought to laboratory for further analysis. Soil samples were oven dried and analyzed for organic matter by Walkley's and black method (Jackson, 1973), Total nitrogen by Kjeldahl method (Wilde *et al.*, 1985), Exchangeable phosphorous (Jackson, 1973), Exchangeable potassium by Flame photometer (Misra 1968). Data collected was further subjected to statistical analysis by using SPSS (Statistical package for Social Science) software.

Results and Discussion

A perusal of data of the study shows that the organic matter in the restored site was higher in comparison to the natural forest. Organic matter was found maximum in site 3 (26218.2 kg ha^{-1}) while in the natural forest 24673.9 kg ha^{-1}. Total nitrogen in the natural forest was 948.15 kg ha^{-1} while it was found highest in site 3 (1065.6 kg ha^{-1}) i.e. 21 years old restored site(Table 1,Figure 1& 2). The reason for this can be the addition of plant litter and other residues to the soil surface in the restored area and also of the fact that natural area is in a highly degraded stage. Site 2 has the relatively lower amount of organic matter, the reason may be the low accumulation of litter as the site has open spaces. Comparatively higher amount of nitrogen in the restored sites may be due to high organic matter accumulation in restored sites by roots and leaching of nitrogen from herbaceous vegetation in the plots. Available phosphorous was found maximum in site 4 (20 years old restored site) i.e. 24.42 kg ha^{-1} while in the natural area it was (4.54 kg ha^{-1}). Restored mine area has relatively alkaline pH which is favourable for release of nutrients and enhancement of microbial occurrence (Cummins *et al*., 1965) and this may be one of the reasons for higher available phosphorous in restored mine area. Exchangeable potassium was again highest in restored site (57.90 kg ha^{-1}) in site 3 while it was 32.63 kg ha^{-1} in natural area. Being rich source of nitrogen, phosphorus, potassium and other mineral elements the high levels of organic matter in soil play a major role in regulating plant nutrient levels in soil with low fertility (NRC, 1981). Due to higher organic material accumulation in restored site and better condition for leaching, higher potassium contents were observed in soils of restored areas as compared to natural forest.

Table 1 Soil nutrients (kg ha^{-1}) in the restored sites and adjoining natural forest area.

Sites	Soil Nutrients (Kg ha^{-1})			
	Total N	Avail P	Ex. K	OM
1	545.16±47.98	12.10±0.93	34.41±1.68	26103.0±5405.56
2	665.76±31.87	9.11±0.71	32.41±2.19	23914.8±3495.91
3	1065.6±59.95	7.41±0.55	57.90±4.33	26218.2±4640.17
4	922.35±31.75	24.41±5.34	39.89±4.53	24624.6±4341.33
5	948.15±95.77	4.54±0.52	32.63±2.39	24673.9±3551.6
Significance	***	***	***	NS
CD	0.0027	0.0012	0.0015	-

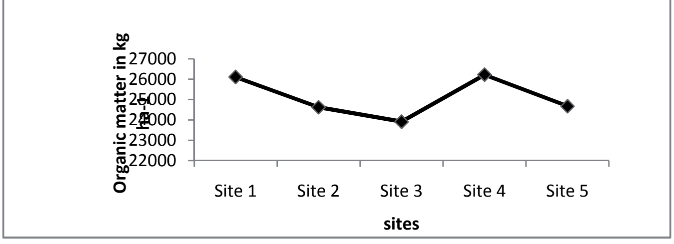


Figure 1. Organic matter accumulation in restored sites and joining atural forest area.

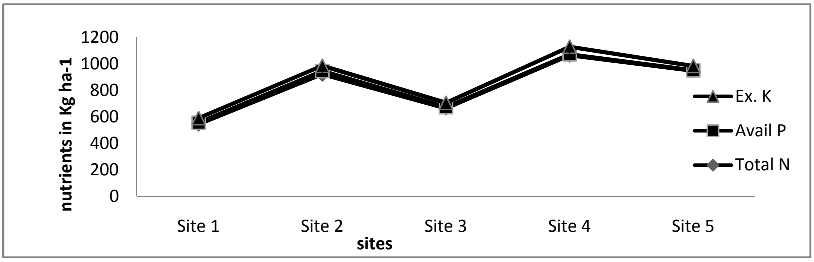


Figure 2. Exchangeable potassium, available phosphorous and total nitrogen in restored sites and natural area.

A highly significant difference was observed between the sites in total nitrogen, available phosphorous and exchangeable potassium while a non- significant difference was observed between the sites in relation to organic matter.

Conclusions

The above study shows that after 23 years of restoration the soil of the restored area has comparatively higher amount of soil nutrients (total N, available P, exchangeable K,) than the natural area fovouring the fact that the restored area has become more nutrient rich than the natural area.

References

Cummins, D.G., Plass, W.T. and Pike, J. 1965. Chemical and physical properties of spoil banks in the eastern Kentusky Coalfields. *USDA For. Serv. Res. Pap*. N.E.: 155,18

Dhar, B.B. and Thakur, D.N. 1995)"*Mining environment*", Proc. of the First World Mining Environment Congress, 11-14Dec., New Delhi, Oxford & IBH Publishers, India, 1038 pp.

Harthill, M. and Mckell, C.M. 1979 "Ecological stability - is this a realistic goal for arid land rehabilitation", *Ecology and Coal Resource Development* (ed. M.K. Wali), Vol.2, Pergamon Press, pp.557-567.

Jackson M.L. 1973 Soil Chemical Analysis. Prentice Hall of India Ltd., New Delhi.

Jha, A.K. and Singh, J.S. 1992 “Influence of microsites on redevelopment of vegetation on coalmine spoils in a dry tropical environment”, *J of Environmental Management*, 36: 95-116.

Meyer, F.H. 1973 "Distribution of ectomycorrhizae in native and man made forests", *Ectomycorrhizae: Their Ecology and Physiology* (eds. G.C. Marks and T.T. Klozlowski), pp. 79-105. Academic Press, NY.

Misra, R. 1968. *Ecology Work Book*, Oxford and IBH Publishing Co. New Delhi.(pH)

Safaya, N.M. 1979 “Dilineation of mineral stresses in mine spoils and screening plants for adaptability”, *Ecology and Coal Resource Development* (ed. M.K. Wali), pp. 830-849. Pergamon Press, New York.

Singh, R.S., Chaulya, S.K., Tewary, B.K. and Dhar, B.B. 1996 “Restoration of a coalmine overburden dump - A case study”, *Coal International*, March: 88-83.

Soni, P. and Vasistha, H.B. 1985. Reclamation of rock phosphate mine at Maldeota. In: (Eds) Sharma, M.R. & Gupta, B.K. Proc. *Recent advances in plant science*. Bishen Singh and Mahendra Pal Singh, Dehradun.

Soni, P. 1998. Concept of ecorejuvenation-its application in mined areas. In (ed) Soni, P., Chandra, V. and Sharma, S.D. 1997. *Environmental Management, Concepts, Strategies and Legislation for Mine Areas.*1-10.

Wilde, S.A., Corey, R.B., Iyer, J.G. and Voigt, G.K. 1985. S*oil and Plant Analysis for tree culture*. Oxford and IBH publishing co., New Delhi.(for nitrogen)

National Research Council 1981. Surface mining, Soil, Coal and society: National Academy Press, Washington. D. C., 233pp.

Soil Minerlogy,Micronutrient Status and Phytoremediation

Soil Micronutrient Status under Different Forest Ecosystems of Dehradun District, Uttarakhand.

C.M. Mathavan and M.K.Gupta

Forest Soil and Land Reclamation Division, Forest Research Institute, Dehra Dun-248 006, Uttarakhand, India

Abstract

Fertility and productivity of soil not only depend on major soil nutrients (N, P and K), soil micronutrients also play an important role in growth and development of plants. An attempt has been made to generate information regarding the EDTA- extractable Iron (Fe), Zinc (Zn), Copper (Cu) and Manganese (Mn) status under five different forest covers of Dehra Dun district. Soil samples (0-30 cm), representing sal, deodar, quercus, chir pine and miscellaneous forest systems, were collected. The collected samples were processed and analyzed for pH and organic carbon by standard procedures. The EDTA extractable Fe, Zn, Cu and Mn were extracted with 0.05 M ethylene di-amine tetra-acetic acid (EDTA) solution and analyzed with the help of atomic absorption spectrophotometer. The soils under sal and deodar forests were acidic in reaction with average pH values of 5.73 and 5.93, respectively whereas quercus and chir pine forest soils were near neutral in reaction. As high as 4.31 per cent of mean organic carbon content observed in soils of deodar forest system followed by quercus (2.82%), miscellaneous forest (2.68%), chir pine forest (2.26%) and sal forest (1.59%). The EDTA-extractable Iron (Fe) content of soil recorded highest mean value of 24.62 mg kg^{-1} under miscellaneous forest system, while the lowest mean content of 11.91 mg kg^{-1} observed under soils of deodar forest system. Mean values of soil EDTA-Zinc content varied from 2.25 mg kg^{-1}in chir pine, 2.80 mg kg^{-1} in sal, 5.25 mg kg^{-1} in miscellaneous, 5.42 mg kg^{-1} in deodar and 6.33 mg kg^{-1} in quercus forest systems. The available copper (Cu) content of soils collected from various forest systems varied widely from 0.73 to 5.63 mg kg^{-1} with the highest mean value of 3.91 mg kg^{-1} observed under chir pine forest soil. Compare to other soil cationic micronutrients, manganese content was the lowest with the mean value varied from 1.03 (quercus) to 1.75 mg kg^{-1} (deodar). As per the soil micronutrient critical limit concept, on an average different forest systems of Dehra Dun district have capacity to maintain sufficient range of micronutrients.

Keywords: Forest soil, EDTA, Iron, Zinc, Copper, Manganese

Introduction

Forests are providing important environmental services such as carbon sequestration, landscape beauty, biodiversity conservation and watershed protection. Foresters have always relied on knowledge of chemical and physical properties of soils to assess capacity of sites to support productive forests. Fertility and productivity of soil not only depend on major soil nutrients (N, P and K), soil micronutrients also play an important role in growth and development of plants. Role of micronutrients in balanced plant nutrition and their importance in plant physiological process are well established by essential nutrient concept. Thus, knowledge of status of micronutrients is helpful in understanding the inherent capacity of soil to supply these nutrients to plants. Availability of micronutrients is influenced by their distribution in soil and other physico-chemical properties of the soil (Sharma and Chaudhary, 2007). Besides soil characteristics, vegetation type and covers also plays a vital role in governing the nutrient dynamics and fertility of soils (Venkatesh *et.al*., 2003). Soils under different vegetation may vary physico-chemical properties which may modify extractable micronutrients content and their availability. So, analysis of these properties along with micronutrients under different forest systems may have significant importance. Scanty information is available on status of soil cationic micronutrients under various forest covers in India especially in the Dehra Dun district of Uttarakhand. Keeping in this view an attempt has been made to generate information regarding the available Fe, Zn, Cu and Mn status and some physico-chemical properties under five different forest covers *viz*. sal, deodar, quercus, chir pine and miscellaneous forest systems of Dehra Dun district, Uttarakhand.

Materials and Methods

Fifty soil samples (0-30 cm), representing sal, deodar, quercus, chir pine and miscellaneous forest systems (10 in each), were collected from different locations of Dehra Dun district, Uttarakhand. The collected samples were processed and sieved through 2mm sieve. Soil samples were analyzed for pH and organic carbon by standard procedures. The available fraction of four micronutrients viz. Fe, Zn, Cu and Mn were analyzed by extracting a portion of 5 g soil with 100 ml of 0.05 M ethylene di-amine tetra-acetic acid (EDTA) solution as per Quevauviller (1998) and subsequently analyzed with the help of atomic absorption spectrophotometer (GBC 904).

Results and Discussion

The data on soil pH and organic carbon status of soils under various forest systems are presented in table 1. The pH values of soils showed marked variations under different forest covers.The soils under sal and deodar forests were acidic in reaction with average pH values of 5.73

and 5.93, respectively whereas quercus and chir pine forest soils were near neutral in reaction. The moderation of pH under perennial vegetation might be due to higher leaf litter addition which helps in mineralization process (Wilson, 2007). Soils under different forests had wide variations in the soil organic matter status; In general organic carbon status was optimum in all the soils. Highest mean organic carbon content (4.31 per cent) was recorded under soils of deodar forest system followed by quercus forest (2.82 per cent), miscellaneous forest (2.68 per cent), chir pine (2.26 per cent) and sal forest soil (1.59). This might be due to addition of larger biomass through leaf litter. Wide variation in soil organic matter accumulation under different forests has also been reported previously by several researchers.

Table 1. pH and organic carbon content of soils under different forest systems of Dehra Dun District.

Sample No.	**Sal**		**Deodar**		**Quercus**		**Chir pine**		**Miscellaneous**	
	pH	**O.C %**	**pH**	**O.C %**	**pH**	**O.C**	**pH**	**O.C %**	**pH**	**O.C %**
1	5.76	1.34	6.13	2.95	7.86	3.79	6.92	2.12	5.96	4.61
2	5.57	1.77	6.54	3.01	7.22	2.73	6.86	1.21	6.12	4.84
3	5.84	1.31	5.68	4.85	7.26	3.77	6.12	4.21	5.88	2.62
4	5.97	1.87	5.85	4.69	7.61	1.56	7.06	1.94	6.32	3.07
5	5.98	1.32	5.97	3.97	7.28	2.02	7.14	2.65	6.52	4.88
6	5.88	1.39	5.91	3.07	7.34	3.62	6.55	2.16	6.34	1.11
7	5.37	1.78	5.16	5.68	7.58	2.49	6.72	2.24	6.82	0.90

8	5.77	1.46	6.2	5.64	7.08	2.88	6.38	1.27	5.78	1.11
9	5.56	1.72	5.89	3.94	7.39	2.45	6.96	1.50	5.32	2.45
10	5.62	1.94	5.96	5.26	7.12	2.90	6.75	3.34	7.06	1.27
Mean	**5.73**	**1.59**	**5.93**	**4.31**	**7.37**	**2.82**	**6.75**	**2.26**	**6.21**	**2.68**

The data pertaining to the EDTA-extractable micronutrients such as Iron (Fe), Zinc (Zn), Copper (Cu) and Manganese (Mn) are presented in tables 2 and 3. Available mean Fe content values varied widely (11.91 to 24.62 mg kg^{-1}) in the soils under different forest systems.

Table 2. EDTA extractable Fe and Zn status of soils under different forest systems of Dehra Dun District.

Sample No.	DTPA- Fe content (mg kg^{-1})					DTPA- Zn content (mg kg^{-1})				
	Sal	Deodar	Quercus	Chir pine	Miscellaneous	Sal	Deodar	Quercus	Chir pine	Miscellaneous
1	16.34	21.55	13.89	26.54	30.76	1.42	3.74	7.72	1.90	12.46
2	13.49	12.88	22.86	25.50	36.12	0.50	5.58	14.74	1.82	8.06
3	16.34	7.67	9.04	16.46	37.20	0.30	4.08	5.64	1.28	5.38
4	12.20	4.97	22.40	19.83	35.27	3.46	3.88	5.78	1.28	3.84
5	11.47	10.58	9.45	13.95	28.16	4.38	3.40	13.00	2.26	5.19
6	11.40	9.48	22.25	12.88	31.98	3.76	2.62	6.22	1.66	2.82
7	17.63	9.85	20.93	10.64	13.21	2.88	8.26	2.34	1.90	3.84
8	20.47	15.11	19.06	13.95	15.48	3.40	6.56	0.98	5.36	4.44
9	22.65	8.90	15.14	30.67	5.80	4.24	6.56	2.62	1.58	2.54
10	21.75	18.11	23.23	14.40	12.23	3.66	9.50	4.24	3.50	3.90
Mea	**16.37**	**11.91**	**17.82**	**18.48**	**24.62**	**2.80**	**5.42**	**6.33**	**2.25**	**5.25**

Soil under miscellaneous forest system recorded highest EDTA extractable iron content of 24.62 mg kg-1 followed by chir pine (18.48 mg kg-1), quercus (17.82 mg kg-1), sal forest (16.37 mg kg-1) and Deodar (11.91 mg kg-1). These variations in EDTA-Fe content were due to difference in nutrient removal pattern under different vegetation also might be ascribed to deposition of nutrient enriched pattern by leaf litter fall under various vegetation.

Table 3.EDTA extractable Cu and Mn status of soils under different forest systems of Dehra Dun District.

Sample No.	DTPA- Cu content (mg					DTPA- Mn content (mg kg-				
	Sal	Deodar	Quercus	Cir pine	Miscellaneous	Sal	Deodar	Quercus	Chir pine	Miscellaneous
1	1.36	3.58	2.14	4.26	3.14	0.98	1.28	1.03	1.36	1.22
2	1.28	3.28	2.06	4.18	3.26	1.06	1.96	0.98	1.28	1.36
3	1.02	2.96	1.94	3.69	2.73	1.35	2.06	0.84	1.58	0.98
4	1.78	4.16	1.85	3.28	2.68	1.32	2.11	0.86	1.36	1.18
5	2.36	4.06	1.06	4.12	2.12	0.88	1.98	0.92	1.54	0.86
6	2.82	3.94	3.23	5.63	2.58	0.94	1.58	1.32	1.09	0.98
7	2.32	3.19	2.58	3.28	3.43	1.16	1.32	1.56	1.18	0.92
8	1.86	3.26	3.52	2.69	2.69	1.08	1.82	1.09	1.98	0.79
9	1.33	2.54	1.96	3.88	2.56	1.52	1.98	0.98	1.35	1.26
10	1.98	2.98	2.34	4.08	1.98	1.33	1.36	0.73	1.72	1.55
Mean	**1.81**	**3.40**	**2.27**	**3.91**	**2.72**	**1.16**	**1.75**	**1.03**	**1.44**	**1.11**

Considering critical limit of 4.5 mg kg-1, proposed by Lindsay and

Norvell (1978), all the soil samples are sufficient in available Fe. These results suggest that some of the soils under deodar forest system had marginal level of Fe which indicates that corrective measures would be required to avoid Fe chlorosis / Fe deficiency in the near future.

Mean values of soil EDTA-Zinc content varied from 2.25 mg kg-1in chir pine,2.80 mg kg-1 in sal, 5.25 mg kg-1 in miscellaneous, 5.42 mg kg-1 in deodar and 6.33 mg kg-1 in quercus forest systems. Critical limits for available Zn identified by Takkar and Mann (1975) are < 0.6, 0.6 to 1.2 and > 1.2 mg kg-1 for deficient, medium and high, respectively. Accordingly Zn content was found to be sufficient in most of the soils under different forest systems except two locations under sal forest and one location under quercus forest. Soils under perennial vegetation and tree plantation had medium to sufficient range of Zn due to addition of leaf litter and deposition of eroded material from slope (Katyal and Datta, 2004).

The available copper (Cu) content of soils collected from various forest systems varied widely from 0.73 to 5.63 mg kg-1 with the highest mean value of 3.91 mg kg-1 observed under chir pine forest soil. Critical limits of copper identified by Katyal and Sharma (1991) are < 0.2, 0.2 to 2.0 and > 2 mg kg-1 for deficient, medium and high status. Accordingly soils under sal forest were found to be medium in mean Cu content, whereas mean Cu content of soils under other forest systems were found to be high. This might be due to continuous organic matter addition through leaf litter fall and acidic to neutral pH increases the solubility and availability of Cu in soil.

Compare to other soil cationic micronutrients, manganese content was the lowest with the mean values of EDTA-Mn content ranged from 1.03 to 1.75 mg kg-1 in soils under different forest systems. The highest value of Mn was recorded in deodar forest soil, while the lowest content was under quercus forest soil.

Considering 1.0 mg kg-1 as critical limit (Lindsay and Norvell 1978), all the soils are sufficient in available manganese. This sufficient value might be due to better supply of manganese through parent material and higher organic carbon may further increase the Mn solubility in soil.

Conclusions

It is apparent from the study that the soils are adequately supplied with available micronutrient (Fe, Zn, Cu and Mn) contents. Sufficient level of organic matter addition through leaf litter, parent material and optimum pH are the main soil characteristics which maintain adequate supply of micronutrient to soils under different forest systems. As per the soil micronutrient critical limit concept, on an average different forest systems of Dehra Dun district have capacity to maintain sufficient range of micronutrients.

References

Katyal, J.C. and Datta, S.P. 2004. Role of micronutrients in ensuring the optimum use of macronutrients. *IFA International symposium on micronutrients* held at New Delhi, India during February 23-25, 2004

Katyal, J.C. and Sharma, B.D.1991. DTPA extractable and total Zn, Cu, Mn and Fe in Indian soils and their association with some soil properties. *Geoderma* 49,165-179

Lindsay, W.L. and Norvell, W.A. 1978. Development of a DTPA soil test for zinc, iron, manganese, and copper. *Soil Science Society of America Journal* 42: 421-428.

Quevauviller, P.H. 1998. Operationally defined extraction procedures for soil and sediment analysis. *Trends in Analytical Chemistry* 17: 289-

298.

Sharma, J.C. and Chaudhary, S.K.2007. Vertical distribution of micronutrient cations in relation to soil characteristics in lower Shiwaliks of Solan district in North- West Himalayas. *Journal of the Indian Society of Soil Science* 55, 40-44.

Takkar, P.N. and Mann, M.S. 1975. Evaluation of analytical methods of estimating available zinc and response of maize to applied zinc in major soil series of Ludhiana, Punajb. *Agrochimica* 20, 420-430

Venkatesh, M.S., Majumdar, B., Kumar, K and Patiram 2003. Status of micronutrient cations under various land use systems of Megalaya. *Journal of the Indian Society of Soil Science* 51, 6.-64.

Wilson, Brian R.2007. Scattered native trees and soil pattern in grazing land on Northern Table lands of New South Wales, Australlia. *Australian Journal of Soil Research* 45, 199-205.

Microbes and Green Technology: Role of Microbial inoculants on Establishment of Plantation and Natural Regeneration in Limestone Mine Spoils

Anuj Kumar Singh and Jamaluddin*
Orissa University of Agriculture & Technology, Bhubaneswar
*Department of Biological Science, Rani Durgavati University, Jabalpur

Abstract

Exploitation of limestone has resulted disturbance of large tract of land. The fertility status of soil is changed to a considerable extent after mining. Mining disrupts soil-plant-microbe system and causes alteration of nutrient dynamics and results into reduction in soil productivity. In such soil conditions, natural regeneration is a very slow process and may take many years to develop a full fledged ecosystem. Merely plantation may not guarantee establishment of plant on mined spoils as there is no constant supply of essential nutrients due to lack or less population of under ground microbial flora. Such degraded land which has low microbial density, low nutrients level with poor nutrient cycling capacity; inoculation of selected microbes are very helpful in the establishment, growth and survival of plants. A consortium of beneficial microbes like plant growth promoting rhizobacteria (PGPRs) along with arbuscular mycorrhizal fungi may play pivotal role in restoration of such harsh sites. An important goal of restoration is to accelerate natural successional processes so as to increase biological productivity, reduce rates of soil erosion, increase soil fertility and increase biotic control over biogeochemical fluxes within the recovering ecosystems. Analysis of different natural successions on natural and artificial substrates suggests that one of the important factors limiting the rate of development is the

process of immigration of flora. Application of microbial inoculants ensure the establishment of nutrient supply , soil development which attracts immigration of surrounding species, accelerates natural regeneration process and ultimately a self sustained system on mined spoils is developed.

Keywords: Limestone mine spoils, PGPRs, natural regeneration, restoration

Introduction

It is universally accepted that the microbes are beneficial in the activity of important functions performed in the ecosystem. Soil microbial biomass, living part of the soil organic matter, is an agent of transformation of organic matter and source of available nutrients. Activities of soil microbes can change the soil environment much rapidly and provide key controlling influence on the rate at which nutrient cycling processes take place and play a very important role in the formation of macro aggregates. The potential of soil microorganisms has been recognized widely in improvement of soil quality, soil formation, aggregation and revegetation through their activities in litter decomposition, phosphate solubilization, nitrogen fixation, oxidation of various inorganic components of soil or mineralization of inorganic components and mycorrhizal symbiosis are major beneficial activities that play a very important role in soil system functioning. Implications of plants and their symbionts like mycorrhizal fungi, nitrogen fixing bacteria and free-living rhizosphere population of bacteria promote plants establishment and growth. Thus, an active soil microbial biomass is an essential factor in the long-term fertility of soils. Application of microbial technology has become an integral element of forestry and agriculture and has substantially contributed in forest and agricultural productivity.

This article reviews some of the important aspects of microbial applications in forestry and discusses implications of microbial inoculation in restoration of limestone mined out lands.

Soil-Plant-Microbe Interaction

Microbial activity in the rhizosphere affects rooting patterns and the supply of available nutrients to plants thereby modifying the quality and quantity of root exudates (Bowen and Rovira, 1999; Gryndler, 2000; Barea, 2000).Carbon fluxes are crucial determinants of rhizosphere function. The release of root exudates and decaying plant material provide sources of carbon compound for the heterotrophic soil biota as either growth substrates or structural material for root associated microbiota (Werner, 1998). Nitrogen-fixing microbes can exist as free-living organisms in associations of different degrees of complexity with other microbes and plants. The most abundant elements in the atmosphere (N_2) are very often the limiting element for the growth of most organisms. Many soil organisms interact with each other to overcome of the limitation. Positive effects of *Rhizobium* sp. inoculation in combination with *Azotobacter* sp. or *Azospirillum* sp. inoculants have been reported for different forage and grain legumes. The role of microorganisms in nutrient cycling is unique. An active biomass is an essential factor in the long-term fertility of restored soil. It is therefore essential that microbes beneficial for plant growth have to be introduced to the spoils. Among the different microbes vesicular- arbuscular mycorrhizal fungi, nitrogen fixers and phosphate solubilizers are very important for any plant. Phosphorus is an important plant nutrient next to nitrogen for plants growth. The most important aspect of phosphorus cycle is microbial mineralization, solubilization and immobilization besides chemical fixation of phosphorus in the soil. Phosphorus solubilising microorganisms convert insoluble inorganic phosphate compounds into soluble form. A considerable higher concentration of phosphate solubilising bacteria is commonly found in the rhizosphere soil. Also the fungal genera with this capacity are *Penicillium* and *Aspergillus* (Suh *et al*., 1995; Whitelaw *et al*., 1999).*Pseudomonas* is a typical PGPR and their interactions with AM fungi mutually enhance each other's colonization and achieve additive plant growth enhancement (Singh and Jamaluddin, 2008). Another mechanism of action of PGPR on plant growth is the production of siderophores. The siderophores are produced by most fungi and bacteria including *Pseudomonas, Rhizobium* and *Azotobacter* (Meyer and Linderman, 1986).Arbuscular Mycorrhiza Fungi (AMF) which are an important group of soil-borne microorganisms; contribute substantially to the establishment, productivity, and longevity of natural or man-made ecosystems. These fungi form symbiotic association with most terrestrial plant families. Due to the extensive network of external hyphae which function as plant rootlets and increase Phosphorus uptake, arbuscular mycorrhizal fungi are considered as beneficial microorganisms. The species of *Pseudomonas, Bacillus, Aspergillus, Penicillium* etc. have been reported to be active in the bioconversion of insoluble phosphorus. These organisms produce organic acids like citric, glutamic, succinic, lactic and tartaric acids which are responsible for solubilization of insoluble forms of phosphorus. Phosphorus solubilising microorganisms synergistically interact with nitrogen fixing microorganisms. These PGPRs are widely being exploited as biofertilizers in agriculture, horticulture, forestry, agro-forestry (Gaur, 1990).

Phosphorus Nutrition of Plants on Mined Spoils

Phosphorus is an important plant nutrient next to nitrogen for plants growth.The most important aspect of phosphorus cycle is microbial mineralization, solubilization and immobilization besides chemical fixation of phosphorus in the soil. Phosphorus solubilising microorganisms convert insoluble inorganic phosphate compounds into soluble form. A considerable higher concentration of phosphate solubilising bacteria is commonly found in the rhizosphere soil. A significant amount of phosphorus is bound in organic forms in the rhizosphere. Phosphatase enzymes produced by plants and microbes are presumed to convert organic phosphorus into available phosphate, which is absorbed by plants. Phosphate availability is one of the major growth limiting factors for plants in many natural ecosystems (Antibus and Dighton, 1993). Plants absorb phosphorus from the soil as inorganic phosphate ions, but there availability is severely restricted by reactions of inorganic and organic phosphates with soil constituents. Phosphatase enzymes can significantly import the availability and recycling of phosphorus in and around the rhizosphere. Mine spoils are infertile strata for the plant growth (Bradshaw, Dancer, Handley, and Sheldon,1975). Since calcareous mine spoils present low level of key nutrients like N,P and K and also lack sufficient level of organic matter. An appropriate level of nutrients and microbial system is a requisite for the growth and establishment of plants. Phosphorus is one of the major constituents of the soil nutrients system, which often becomes inadequate in mine spoils. In such unfavorable conditions phosphatase enzyme activity of plants may prove significant in the phosphorus liberation from organically bound phosphorus to available inorganic form. This liberated and available form of phosphorus is mineralized by rhizosphere microbes and is made available for plants uptake. A study on effect of AMF inoculation on phosphatase enzyme activity conducted by Singh and Jamaluddin (2008) reported that the inoculation of AM fungi influenced both the phosphatases (acid and alkaline) activity. By inoculation of AM fungi; activity of both acid and alkaline phosphatases was found to be increased in the rhizosphere soil of *Jatropha curcas.* There was significant variation ($p<0.05$) in the acid phosphatase activity in the rhizosphere soil of inoculated and un-inoculated plants. Alkaline phosphatase activity was also found enhanced in the rhizosphere soil of inoculated plants. From the above records, it is clearly evident that arbuscular mycorrhizal fungi affected the activity of both the phosphatases. Mutualistic association thus may improve the phosphorus mineralization and its acquisition by plants. In this study, acid phosphatase activity was found greater than alkaline phosphatase activity in rhizosphere soil of both inoculated and uninoculated plants. Acid phosphatases contribute significantly to the mineralization of organic phosphorus compounds in soil, thus enhancing the biological availability of released inorganic phosphorus. Kennedy and Rangarajan (2001) observed significant increase in both the acid and alkaline phosphatase activity in three varieties of Papaya and observed comparatively higher acid phosphatase activity than alkaline phosphatase activity. Mohandas (1992) observed significant enhancement in the activity of acid and alkaline phosphatase in the root surface of papaya inoculated with AM fungi, also observed that *G. mosseae* inoculation resulted in a higher increase compared to *G. fasciculatum* and acid phosphatase activity was higher than the alkaline phosphatase activity. Tisserant *et al*. (1993) suggested that alkaline phosphatase activity was induced by colonization of host roots and this enzyme could be used for analyzing the symbiotic efficiency of arbuscular mycorrhizal infection. Thiagarajan and Ahmad (1994) reported increased acid and alkaline phosphatase activity in AM inoculated cowpea

(*Vigna unguiculata*) plants as compared to uninoculated plants. Joner and Johansen (2000) studied comparative effect of different arbuscular mycorrhizal fungi on phosphatase activity in soil and found that *G. intraradices* showed the highest external phosphatases activity in two experiments and *G. claroides* had the same activity in one experiment. Dodd *et al*. (1987) observed comparatively enhanced acid and alkaline phosphatase activity in the rhizosphere of AM inoculated pants than uninoculated ones. Studies conducted at the International Crops Research Institute for the Semi Arid Tropics (ICRISAT), Andhra Pradesh, India showed that in sterilized soil, acid and alkaline phosphatase activities in the rhizospheres of mycorrhizal and non-mycorrhizal plants were higher than in non- rhizosphere soil. With acid phosphatase, the activity was highest in the rhizosphere of mycorrhizal plants followed by rhizosphere of non-mycorrhizal plants and non-mycorrhizal soil (Krishna and Bagyaraj, 1985).These studies reflect significance of microbes in phosphorus nutrition of the plants.

Microbial Solubilization of Calcite Rocks

Soil microorganisms inhabiting the rhizosphere environment interact with plant roots and mediate nutrient cycling. Solubilization of rock materials by microorganisms contribute to a great extent and play very important role in maintaining supplies of inorganic nutrients for plants. Limestone mine overburden dumps are composed of large amount of infertile soil along with waste rocks. These over burden dumps are deficient in nutrients and are unable to support vegetation on mined dumps. In such alkaline soil, the activity of calcium and its minerals become high. As these minerals are rock bound, their release into the soil is very slow. The solubilization of these rock bound minerals is very important for the enrichment of the fertility of the mined spoils. The soil microorganisms play an active role in the solubilization of calcite rocks and the minerals released into the soil may be utilized by the plants grown in calcite medium of limestone mined spoils. Singh and Jamaluddin (2010) reported an increase in the phosphate solubilization efficiency of *Pseudomonas fluorescens* and *Azospirillum sp.* when the isolates of both the bacterial strains repeatedly exposed in calcium rich medium. The in vitro assay showed the bacterial inoculation solubilized the added rock power more efficiently at when they repeatedly inoculated in calcium rich medium. It may be an indication of development of more tolerant and more efficient strain of the same bacterial isolates. Such efficient strains may be developed and multiplied for use in the field poor in nutrients Phosphorus in particular. Leyval *et al*. (1990) also reported bacterial solubilization of Mica mineral which led release of unavailable nutrients to Pine and Beech. Watteau and Berthelin (1994) emphasized that the organic acids produced by rock dissolving bacteria enhanced the weathering of primary rock minerals by chelating cations from minerals. The rhizosphere of the Plant which is rich in microbial diversity especially of bacteria, contribute significantly to the supply of nutrients to plants (Hinsinger and Gilkes,1993).These bacterial population can be developed in more capable strains and can be multiplied for application in the field. Chang and Li (1998) demonstrated induced weathering processes by combined effect of plant root and soil microbes which may be responsible for transformation of mineral structure, removing cations from the minerals for rapid uptake by plants. Seshadri *et al.* (2000) tested three strains of *Azospirillum sp.* to study their capability to solubilize inorganic phosphate *in- vitro*. Gaur (1990) reported solubilization of tricalcium phosphate in liquid medium by using bacterial inoculants and demonstrated phosphorus solubilising bacteria as a significant bacterial biofertilizers. Agnihotri

(1970) tested some fungal isolates for efficiency of solubilization of insoluble phosphate and observed the solubilization process to a maximum extent. Similar observations in respect to the activity of S*treptomyces sp*. against rock phosphate solubilization were made by Bardiya and Gaur (1974). The periodic solubilization of ferric and Aluminium phosphate was investigated in liquid medium by Gaur and Gaind (1983).Ahmad and Jha (1968) reported the solubilization of rock phosphate and hydroxyapatite by some bacteria and fungi. Wani *et al.* (1979) also confirmed the rock solubilization ability of selected strains of *Pseudomonas striata* and *Bacillus polymyxa* on both solid and liquid mediums. The investigations carried out in the present study are an indication of the development of new strains of the test organisms. These improved strains can be further multiplied in bulk and can be used for biological solubilization of rock bound minerals in nutrient deficient soils like limestone mined overburden dumps.

Mycorrhizal Technology and Mines Restoration

Arbuscular Mycorrhizal associations are important in natural and managed ecosystems due to their nutritional and non- nutritional benefits to their symbiotic partners. They can alter plant productivity because AMF acts as biofertilizers, bioprotectant or biodegraders and are known to improve plant growth and health by improving mineral nutrition or increasing resistance or tolerance to biotic and abiotic stresses.

Mycorrhizal fungi are species of fungi that intimately associate with plant roots forming a symbiotic relationship, with the plant providing ca for the carbohydrate for fungi and the fungi providing nutrients such as phosphorus, to the plants. Mycorrhizal fungi can absorb, accumulate and transport large quantities of phosphate within their hyphae and release to plant cells in root tissue. Mycorrhizal symbiosis is very important in agriculture and forestry. Plants inoculated with arbuscular mycorrhiza have been shown to be more resistant to some root diseases. It is now generally recognized that they improve not only the phosphorus nutrition of the host plant but also its growth, which may rest in an increase in resistance to drought stress and some diseases. Therefore, AM fungi offer a great potential for sustainable agriculture, and the application of AM fungi to agriculture has been developed.

AM fungi modify the quality and abundance of micro flora and alter overall microbial activity. Following host root colonization the AMF induces changes in the host root exudation pattern, which alters the microbial equilibrium in the rhizosphere (Pfledger and Linderman, 1994). These interactions enhance plant growth, health and productivity (Paulitz and Linderman, 1989). Applications of biofertilizers have great potential in preventing soil degradation and restoring soil fertility of drastically disturbed lands. Plant succession following drastic disturbance due to mining is a subject of both practical and ecological interest. Wali and Freeman (1973) pointed out that an adequate understanding of natural revegetation processes should be included in all rehabilitation efforts without which no desired plant cover will be possible. Bradshaw (1983) reported that natural processes of ecosystem development on derelict lands are slow and stochastic.In fact, in some countries the AM fungal inocula have been commercialized. Since it is laborious and cost-consuming for production of AM fungal inocula because of their obligate biotrophic nature, the ways to increase the function of the indigenous AM fungi in soil have also been developed. AM fungal association enhances nitrogen gain in ecosystems by increasing the nitrogen fixation rates of plant and nitrogen fixing bacterial associations. In many ecosystems a large fraction of the available nitrogen in the soil is ammonium and mycorrhizal fungi readily transport ammonium from soil to plant (Ames *et al*., 1983).

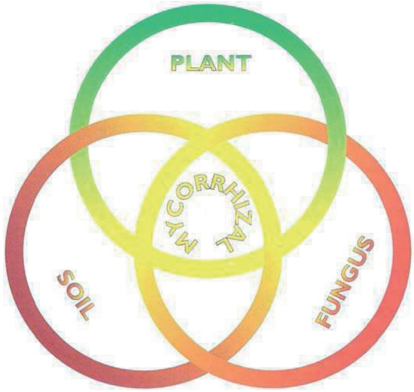


Figure 1.Mycorrhizal association, showing the interactions between fungus, plant and soil. (Source: Brundrett *et al*., 1996).

Nitrogen fixed in association with one plant is transported to an adjacent plant via hyphal connections fixed soybeans was transported to maize via the mycorrhizae and significantly increased the growth and nitrogen status of maize plants (Van Kessel *et al*., 1985).So, arbuscular mycorrhizal symbiosis has a very important role in nutrients transportation in soil-plant system.

The benefits of optimization (via inoculation) of AMF in production systems with low indigenous inoculums or efficacy have included:

- Increased plant nutrient uptake via the AM fungus e.g. Phosphorus
- Increased tolerance of root pathogens by the plant system
- Increased tolerance of water stress and adverse environmental conditions (e.g. heavy metal pollutants)

- Increased efficacy of N-fixation by *Rhizobium* and other nitrogen fixing bacteria
- Increased natural succession
- Increased plant biodiversity in restored ecosystems
- Increased stability of soils

Microbes, Mines Restoration and Natural Regeneration

Soil acts as a critical controlling component in the development of any ecosystem. Mine spoils are not suitable for both plant and microbial growth because of low organic matter content, unfavorable pH, drought arising from coarse texture or oxygen deficiency due to compaction. The other factors for revegetation of mine spoil may be salinity, alkalinity, poor water holding capacity, inadequate supply of plant nutrients and accelerated rate of erosion. The soils of disturbed sites are frequently low in available nutrients and lack the nitrogen-fixing bacteria and mycorrhizal fungi usually associated with root rhizospheres. As such, land restoration in semi-arid areas faces a number of constrains related to soil degradation and water shortage. As mycorrhizae may enhance the ability of the plant to scope with water stress situations associated to nutrient deficiency and drought. The use of AMF could reduce the amount of fertilizer needed for the establishment of vegetation and could also increase the rate at which the desired vegetation becomes established by stimulating the development of beneficial microorganisms in the rhizosphere. Degraded soils are common targets of revegetation efforts in the tropics, but they often exhibit low densities of AMF fungi . This may limit the degree of mycorrhizal colonization in transplanted seedlings and consequently hamper their seedling establishment and growth in those areas. Soil inoculation with consortium of AMF and PGPRs has significantly enhanced plant growth and biomass production in limestone mine spoils. Inoculation of native and well adapted microbial flora may prove a proficient tool for restoration of heavily degraded limestone mine spoils. Native benefifical microbial flora like arbuscular mycorrhizal fungi along with Phosphorus solubilising bacteria(PSB) and nitrogen fixing bacteria were isolated, multiplied and re-inoculated in different important plant species viz *Pongamia pinnata, Jatropha curcas, Withania somnifera* and *Ailanthus excelsa*. All the inoculated plants exhibited enhanced growth and development as compared to uninoculated ones. Moreover, inoculation with beneficial plant growth promoting rhizobacteria (PGPRs) changed the soil characteristics and also allowed increased invasion and natural succession on reclaimed spoil as compared to unreclaimed sites (Singh and Jamaluddin,2009;Dutta and Agrawal,2002;Singh,2004).

Numerous studies have demonstrated that land restoration benefits from microbial inoculation in plantations on mines spoil. Plantation allows jump start succession. The catalytic effects of plantations are due to changes in under story microclimatic conditions (increased soil moisture, reduced temperature etc.), increased vegetational structure complexity, development of litter and humus layers and the soil physical and chemical environment and accelerating development of diversity on degraded sites. Plantations have an important role in protecting the soil surface from erosion and altering the accumulation of fine particles. They can reverse degradation process by stabilizing soil through development of extensive root systems. Plantation of suitable species speed up succession that fulfills revegetation goal. Besides controlling leaching of nutrients through soil erosion increases plant diversity. Earlier studies indicated that well adapted plant species could be recommended to establish self-sustaining cover, which require little maintenance activities. In restoration, emphasis is given first to build soil organic matter, nutrients and vegetation cover to accelerate natural recovery process. Plantation can be used as a tool for mine spoil restoration as well as carbon sequestration. Once plantation is established, plants increase soil organic matter, lower soil bulk density, moderate soil pH and bring mineral nutrients to the surface and accumulate them in available form. The plants accumulate these nutrients and re-deposit them on the soil surface in organic matter, from which nutrients are much more readily available for microbial breakdown. Once the soil characteristics have been restored, it is not difficult to form the full suit of self sustained plantation on mined lands. Some of the plant species viz. *Jatropha curcas, Pongamia pinnata, Ailanthus excelsa* and *Withania somnifera* have been successfully experimented on limestone mined out areas of Madhya Pradesh in India. These important biodiesel and medicinal plant species ensured their survival and also attracted different other shrubs, grasses and tree species to grow under planted area. Plantation on mined spoil created catalytic effects to restore soil fertility and ameliorate microclimatic conditions.. A number of restoration ecologists have suggested many approaches for restoration of mined land (Soni et al., 1989); however they all recommend afforestation approach which is uniformly accepted. However, the plantation supplemented with beneficial microbial inoculants has greater influence on the natural regeneration process on mined spoil (Singh and Jamaluddin, 2009). Consortium of bacterial inoculants and arbuscular mycorrhizal fungi is supposed to accelerate nitrogen fixation and phosphatase enzyme activity in the rhizosphere of plants which ensures the supply of nitrogen and phosphorus in the soil. More over, plant cover prevents soil from erosion thus increasing the infiltration rate of the water in the soil. All these changes and favorable alteration of soil characteristics causes immigration of surrounding native herb and tree species and results into jump start succession on mined site.

For reclamation of such problematic mine spoils, microbial inoculants like phosphate solubilizing microorganisms, *Azospirillum, Rhizobium* and Vesicular - Arbuscular Mycorrhiza are recommended to use. Fixation of atmospheric nitrogen and mobilization of essential micronutrients make them easily accessible to plants. This approach leads to achieve the fertility, thus improving the water holding capacity of soil and creating topsoil to sustain high quality vegetation cover. The rejuvenation of mine spoil dump and mined land productivity and fertility through amendment of these microbial inoculants would enable restoration of the degraded land and creation of a self sustained ecosystem. Thus, the improvement in the physico-chemical and microbial status of soil through organic blending, inoculation with biofertilizers, plantation of suitable plant species and establishment of bio-geochemical cycle in the mine spoils are, therefore, essential to achieve the objectives of restoration of land fertility, productivity and biological rejuvenation of limestone mined spoils.

References

Agnihotri,U.P.1970. Solubilization of insoluble phosphates by some soil fungi isolated from nursery seedbeds.*Canadian J.Microbiology,* 16:877-880.

Ahmed, N. and Jha. K.K. 1968. Solubilization of rock phosphate by microorganisms isolated from Bihar soils. *J. Gen. Appl. Microbiol.,* 14:89-95.

Ames, R.N., Reic, C.P.P., Proter, L.K. and Cambardella, C. 1983. Hyphal uptake and transport of nitrogen from two N-labeled Sources by Glomus mosseae a vesicular arbuscular mycorrhizal fungus. *New*

Phytologist, 95: 381-396.

Antibus, R.K. and Dighton, J. 1993. Acid phosphatase activities and oxygen uptake in mycorrhizas of selected deciduous forest trees, 65: Proceedings of the 9th North American Conference on Mycorrhizae, 8-12 August, 1993,University of Guelph, Guelph, Ontario, Canada.

Barea, J.M. 2000. Rhizosphere and Mycorrhizae of field crops, In Biological Resource Management, connecting science and Policy(OECD),Toutant, P., Balazs, E., Galante, E. (eds.), INRA and Springer, Berlin, Heidelberg, New York.

Bowen, G.D. and Rovira, AD. 1999. The rhizosphere and its management to improve plant growth. *Advances in Agronomy*, 66:1-102.

Bradshaw, A.D., Dancer, W.S., Handley, J.F. and Sheldon, J.C. 1975. Biology of land revegetation and reclamation of china-clay wastes, 363-384 : In The ecology of Resource degradation and renewal, Chadwick, M.J. and Goodman, G.T. (eds.), Blackwell Scientific Publication, Oxford, England.

Brundrett M, Beegher N, Dell B, Groove T, Malajczuk N (1996) Working with mycorrhizas in Forestry and Agriculture. ACIAR Monograph 32. 374 + xp. ISBN 186320 1815

Chang, T.T. and Li, C.Y. 1998. Weathering of limestone, marble and calcium phosphate by ectomycorrhizal fungi and associated microorganisms. *Taiwan J. Forestry Sci*., 13(2): 85-90.

Chen BD, Li XL, Tao HQ, Christie P, Wong MH (2003). The role of arbuscular mycorrhiza in zinc uptake by red clover growing in calcareous soil spiked with various quantities of zinc. *Chemosphere*,50(6): 839-846

Cook, C.W., Hyde, R.M. and Sims, P.L. 1974.Guidelines for revegetation and stabilization of surface mined areas in the western states. Colorado State University, Range Science Series, 16: 70 pp.

Cumming Jr, Ning J (2003). Arbuscular mycorrhizal fungi enhance aluminium resistance of broomsedge (*Andrpongon virginicus* L). *J.Exp. Bot.*54(386):1477-1459.

Dancer, W.S., Handley, J.F. and Bradshaw, A.D. 1977. Nitrogen accumulation in kaolin mining wastes in Cornwall. II. Forage Legumes. *Plant and Soil*,48:303-314.

Dodd, J.C., Burton, C.C., Burns, R.G. and Jeffries, P. 1987. Phosphatase activity associated with the roots and the rhizosphere of plants infected with vesicular- arbuscular mycorrhizal fungi. *New Phytologist*, 107(1): 163-172.

Dutta, R.K. and Agrawal, M. (2002).Effects of tree plantations on the soil characteristics and microbial activity of coal mine spoil land. *Tropical ecology*, 43(2):315-324.

Gaur, A.C. and Gaind, S.1983. Microbial solubilization of phosphates with particular reference to iron and aluminium phosphate. *Sci. Cult*.,49:110-112.

Gaur,A.C.1970.Role of phosphate solubilizing microorganisms and organic matter in soil productivity,259-268, National symposium on Soil productivity, National Academy of Sciences.

Gaur,A.C.1990. Phosphate solubilizing bacteria as biofertilizer,160-176:In Phosphate solubilizing microorganisms as biofertilizers. Omega Scientific Publishers, New Delhi.

Gonzalez-Chavez, M.C., Carrilo-Gonzalez, R., Wright, SF. and Nichols, K. 2004. The role of Glomalian, a protein produced by arbuscular mycorrhizal fungi, in sequestering potentially toxic elements.

Environ.Pollution,130:317-323.

Gryndler, M.2000. Interactions of arbuscular mycorrhizal fungi with other soil organisms,239-262: In Arbuscular mycorrhizas: Physiology and function, Kapulnik, Y. and Douds Jr, D.D. (eds.), Dordrecht Kluwer academic publishers, The Netherlands.

Hinsinger, P. and Gilkes, R.J. 1995. Root-induced dissolution of phosphate rock in the rhizosphere of lupins grown in alkaline soil. *Australian J. Soil Res.* 33: 477-489.

Jamal A, Ayub N, Usman M, Khan AG (2002). Arbuscular mycorrhizal fungi enhance zinc and nickel uptake from contaminated soil by soybean and lentil. *International Journal of Phytoremediation*, 4(3):203-221.

Joner, E.J. and Johansen, A. 2000. Phosphatase activity of external hyphae of two arbuscular mycorrhizal fungi. *Mycological Research*, 104:81-86.

Kennedy,Z.J. and Rangarajan ,M. 2001.Biomass production, root colonization and phosphatase activity by six mycorrhizal fungi in papaya. Indian phytopathology, 54 (1):72-77.

Krishna, K.R. and Bagyaraj, D.J. 1985. Phosphatases in the rhizospheres of mycorrhizal and non-mycorrhizal groundnut. Journal of Soil Biology and Ecology 5(2): 81-85.

Leyval, C.,Laheurte, F., Belgy, G. and Berthelin, J. 1990. Weathering of micas in the rhizospheres of maize, pine and beech seedlings influenced by mycorrhizal and bacterial inoculation. Symbiosis, 9:105-109.

Liao JP, Lin XG, Cao ZH, Shi YQ, Wong MH (2003). Interactions between arbuscular mycorrhizae and heavy metals under sand culture experiment. Chemosphere 50 (6) :847-853.

Marin M, Ybarra M, Fe A, Garcia-Ferriz L (2002). Effect of arbuscular mycorrhizal fungi and pesticides on *Cyanara cardunculatus* growth. *Agricultural and Food Science in Finland* 11 (3): 245-251.

Meyer, R.J. and Linderman, R.G.1986.Response of subterranean clover to dual inoculation with vesicular arbuscular mycorrhizal fungi and plant growth promoting rhizobacterium Pseudomonas putida. *Soil Biol.Biochem*.,18 (2):185-190.

Mohandas, S.1990. Enhanced phosphatase activity in mycorrhizal Papaya (*Carica papaya* cv. Coorg honey dew) roots, 55-56: In Current Trends in Mycorrhizal Research, Jalali B.L. and Chand, H. (eds.), Proceedings of the National Conference on Mycorrhiza, Haryana agriculture University, Hisar, Haryana.

O'Connor, P.J., Smith, S.E. and Smith, F. 2002.Arbuscular Mycorrhizas influence plant diversity and community structure in a semi arid herb land. New Phytologist,154 (1):209-218.

Palaniappan,S.P. and Natarajan.1993.Practical aspects of organic mater maintenance in soils.23-41:In Organics in soil health and crop production, Thompson, P.K.(eds.),Tree crops development foundation, Indiaseed.675pp.

Sheshadri, S.,Muthukumarasamy,Lakshminarsimhan, C.and Ignacimuthu, S. 2000.Solubilization of inorganic phosphates by Azospirillum halopraeferans.*Current Science*, 79(5): 565-567.

Rao AV, Tak R (2002). Growth of different tree species and their nutrient uptake in limestone mine spoil as influenced by arbuscular mycorrhizal (AM)-fungi in Indian arid zone. *J. Arid Environ*. 51(1):113-119.

Rufykiri G, Thiry Y, Wang L, Delvaux B, Declerck S (2002). Uranium uptake and translocation by the arbuscular fungus, *Glomus* *intraradices*, under root-organ culture conditions. New Phytol.156(2): 275-281.

Singh,A.(2004).Herbaceous biomass yield on an age series of naturally revegetated mine spoils in a dry tropical environment. *Journal of Indian Institute of Science*.84:53-56.

Singh, Anuj Kumar and Jamaluddin (2008). Phosphatase activity in the rhizosphere of medicinal plants inoculated with Arbuscular Mycorrhizal Fungi. *Mycorrhiza News*, 19(3):11-12.

Singh, Anuj Kumar and Jamaluddin (2009). Effect of bio-inoculants and stone mulch on performance of biodiesel and medicinal plant species on limestone mined spoil. *Mycorrhiza News*, 21(3):31-33

Singh, Anuj Kumar and Jamaluddin(2009).Effect of microbial inoculants on performance of *Pongamia pinnata* in calcareous mined spoils. *Indian Forestry*, March: 1-5.

Singh, Anuj Kumar and Jamaluddin (2010).Synthesis of resistance and enhanced mineral solubilization capacity of Plant Growth Promoting Rhizobacteria (PGPRs) native to calcareous soils of limestone mined spoils. *Indian Forester* (In press).

Soni, P., Vasistha, H.B., Kumar, O. and Bhatt, V. 1989. Successional trends in mined ecosystems. *J. Nat. Cons*., 1:115-122.

Suh, J. S., Lee, S. K., Kim, K.S. and Seong, K. Y. 1995. Solubilization of Insoluble Phosphates by Pseudomonas putida, Penicillium sp. and Aspergillus niger isolated from Korean Soils. JKSSF, 28(3):278-286.

Thiagarajan, T.R. and Ahmad, M.H. 1994. Phosphatase activity and cytokinin content in cowpeas (Vigna unguiculata) inoculated with a vesicular arbuscular mycorrhizal fungus. *Biology and Fertility of Soils*, 17(1):51-56.

Tisserant, B., Gianinazzi-Pearson, V., Gianinazzi, S. and Gollett, A. 1993. Plants histochemical staining of fungal alkaline phosphatase activity for analysis of efficient arbuscular mycorrhizal infections. *Mycological Research*, 972: 245-250.

Vankessel, C., Singleton, P.W. and Hoben, H.J. 1985.Enhanced nitrogen transfer from a soybean to maize by vesicular-arbuscular mycorrhizal fungi. *Plant Physiology*,79: 562-563.

Wani, P.V.,More, B.B. and Patil, P.L. 1979.Physiological studies on the activity of phosphorus solubilizing microorganisms. *Indian J. Microbiology*, 19:23-25.

Watteau, F. and Berthelin, J. 1994. Microbial dissolution of iron and aluminium from soil minerals: efficiency and specificity of hydroxamate siderophores compared to aliphatic acids. *European J. Soil Biol*., 30:1-9.

Werner, D. 1998. Organic signals between plants and micro-organisms, 197-222: In The Rhizosphere : Biochemistry and organic substances at the soil-plant interfaces, Pinton, R.,Varanini, Z. and Nannipieri, P.(eds.), New York, Marcel Dekker.

Whitelaw, M.A. 2000. Growth promotion of plants inoculated with phosphate- solubilizing fungi. *Advances in Agronomy*, 69:99-151.

Whitelaw, M.A., Harden, R.J. and Helyar, K.R. 1999. Phosphate solubilization in culture by the soil fungus Penicillium radicum. *Advances in Agronomy*,31:655-665.

Pedospheric Distribution of Soil Cationic Micronutrients under Various Land Use Systems in Uttarakhand.

C.M. Mathavan and A.K.Raina

Forest Soil and Land Reclamation Division, Forest Research Institute, Dehra Dun-248 006, Uttarakhand, India

Abstract

Soils exhibit great spatial variability across any landscape as a result of morphogenic properties unique to the environment under which they were formed. The Pedosphere variations due to parent material, topography, climate *etc*. lead to spatial variation of micronutrients in the soil. The present study was undertaken to analyze the influence of physiography on availability of DTPA extractable micronutrients (Fe, Zn, Cu and Mn) *vis a vis* soil characteristics in typical five soil profiles of Dehra Dun Dist. Uttarakhand developed under different vegetation. Typical soil profiles representing different land form units viz. Dhanaulti (Deodar forest), Dhanaulti (Pine forest), Bansiwala (Sal forest), Mohand (Mixed forest) and Kempty (Oak forest) were exposed and horizon wise sampling was carried out. The collected samples were processed and analyzed for pH, texture and organic carbon by standard procedures. The DTPA extractable Fe, Zn, Cu and Mn were extracted and subsequently analyzed with the help of atomic absorption spectrophotometer. The soils were near neutral to acidic in reaction with pH ranging from 5.45 to 7.00. The soil organic carbon content prominently decreased from top layer of the profile to down layers in all five profiles. The surface soils of all the profile had lower DTPA- Zn content compared to sub surface layers as high as 13.8 mg kg^{-1} observed under lower profile layer (150-170 cm depth) of sal forest (Bansiwala)

compared to other profiles. DTPA- Cu content in soils varied from 4.72 to 21.18 mg kg^{-1} in profiles developed under various land forms. Available Fe ranged between 7.68 to 26.36 mg kg^{-1}, it was in the order of Pine forest > Sal forest > Oak forest > Deodar forest > Mixed forest. In general DTPA – Fe decreased with increasing soil depth as the soil become coarser Fe content decreased significantly. The available Mn content ranged between 1.08 to 8.16 mg kg^{-1} in the soils irrespective of soil depth and physiography. It is evident from the study that the DTPA extractable micronutrient status of soil varied widely under different land use systems.

Keywords. Pedosphere, DTPA and micronutrients

Introduction

The soil layer or pedosphere is essentially the skin of the terrestrial earth,

functioning as earth geomembrane, regulating the biogeochemical and hydrological cycling of matter and energy with terrestrial surfaces (Huete 2004). The pedosphere is a unique biologically active dynamic layer forming a continuous interface between the lithosphere, atmosphere, hydrosphere and biosphere. Soils exhibit great spatial variability across any landscape as a result of morphogenic properties unique to the environment under which they were formed. The pedospheric variations due to parent material, topography, climate etc. lead to spatial variation of micronutrients in the soils (Sharma *et al*. 2005). Soil formation process influenced by water, temperature, soil erosion and microclimate relations which in turn affects the pedogenic processes producing soils of various nutrient supplying capacities (Verma *et al*. 2005). Micronutrients play an important role in physiological processes of plants which is directly linked with plant growth and stabilization. Profile distribution of micronutrients under different forest systems has not been investigated in the state of Uttarakhand. Keeping in view the close relationship, the present study was undertaken to analyze the influence of physiography on availability of DTPA extractable micronutrients (Fe, Zn, Cu and Mn) *vis a vis* soil characteristics in typical five soil profiles from various forest Divisions of Uttarakhand state.

Materials and Method

The study area is located under various forest divisions of Dehra Dun district,Uttarakhand. Typical soil profiles developed under different vegetation has been selected for the study. Five soil profiles representing different land form units viz. Dhanaulti (Deodar forest), Dhanaulti (Pine forest), Bansiwala (Sal forest), Mohand (Mixed forest) and Kempty (Oak forest) were exposed and horizon wise sampling was carried out. The soil samples were air-dried, ground in a wooden plank and roller, passed through 2mm sieve and analyzed for various chemical characters. Soil pH was measured in 1.2 soil. water suspension using glass electrode. The organic carbon was determined by rapid titration method (Walkley and Black 1934) and particle size analysis by international pipette method (Day 1965). The available fractions of Fe, Zn, Cu and Mn were extracted with DTPA-TEA buffer (0.005 *M* DTPA + 0.01 *M* $CaCl_2$ + 0.1 *M* TEA, pH 7.3) as per the method of Lindsay and Norvell (1978) and the concentration of Fe, Zn, Cu and Mn in the DTPA extracts was determined using atomic absorption spectrophotometer (AAS).

Results and Discussion

The data of some important soil properties are presented in table 1. The profile soils under different vegetation were near neutral to acidic in reaction with pH values ranging from 6.70 to 7.00 Dhanaulti (Deodar forest), 6.10 to 6.40 Dhanaulti (Pine forest), 5.90 to 6.20 Bansiwala (Sal forest), 6.65 to 7.00 Mohand (Mixed forest) and 5.45 to 6.05 Kempty (Oak forest). The organic matter content of the soils was low to high and values varied from 0.10 to 5.17 per cent. The soil organic matter content prominently decreased from top layer of the profile to down layers in all five profiles. This may be due to accumulation of leaf litters and debris enriches the organic carbon / organic matter content of top soil. The soils of the area have developed on almost similar kind of parent material due to this there is no variations in the texture of these soils depending upon topographic positions. The texture of the soils was loam to sandy clay loam in nature, finer and clay content exhibiting increase with depth.

The data pertaining to the DTPA-extractable micronutrients such as Iron (Fe), Zinc (Zn), Copper (Cu) and Manganese (Mn) are presented in table 2.The DTPA-Fe content in the surface horizons of all the pedons ranged between 7.68 to 26.36 mg kg^{-1}.These variations in DTPA-Fe content were due to difference in nutrient removal pattern under different vegetation also might be ascribed to deposition of nutrient enriched pattern by leaf litter fall under various vegetation. In general, available iron content decreased with increasing soil depth, which may be due to lower content of organic carbon in the subsurface soil than the surface soils. Presence of organic matter in the surface layer leads to formation of organic chelating agents which could have transformed insoluble phase of Fe into soluble metallic complexes. These results get support from the findings of Singh *et.al*. (1990). As high as 26.36 mg kg^{-1} of DTPA – Fe recorded under surface layer of (0-10cm) pine forest soil of Dhanaulti forest division. Considering critical limit of 4.5 mg kg^{-1}, proposed by Lindsay and Norvell (1978), all the soil samples are sufficient in available

Fe.The DTPA extractable zinc content (Zn) ranged from 4.82 to 11.86 mg kg^{-1}, irrespective of physiography and depth (Table 2). Physiographically, the content of Zn was found in the order of Bansiwala (Sal forest) > Dhanaulti (Deodar forest) > Kempty Oak forest > Dhanaulti (Pine forest) > Mohand (Mixed forest). The relative high value of available Zn content in soils of Bansiwala (Sal Forest) may be attributed to variable intensity of pedogenic processes and more complexation with organic matter which resulted in chelation of Zn.

Table 1. Chemical Characteristics of Soils.

Depth (cm)	pH	Organic matter (%)	Sand	Silt	Clay	Texture
Dhanaulti (Deodar forest)						
0-15	6.90	3.95	5.1.55	24.10	24.35	Loam
15-30	7.00	2.33	48.80	20.40	30.80	Loam
30-60	6.80	1.15	53.60	25.40	21.00	Loam
60-90	7.00	0.90	48.50	20.65	30.80	Loam
90-120	6.70	0.45	53.50	20.40	26.10	Loam
Dhanaulti (Pine forest)						
0-10	6.40	4.17	59.96	28.80	11.24	Sandy Clay Loam
10-25	6.20	3.68	58.60	20.60	20.80	Sandy Loam
25-60	6.30	2.50	60.50	19.40	20.10	Sandy Clay Loam
60-80	6.20	0.50	60.15	18.60	21.25	Sandy Clay Loam
80-110	6.10	0.10	61.35	20.55	18.10	Sandy Clay Loam
Bansiwala (Sal forest)						
0-20	6.10	5.17	65.50	20.70	13.80	Sandy Loam
20-50	6.20	4.70	63.25	18.70	18.05	Sandy Loam
50-85	6.15	1.00	62.55	17.60	19.85	Sandy Loam
85-150	6.00	0.60	64.00	16.30	19.70	Sandy Loam
150-170	5.90	0.40	69.75	17.70	12.55	Sandy Loam
Mohand (Mixed forest)						
0-10	6.70	1.89	66.50	19.60	13.90	Sandy Loam
10-35	6.65	1.00	65.25	17.70	17.05	Sandy Loam
35-60	6.90	0.80	66.50	15.55	17.95	Sandy Loam
60-90	7.00	0.55	64.00	18.30	17.70	Sandy Loam
90-110	6.80	0.20	67.75	18.70	13.55	Sandy Loam

Kempty (Oak forest)						
0-20	6.05	4.14	61.10	18.00	20.90	Sandy Loam
20-46	5.85	3.90	62.50	14.60	22.90	Sandy Loam
46-76	5.80	2.45	63.10	14.00	22.90	Sandy Loam
76-100	5.75	1.15	63.70	16.40	19.90	Sandy Loam
100-150	5.45	0.50	64.10	15.80	20.10	Sandy Loam

An irregular distribution DTPA-Zn was observed in all profiles, the available Zn content increased with increasing soil depth. These results are contradictory with the findings of Sharma *et.al.* (2002) and this has to be studied further. Critical limits for available Zn identified by Takkar and Mann (1975) are < 0.6, 0.6 to 1.2 and > 1.2 mg kg^{-1} for deficient, medium and high, respectively. Accordingly Zn content of the soils collected under different vegetation was found to be sufficient.

The available copper (Cu) content in profiles developed under different landforms and vegetation ranged from 9.72 to 21.18 mg kg-1 Dhanaulti (Deodar forest), 7.68 to 14.58 mg kg-1 Dhanaulti (Pine forest), 4.72 to 10.52 mg kg-1 Bansiwala (Sal forest), 5.46 to 16.58 mg kg-1 Mohand (Mixed forest) and 5.88 to 14.72 mg kg-1 Kempty (Oak forest).

Table 2. Pedospheric distribution DTPA extractable micronutrient of soils under different land use.

Depth (cm)	Fe(mg kg^{-1})	Zn(mg kg^{-1})	Cu(mg kg^{-1})	Mn(mg kg^{-1})
Dhanaulti (Deodar forest)				
0-15	18.86	7.52	21.18	3.28
15-30	14.00	8.36	18.64	2.66
30-60	12.28	8.98	14.28	1.92
60-90	10.06	9.22	10.56	1.53
90-120	8.66	11.56	9.72	1.18

Dhanaulti (Pine forest)				
0-10	26.36	6.36	14.58	8.16
10-25	22.92	6.52	12.26	3.22
25-60	20.44	6.48	10.18	2.68
60-80	19.38	6.73	9.24	1.92
80-110	14.64	7.06	7.68	1.56
Bansiwala (Sal forest)				
0-20	3.80	10.56	10.52	3.38
20-50	3.34	10.88	8.42	1.64
50-85	2.60	11.06	7.28	1.54
85-150	2.07	11.86	5.24	1.23
150-170	1.98	13.80	4.72	1.08
Mohand (Mixed forest)				
0-10	16.82	5.66	16.58	8.08
10-35	10.48	4.82	14.24	6.58
35-60	9.64	6.76	10.18	5.72
60-90	6.42	7.21	8.24	5.18
90-110	6.18	7.96	5.46	4.86
Kempty (Oak forest)				
0-20	12.18	7.18	14.72	4.76
20-46	10.46	7.52	11.58	3.28
46-76	5.28	7.36	9.08	3.00
76-100	4.19	7.22	7.64	2.58
100-150	4.06	8.06	5.88	1.34

The DTPA extractable Cu content decreased with increasing soil depth in all the five profiles (Table 2). Accumulation Cu in the surface horizons of all the soils may be due to its regular turnover by leaf litters and plant residues. (Sharma *et.al*. 2004). Critical limits of copper identified by Katyal and Sharma (1991) are < 0.2, 0.2 to 2.0 and > 2 mg kg^{-1} for deficient, medium and high status. Accordingly profile soils under different forest systems were found to be high. This might be due to continuous organic matter addition through leaf litter fall and acidic to neutral pH increases the solubility and availability of Cu in soil.

The distribution of DTPA-Mn in the A horizons of different physiographic unit was maximum under Dhanaulti (pine forest) followed by Mohand (mixed forest) and Kempty (oak forest), respectively. Available manganese content decreased towards increase in depth of soil profile. Considering 1.0 mg kg^{-1} as critical limit (Lindsay and Norvell 1978), all the soils are sufficient in available manganese. This might be due to better supply of manganese through parent material, higher organic carbon and acidic pH condition may increase the solubility of manganese in soil.

Conclusions

It is evident from the study that the available micronutrients (Fe, Zn, Cu and Mn) content is relatively sufficient to high in all profile samples. Higher DTPA extractable micronutrients observed under different forest systems due to higher organic matter addition through leaf litter, acidic soil pH and parent material. Except zinc other micronutrient content decreased towards increase in depth, this has to be studied further and need to check total micronutrient status of profile soil which may provide detail information about micronutrient distribution.

As per the soil micronutrient critical limit concept, on an average different forest systems have capacity to maintain sufficient range of micronutrients.

References

Day, P.R. 1965. Particle fractionation and particle size analysis. In *methods of Soil Analysis.* Part I (Black, C.A. *et.al.*) American Society of Agronomy. Madison, Wisconsin, USA pp 545-546.

Huete, A. 2004. Remote sensing of soils and soil processes. *In Remote Sensing for Natural Resources management and Environmental Monitoring. Manual of Remote Sensiing* Volume 4, John Wiley and Sons, Inc., New York.

Katyal, J.C. and Sharma, B.D.1991. DTPA extractable and total Zn, Cu, Mn and Fe in Indian soils and their association with some soil properties. *Geoderma* 49, 165-179

Lindsay, W.L. and Norvell, W.A.1978. Development of a DTPA soil test for zinc, iron, manganese, and copper. *Soil Science Society of America Journal* 42.421-428

Sharma, B.D., Aggarwal, V.K., Mukhopadhyay, S.S. and Arora, H. 2002.Micronutrient distribution and their association with soil properties in Entisols of Punjab. *Indian Journal of Agricultural Sciences* 72, 334-340.

Sharma, B.D., Mukhopadhyay, S.S and Arora, H. 2005. Total and DTPA extractable micronutrient in relation to pedogenesis in some Alfisols of Punjab. *Soil Science* 170, 1-14.

Singh, K., Goyal, V.P and Singh, M 1990. Distribution of micronutrient cations in semi-arid alluvial soil profiles. *Journal of the Indian Society of Soil Science* 38, 736.-737.

Takkar, P.N. and Mann, M.S. 1975. Evaluation of analytical methods of estimating available zinc and response of maize to applied zinc in major soil series of Ludhiana, Punajb. *Agrochimica* 20, 420-430.

Verma, V.K., Setia, R.K., Sharma, P.K and Kumar, Ashok 2005. Pedospheric variations in distribution and proposed modification of the chromic acid titration method. *Soil Science* 37, 29-38.

Walkley, A. and Black, I.A. (1934). An examination of the Degtjareff method for determining soil organic matter,

Environmental Application of Forest Tree Species n Phytoremediation and Reclamation

Preeti Pandey Pant & A.K. Tripathi

Ecology and Environment Division,

Forest Research Institute, P.O. New Forest, Dehradun

Abstract

Due to rapid deforestation and depletion of genetic resources coupled with escalating human needs, there is a great need to conserve and improve tree ecosystems in general and their biodiversity in particular. Phytoremediation is an emerging technology for remediating Brownfield's, landfills, and other contaminated sites. Many laboratory and field tests have demonstrated that trees can absorb, transform, or contain a variety of contaminants, including soft and heavy metals and volatile organics through hydraulic control, absorption, and mycorrhizal activity in the root zone. This paper presents a short review about phytoremediation, its principles, mechanisms and possibilities of application. The paper also illustrates results of research conducted at the Forest Research Institute, Dehradun, using six forestry tree species for phytoremediation. Information collected worldwide shows the great potential of using trees, in phytoremediation and their potential contribution for improvement of environment. This paper presents a short review about phytoremediation, its principles, mechanisms and possibilities of application.

Keywords: Bio concentration factor, phytoremediation, trees.

Introduction

Groundwater and soils can became contaminated as a consequence of natural activities; such are geological erosions and salt drainage, by human activities in industry, agriculture, wastewaters, constructions and mining. Contaminants can be both of organic and of inorganic origin (heavy metals, radionuclide's, nitrates, and phosphates, inorganic and organic compounds) (Sparks, 1995). Processes of remediation by mechanically-physically-chemical techniques can be significantly expensive and, according to Schnoor (1997), their cost may range between 100 and 1500 US$ per ton of soil, depending upon the selected technique. Phytoremediation can therefore represent a valid as alternative to these techniques. In the last decade of 20th century, American scientists developed research about plant-affection on sites contaminated by heavy metals, organic and non-organic compounds produced by industry. Researchers showed plant-affection in decrease of their concentrations in soil, surface and groundwater. This developed an idea for planting plants at these sites and the technique is called phytoremediation. Phytoremediation is an emerging technology that uses various plants to degrade, extract, contain or immobilize contaminants from soil and water (EPA, 2000).

Phytoremediation is use of plants and their associated microorganisms for cleaning up the environment (Salt et.al., 1995; Raskin et al., 1997). According to Salt (1995), one of the mechanisms of phytoremediation is phytodegradation, during which plants and their rhizospheric microorganisms degrade organic contaminants. Some authors (Arthur et al., 2005; Epa, 2000) consider degradation of contaminants by rhizosphere microorganisms as a separate mechanism called rhizodegradation. In the northern hemisphere only a limited number of wooden species are suitable for phytoremediation. Poplars (Populus sp.) and Willows (Salix sp.) are the most common tree species used for phytoremediation because they grow rapidly, have many and deep roots, and take up large quantities of water (licht and isebrands, 2005). They were originally bred and grown as a cash crop for use as pulp wood and as renewable energy source, but because of their rapid growth rates and high evapotranspiration rates, they can be considered as ideal candidates for phytoremediation (Chappell, 1997.) Their large root systems with a high proportion of fine roots (diameter smaller than 1mm) have a considerable ability of retaining large amounts of water in the vamoose zone above the groundwater table, thus providing high transpiration rates (Quinn et al.., 2001). Various researches showed significant potential of Poplars for phytoremediation from different contaminants with use of different phytoremediation mechanisms like phytodegradation of voc's (volatile organic compounds) (Newman et al..,1997; Xingmao and Burken, 2004), fertilizers and pesticides (Licht and Schnoor, 1993), rhizodegradation (Federle and Schwab,1989) and phytoextraction (Banuelos et al., 1997; Pilipovic et al., 2005). Researchers up to date defined various different systems of phytoremediation of soils and groundwater depending upon the way plants affects contaminants. According to environmental protection agency of United States of America (epa, 2000), the following mechanisms of phytoremediation should be considered:

A) phytoextraction is the process of up-taking contaminants by plants roots and of trans-locating them to upper parts of plants. With plant harvesting, the contaminants are removed from the contaminated site, which is easier simpler than excavating and removing soil layers. This technology is used for phytoremediation of soils, sediments and sludges. In some cases plants that accumulated metal can be used as a source for food, e.g. plants grown on soils with high concentration of selenium (se) can be used for feeding of animals (Banuelos et al.,1997).

B) Phytostabilization is the process of (1) immobilization of contaminants in soils by adsorption and accumulation in roots of plants or sedimentation root zone, (2) use of plants and plants roots to prevent migration of pollutants by wind and water erosion, drainage and dispersion in soils.

Process of phytostabilization is carried out through the root zone, by microbiological and chemical mechanisms, with change of soil and/or contaminant chemistry. Due to the production of root exudates and CO_2, changes in pH value of soil are very frequent. Phytostabilization can change metal solubility, or affect solubility of organic compounds. Plant affected soils can transfer metals from insoluble to a soluble oxidizing state (Salt et al., 1995). In some cases, phytostabilisation can result in phytolignification, in which case organic matter is incorporated in plant lignin (Cunningham et al., 1995). Soils, sediments and sludges containing contaminants in the root zone can be treated with this mechanism, where influence of roots can be extended with transport of exudates to lower layers. An advantage of this mechanism is in situ treatment, return of vegetation and unnecessary disposal of dangerous materials. Disadvantages of phytostabilization are represented by the fact that contaminants are not removed from site, and by the need for fertilizing in order to prevent drainage.

C) Rhizodegradation is degradation of organic contaminants with microorganisms supported by presence of roots. This mechanism is also called biodegradation. Root exudates contain sugars, aminoacids, organic and fatty acids, sterols, growth hormones, enzymes and other compounds that stimulate development of microorganisms (Schnoor et al., 1995a). Microorganism abundance and activity in the rhizosphere can be increased by presence of exudates, which can result in increased biodegradation. Also, the rhizosphere area can be increased by stimulated biodegradation. Biotransformation processes in the rhizosphere are the of consequence of secretion of enzymes by microorganisms amongst which, according to Coats (1991), there are oxidation, reduction, hydrolysis, conjugation etc.

Interaction of plants and microorganisms also determines a mutual assistance, because microorganisms create better conditions for plants through detoxification of phytotoxic compounds, thus increasing availability of nutrients (Anhalt et al., 2000), and plants supply nutrients for microbic development through root exudates (Chappell, 1997).

D) Phytodegradation (phytotransformation) is degradation of contaminants carried out by plants' metabolism. Main mechanism in this process is uptake and metabolizing of contaminants by plants. Uptake of contaminants depends upon their solubility, hydrophobic and polarity. Moderately hydrophobic compounds are easily up taken, while highly hydrophobic organic contaminants are most often sediment on root surface and rarely translocated, together with highly soluble compounds (Schnoor et al., 1995b). Non polar molecules with mr < 500 will be bounded to root surface, while polar molecules will be uptaken and translocated (Bell, 1992). Advantage of this mechanism is possibility of application in solis without suitable microflora, while disadvantage is possibility of presence of toxic metabolites and intermediary products of metabolism.

E) Phytovolatilization is process of uptake of contaminates by plants and their transpiration into the atmosphere, unchanged or slightly modified, where they are then degraded by solar radiation. In concomitance with this process, rhizo- and phytodegradation can also occur. This method is used for groundwaters, for soils, sediments and sludge with sufficient hydraulic conductivity, in which the amount of transpired contaminants is strongly affected by climatic conditions (temperature, precipitation, insolation and wind). In case of partial degradation, there is a possibility of photodegradation by the sun (Chappell, 1997). Disadvantage is that transpired contaminants such as vinyl-chloride are cancerogenous and is a product of trichlor- ethene. Another disadvantage can be the potential accumulation of contaminants in plants and their fruits.

F) Hydraulic control presents system of phytoremediation in which plants uptake groundwater and control contaminant plume and also called phytohydraulics. This mechanism is used for phytoremediation of surface and groundwaters. Advantage is lower costs compared to pumping systems, but disadvantages reflect in dependence upon season's changes, climate conditions and depth of penetration of roots.

G) Vegetative cover is long life sustainable vegetation system that is used for covering of landfills and dangerous waste disposal sites. Plants can be either planted in the material and do the phytoremediation, or planted in soil cover above the material.

Both these two systems should prevent contact of human and animals with contaminated material and minimize water drainage and circulation through waste in order to prevent migration of contaminants. Advantage is erosion prevention and sustainability of these systems (Dwyer, 1997) and stimulation of microorganism's development.

This mechanism is mixture of water uptake, contaminant uptake, plant metabolism, rhizo- and phytodegradation, phytovolatilization and phytoextraction. Disadvantage of this model is the fact that it can be applied only for easy assimilating and metabolizing components like fertilizers and pesticides that are very water soluble. Amongst the various numbers of contaminants present in the environment, nitrates play a significant role in ground and surface water contamination.

Clean and safe drinking water is reasonably considered to be a basic human right, and water quality will undoubtedly be one of the most important ecopolitical issues in the coming decades (Landis et al., 1992). According to Newbould (1989), if nitrates present in drinking water are converted to nitrites they can cause methemoglobinemia in infants, while their excess in surface waters, together with phosphorus, can cause eutrophication. This contamination is mainly caused by agriculture, and increase of fertilization with mineral fertilizers plays a significant role in increase of nitrate concentrations both in plant tissues and environment (Kastori and Petrović, 2003).

Table 1 Bioconcentration Factor (BCF) and Translocation Factor (TF) values for different species after treatment

Metal mg/l	*E. hybrid*		*S. robusta*		*C. fistula*		*M. indica*		*S. cumini*		*A. procera*	
	BCF	**TF**	**BCF**	**TF**	**BCF**	**TF**	**BCF**	**TF**	**BCF**	**TF**	**BCF**	**TF**
1	1.05	1.25	0.99	0.8	0.11`	0.98	0.99	0.66	0.45	0.26	0.74	1.01
5	0.64	1.54	0.61	0.0	0.44	1.07	0.80	0.39	0.53	0.75	0.99	1.18
10	0.37	0.47	0.89	0.0	0.84	1.59	0.47	0.35	0.60	0.68	1.03	0.96
1	0.16	0.30	*2.09	1.1	1.39	1.73	1.33	0.24	0.99	0.55	1.05	3.48
5	1.76	0.99	*2.28	1.0	*6.55	0.92	1.91	1.34	0.98	1.26	1.96	3.13
10	*5.44	1.06	1.45	2.6	*12.1	0.80	*2.40	1.35	1.29	1.17	0.89	0.95
1	0.92	0.76	0.85	0.9	1.405	0.93	1.03	1.03	1.11	1.21	0.93	0.95
5	*0.95	0.97	0.56	0.9	1.76	1.41	0.20	1.39	0.42	0.96	0.75	0.54
10	3.19	7.34	0.16	0.7	0.37	0.64	0.43	1.03	0.56	1.06	0.60	0.32

* High BCF value > 2(Accumulators) TF< 1 (Excluders)

Also, excess of nitrates in soils enlarges their denitrification and emission of nitrous oxides such as N_2O, which provoques up to 300 times more harmful effect than CO_2 (Schepers et al.., 2005). The results of Bio concentration factor (BCF) of six species are given in Table 1; the experiment was conducted at the Forest Research Institute, Dehradun. Table summarise that the hyperaccumulating plants are those plants which have BCF > 2 and TF >1. The species which have Translocation Factor (TF) < 1 can be termed as metal excluders and the plants with TF ~ 1or > 1can be termed as metal accumulators Mellem, (2005).

Plants have evolved to tolerate the presence of large amounts of metals in their environment by the following three ways:

1. Excluders, whereby transport of metals is restricted and constant metal concentrations are maintained in the stalk over a wide range of soil levels.
2. Inclusion, whereby stalk metal concentrations reflect those in the soil solution in a linear relationship.
3. Accumulators where by metals are accumulated in the roots and upper plant parts at both high and low soil concentrations.

Conclusions

The significant role of trees in phytoremediation is illustrated in this paper both through review of references and through results of research conducted at the Forest research Institute, Dehradun. Plant roots can penetrate through deeper soil layers and remediate wider area. Their higher biomass, compared to herbaceous plants, can extract greater amounts of contaminants, providing great environmental benefit such as carbon sequestration, oxygen production and microclimate improvement. It may be concluded that there is a direct relationship between the concentration of heavy metals and morphological and biochemical responses of plants and chemical characteristics of soil.

Metabolically, physiological, biochemical responses of plants to heavy metal concentration can be viewed as potentially adaptive changes that decline the operation of metabolic regulatory mechanisms which favours the functioning of the plants during or after stress. Tolerant species with high remediation capacities showing least adverse impact would be proposed for the phytoremediation of industrial waste disposal sites or soil affected by those particular heavy metals. Therefore, efforts should be geared towards conservation of the remaining and establishment of more mangrove plant species including other types of vegetation in this ecological zone in such a way that will assist in exploiting this technique of environmental pollution remediation.

References

Anhalt,J.C.,Arthur,E.L., Anderson,T.A., and Coats, J.R.2000. Degradation of atrazine,metolachlor, and pendimethalin in pesticide-contaminated soils: effects of aged residues on soil respiration and plant survival. *J. Environ. Sci. Health*.35: 417–438.

Arthur,E.L.,Rice P.J.,Anderson, T.A., Baladi, S.M., Henderson, K.L.D., Coats, J.R.2005. Phytoremediation-an overwiew. *Critical rewiews in plant science*.24: 109-122.

Banuelos, G.S., Ajwa, H.A., Mackey, B., Wu, L. L., Cook, C., Akohoue, S., Zambrzuski, S. 1997. Evaluation of different plant species used for phytoremediation of high soil selenium. *Journal of environmental quality*, 26:639-646.

Bell, R.M. 1992. Higher plant accumulation of organic pollutants from soils. Risk reduction engineering laboratory, Cincinnati, Ohio. EPA/600/r-92/138

Chappell,J.1997.Phytoremediation of tree using populus. Status report prepared for the US epa technology innovation office under a national network of environmental management studies fellowship compiled June - August 1997.

Coats,J.R.1991.Pesticide degradation mechanisms and environmental activation. In: somasundaram, l., and coats, j. R. (eds.): pesticide transformation products: fate and significance in the environment. Pp. 10–29., American Chemical Society Symposium Series 459, Washington, D.C.

Cunningham, S.D., berti, W.R., Huang, J.W. 1995. Phytoremediation of contaminated soils. *Trends in biotechnology.,* 13: 393-397.

Dwyer, S.F. 1997. Large-scale field study of landfill covers at sandia national laboratories. Conference proceedings landfill capping in the semi-arid west: problems,perspectives, and solutions, May 21-22. Grand tetonnational park, Pp-87-107.

Epa/600/r-99/107. 2000. Introduction to phytoremediation, u.s. environmental protection agency, national risk management research laboratory office of research and development cincinnati, ohio 45268. February 2000

Federle, T.W., and B.S. Schwab. 1989. Mineralization of surfactants by microbiota of aquatic plants. *Appl. Environ. Microbiol*., 55: 2092-2094.

International poplar comission 1979. poplars and willows in wood production and land use. 328 pp. Rome, Italy. Food and Agriculture Organization

Kastori R., Petrovic, N. 2003. Nitrates in vegetables: physiological, ecological and agrotechnical aspects; naucni institut za ratarstvo i povrtarstvo - novi sad; verzal, novi sad, jugoslavija (Serbian with English summary)

Landis, T.D., Campbell, S., Zeusen, F. 1992. Agricultural pollution of surface water and groundwater in forest nurseries; proceedings, intermountain forest nursery organization, USDA Forest Service, gen. Tech. Report 2, August 12-16, 1991, Park City,Utah,USA,1-15.

Licht, L.A., Schnoor, J.L. 1993. Tree buffers protect shallow ground water at contaminated sites. Epa ground water currents, office of solid waste and emergency response. Epa/542/n-93/011.

Licht, L.A., Isebrands, J.G. 2005. Linking phytoremediated pollutant removal to biomass economic opportunities. *Biomass and bioenergy*, 28: 203-218.

Nanda Kumar, P.B.A., Dushenkov, V., Motto, H., Raskin, I. 1995. Phytoextraction: the use of plants to remove heavy metals from soils. *Environmental science and technology,* 29(5): 1232-1238.

Newbould, P. 1989. The Use of nitrogen fertilizer in agriculture. Where do we go practically and ecologically. *Plant and soil,* 115: 297-311

Newman, L.A., Strand, S.E., Domroes, D., Duffy, J. Ekuan, G., Karscig, G., Muiznieks, I. A., Ruszaj, M., Heilman, P., Gordon, M.P. 1997. Abstract: Removal of trichloreth-ylene from a simulated aquifer using poplar. Fourth international in situ and on-site bioremediation symposium, April 28 - May 1,1997, New Orleans, la. 3: 321.

Pilipovic, A. 2005. The role of poplars (populus sp.) In phytoremediation of nitrate contaminated waters; m.sc. Thesis; University of Novi Sad, Faculty of Agriculture, Novi Sad, Serbia

Pilipovic, A., Nikolic, N., Orlovic, S., Petrovic, N., Krstic, B. 2005. Cadmium phytoextraction potential of polar clones (populus spp.). Z. Naturforsch. 60c:247-251.

Pilipovic, A., Nikolic, N., Orlovic, S., Krstic, B., Roncevic, S. and Borisev, M. 2008.The effect of crude oil contaminated soil on growth of different populus sp. And salix sp. Genotypes. , 2nd international scientific conference "remediation in environmental protection – present state and future prospects", Belgrade, Serbia May 14-15, 2008, proceedings book, pp 29-37.

Pilipovic, A., Nikolic, N., Orlovic., S. 2006. Rewiew of researches conducted on heavy metal and nitrate phytoremediation with use of poplars. Proceedings of scientific gathering implementation of remediation in environmental improvement with international participation, belgrade, november 27th2006.(ed. Ljiljana tanasijevic), ISBN 86-80809-32-2, pp 55-65

Quin, J.J., Negri, M.C., Hinchman, R.R., Moos, L.P. and Wozniak 2001. Predicting the effect of deep-rooted hybrid poplars on the groundwater flow system at a large-scale phytoremediation site. *International juornal of phytoremediation,*3(1): 41-60.

Raskin, I., Smith, R.D., Salt, D.E. 1997. Phytoremediation of metals: using plants to remove pollutants from the environment. *Curr. Opin. Biotechnol*., 8: 221-226.

Salt, D.E., Blaylock, M., Kumar, N.P.B.A., Dushenkov, V., Ensley, B.D. 1995.Phytoremediation: a novel strategy for the removal of toxic metals from the environment using plants. *Biotechnology,* 13: 468-474.

Salt, D.E., Smith, R.D., Raskin, I. 1998. Phytoremediation. Annu.rev. Plant physiol.*Plant mol. Biol*., 49: 643-668.

Schepers, J.S.; Francis, D.D.; Shanahan, J.F. 2005. Relay cropping for improved air and water quality. A journal of biosciences, zeitschrift fur naturforschung c, l60 (3/4), 186-190.

Schnoor J.L. 1997. Phytoremediation. Groundwater technology analysis center:technology evaluation report te-98-01.

Schnoor, J. L., Licht, L. A., Mccutcheon, S.C., Wolfe, N. L., Carreira, L.H. 1995a.Phytoremediation of organic and nutrient contaminants. *Environmental science and technology*, 29: 318-323.

Schnoor, J. L., Licht, L. A., Mccutcheon, S. C., Wolfe, N. L., Carreira, L.H. 1995b.Phytoremediation of organic and nutrient contaminants. *Environmental science and technology,* 29: 318-323.

Sparks, D.L. 1995. Environmental soil chemistry. Academic Press, San Diego, CA, USA.Vovk Koze, A.; Vrhovsek, D. 2008. Ecoremediatioan as strategic development approach, 2nd international scientific conference "Remediation in environmental protection – present state and future prospects", Belgrade, Serbia, May 14-15, 2008, proceedings book, pp 109-119.

Xingmao,M.and Burken,J.2004.Modeling of tce diffusion to the atmosphere and distribution in plant stems.*Environmental sci. and technology* 38:4580-4586.

Biotreatment of Textile Wastewater Using Fungi

Nutan Gupta, A.K Tripathi, and N.S.K Harsh*

Forest Ecology and Environment Division

* Forest Pathology Division, Forest Research Institute, Dehradun

Abstract

Wastewater released from textile and dye industry can cause serious environmental effects due to the presence of toxic dyes and dark coloration. Colour from this effluent makes the receiving water bodies unaesthetic affecting its water transparency and gas solubility. Over the past decade, the white rot fungi have been studied for their ability to degrade recalcitrant organo-pollutants such as polycyclic aromatic hydrocarbons, cholorphenols, and polychlorinated biphenyls. Many white rot fungi, actinomycetes and bacteria are used for the development of biological processes for the treatment of textile effluents. Many physical and chemical methods such as adsorption, coagulation, precipitation, chemical oxidation, photodegradation and filtration have been used for colour removal from wastewaters. Unfortunately, due to high operating costs and operational problems such as development of toxic intermediates, lower removal efficiency, and higher specificity for a group of dyes, among others. Apart from this, these methods produce large quantities of sludge, which again causes a problem in its disposal. Biological decolorization being simple to use and low in cost have been the main focus in recent studies, since it results in partial or complete bioconversion of pollutants to stable nontoxic end products. Most of the studies have been focused to the decolorization of a single dye or even to a mixture of dyes. Many white rot fungi e.g. *Phanerachaete chrysosporium*, *Ganoderma* sp., *Trametes trogii*, *Irpex lacteus*, *Dichomitus squalens*, *Pycnoporus* strains etc. have been intensively studied in connection with their ligninolytic enzyme production and their decolorisation ability. The present study shows the potential of various fungi for their capacity to decolorize the textile effluent and their capability for heavy metal removal. Maximum decolorization (92%) was achieved by *Trametes versicolor*, whereas maximum concentration of chromium was removed by *Mucor hiemalis*.

Keywords : wastewater,heavy metal,fungi,textile

Introduction

Textile industry is one of the oldest and largest industries of India. Not going far back in the history of textile industry in India, the East India Company started its business by cotton industry. Now-a-days, India is a major exporter of textile-finished materials. Textile industry in India is a fast growing industry (Hussain *et al.,* 2004) and its wastewater is rated as the most polluting among all industrial sectors considering both volume and composition of effluent (Vanndevivera *et al*., 1998). It is a complex and highly variable mixture of many polluting substances ranging from inorganic compounds and elements to polymers and organic products (Banat *et al*.,1996). It induces persistent color coupled with organic load leading to disruption of the total ecological/symbiotic balance of the receiving water stream.

The increasing trend of requirement and production of dye and dye intermediates is also associated with the anticipated generation of both liquid and solid wastes (CPCB, 1990). The removal of dyes from industrial effluents is becoming a major problem for the textile industry as government legislations are becoming more stringent. The effluents of wastewater in some industries such as dyestuff, textile, leather, etc., contain synthetic dyestuff and toxic chemicals (Choiu,2003). About

10-20% of the dye comes in wastewater during textile processing and enters into different environmental segments (Inbaraj *et al.,* 2002). Dyes have a tendency to sequester metal ions producing micro toxicity to fish and other organisms (Mittal and Venkobachar, 1989). According to Inbaraj *et al.* (2002), some dyes are also reported to cause allergic dermatitis, skin irritation, cancer and mutations in humans.

Moreover, the dyes without an appropriate treatment can persist in the environment for extensive periods of time and are deleterious not only for the photosynthetic processes of the aquatic plants but also for all the living organisms since the degradation of these can lead to carcinogenic substances (Hao *et al.,* 2000; Pinheiro *et al.,* 2004). The release of dyes into the environment constitutes only a small proportion of water pollution, but dyes are visible in small quantities due to their brilliance. Tightening government legislation is forcing textile industries to treat their waste effluent to an increasingly high standard. Currently, removal of dyes from effluents is being done by physico-chemical means. Such methods are often very costly and although the dyes are removed, accumulation of concentrated sludge creates a disposal problem. There is a need to find alternative treatments that are effective in removing dyes from large volumes of effluents and are low in cost, such as biological or combination systems.

Heavy metals beyond permissible limits cause direct toxicity to all living beings. Metallic effluents can have ecological impacts on water bodies leading to increased nutrient load especially if they are essential metals. These metals in effluents may increase fertility of the sediment and water column and lead to eutrophication, which leads to oxygen deficiency, algal bloom and death of aquatic life.

The microorganisms produce both constitutive and inducible enzymes to bioremediate heavy metals and chemical compounds present in wastewater. Strains of bacteria, fungi and algae can be used extensively in bioremediation of textile effluents. The majority of bioremediation studies have been concentrated upon bacterial cultures, largely excluding the fungi, even though they represent a major component of microbial life in the biosphere. For example it has been estimated that 1g of forest litter can contain as much as 1 km of fungal hyphae (Evans and Bucke,1998).

Microorganisms have been shown to take up heavy metals from aqueous solutions (Gadd, 1988). There is a need for innovative treatment technologies for the removal of heavy metal ions from wastewater. Fungi are recognized for their superior aptitudes to produce a large variety of extracellular proteins, organic acids and other metabolites, and for their capacities to adapt to severe environmental constraints. Besides the production of various relevant metabolites, fungi have been attracting a growing interest for the bioremediation of wastewater ingredients such as metals, inorganic nutrients and organic compounds (Akthar and Mohan, 1995). White rot fungi belong primarily to the Basidiomycetes, but may also include some Ascomycetes from the order *Sphaeriales* (Rayner and Boddy, 1988). Basidiomycetes are usually recognised by their sexual fruiting bodies (the mushrooms, toadstools and brackets) but it is the main body of the fungus, the mycelium that is of interest in bioremediation studies. The present study was undertaken to the study the biotreatment potential of various fungi in treating the textile wastewater and heavy metal removal.

Material and Methods

The fungi used were collected from National Type Culture Collection , Forest Pathology Division, Forest Research Institute**.** Samples of the effluents and / the dead organic matter (wood, leaves, etc.) floating/ lying in and around effluent affected localities were brought to the laboratory for examination and isolation of the fungi. The textile effluent was collected from Malwa Cotton Spinning Mills Ltd. (Paonta Sahib).

The following fungal cultures were used in this study: *Bjerkandera adusta, Flavodon flavus, Geotrichum candidum, Merulius tremellosus, Mucor hiemalis, Oxyporus ravidus, Pycnoporus sanguineus, Penicillium* sp.*, Schizophyllum commune, Trametes hirsuta, Trametes versicolor,* and *Trichoderma* sp. Of these, *Geotrichum candium, Mucor hiemalis, Penicillium* sp., *Schizophyllum commune* and *Trichoderma* sp. have been isolated from effluent and surrounding areas.

As the pH of textile effluent was alkaline pH of the effluent was adjusted between 5.5-6.0 using buffers and dilute acids to provide optimum pH for fungal growth. After inoculation of fungus into the flasks containing effluent they were incubated at required optimum temperature. Aliquots of culture supernatant were removed at regular intervals and analyzed for colour removal.

Decolourization was monitored at maximum wavelength and over a range of wavelengths in culture supernatants using a scanning spectrophotometer. Distilled water was taken as blank. For each reading, a few mL liquid was taken from the sample, and then analyzed instrumentally. The experiment was performed in duplicate and mean readings were taken. % decolorization was calculated by using the following equation.

$$\% \text{ Decolourization } \frac{A_0\text{-}A_t}{A_0} \text{x } 100$$

Where A_O = initial absorbance and A_t = absorbance after time t (Olukanni *et al*., 2006) For heavy metals estimation effluent samples after 15 days of inoculation of the selected fungi into the flasks taking one set of flasks as control (no fungus) were digested according to Clesceri *et al*. (1989). The solutions were then aspirated into flame atomic absorption spectrophotometer for the determination of Iron, Zinc, Chromium and Manganese at 248.3nm, 213.9nm, 357.9nm and 279.5nm respectively.

Results and Discussion

The results of adaptivity and decolourisation of the fungi are shown in Table 1.

Table 1. Preliminary screening of fungi in textile effluent and their decolourization.

Fungi	Adaptivity	Decolourisation %
Flavodon flavus[a]	++	17.6
Geotrichum candidum[a]	+++	21.68
Bjerkandera adusta	++	67.61
Merulius tremelosus	++	74.03
Mucor hiemalis	+++	71.66
Oxyporus ravidus	++	83.61
Pycnoporus sanguineus	+	42.09
Penicillium sp[a]	+++	12.30
Schizophyllum commune	+++	86.44
Trametes hirsute	+	79.16
Trametes versicolor	+	92.00
Trichoderma sp.	+++	70.82

+ moderate, ++ good and +++ very good

[a] These fungi were not screened based on decolourizaton for heavy metal removal study

Source: Fictitious data, for illustration purposes only

The isolated fungi showed more adaptivity in the textile effluent but *Geotrichum candidum and Penicillium* sp., gave a poor percent of decolorization hence these two fungi along with *Flavodon flavus* (which was used as a white rot test fungi) were not used for heavy metal removal studies.

Study was also done to test the capability of fungi for heavy metal removal from effluent (Figure 1). It was observed that there was significant concentration of chromium only as compared to control. Maximum reduction in the concentration of chromium was shown by *Mucor hiemalis* followed by all other white rot test fungi. Some heavy metals were essential for the fungal metabolism, whereas others have no known biological role. Both essential and nonessential heavy metals are toxic for fungi, when present in excess.

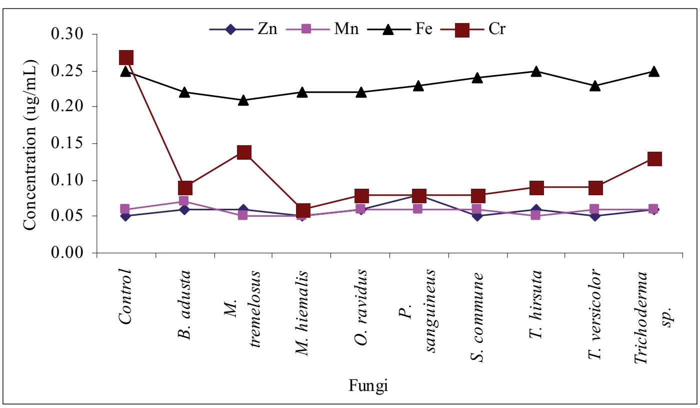


Figure 1. Heavy metal removal by selected fungi

Whereas fungi have metabolic requirements for trace metals, the same metals are often toxic at concentrations only a few times greater than those required (Hughes and Poole, 1991).The metals necessary for fungal growth include copper, iron, manganese, molybdenum, zinc, and nickel. Nonessential metals commonly encountered include chromium, cadmium, lead, mercury and silver (Gadd, 1993). Mullen *et al.* (1992) reported on the biosorption of Cd, Cu, Ag and La by two fungi, *Aspergillus niger* and *Mucor rouxii.* Yetis *et al.* (1998) studied the adsorptive capacity of *Trametes versicolor* and found it in the order of Pb>Ni>Cr>Cd>Cu. Tham *et al.* (1999) revealed that in *Ganoderma lucidum*, toxicity of heavy metals decreased in the order Hg>Cd>Cu>U>Pb>Mn=Zn. The decrease of fungal growth rate is sometimes accompanied with the increase of the lag phase. Lengthening of lag phase was also recorded on media containing Hg in case of *Pycnoporus cinnabarinus* (Mandal *et al.,*1998).

Conclusions

In this study, the biotreatment potential and heavy metal removal from the textile wastewater using fungi were investiagted. White rot fungi show considerable promise for the decolourisation. Maximum decolorization was shown by *Trametes versicolor* followed by *Schizophyllum commune* and *Oxyporus ravidus*. Maximum reduction in the concentration of chromium was shown by *Mucor hiemalis*.

The results of the present study suggest that white rot fungi can be used for decolourising the textile wastewater. Considering the fact that, due to high operating costs and operational problems such as development of toxic intermediates, lower removal efficiency, and higher specificity for a group of dyes, among others, these methods produce large quantities of sludge, which again causes a problem in its disposal. Therefore, bioremediation using fungi can be cost effective for removing heavy metal and colour from the textile wastewater.

Acknowledgements

The authors are thankful to the Director, Forest Research

Institute for providing necessary facilities for carrying out this investigation.

References

Akthar, M.N. and Mohan, P.M. 1995. Bioremediation of toxic metal ions from polluted lake waters and industrial effluents by fungal biosorbent. *Current Science*, 69:1028-1030.

Banat, I. M., Nigam, P., Singh, D. and Marchant, R. 1996. Microbial decolorization of textile dye containing effluents: a review. *Bioresource Technology*, 58:217-227.

Choiu,M.S.and Li, H.Y.2003.Adsorption behaviours of reactive dye in aqueous solution on chemical cross-linked chitosan beads.*Chemosphere*,50(8):095-1105.

CPCB. 1990. Minimal National standards-Dye and Dye Intermediate Industry.Central Pollution Control Board, New Delhi.

Dionmez, G. 2002. Bioaccumulation of the reactive textile dyes by Candida tropicalis growing in molasses medium. *Enzyme and Microbial Technology*, 30:363–366.

Diorio, L., Mercuri, A.A., Nahabedian, D.E. and Forchiassin, F. 2008. Development of a bioreactor system for the decolorization of dyes by *Coriolus versicolor* f. *antarcticus*. *Chemosphere*, 72:150–156.

Evans, C.S. and Bucke, C. 1998. Bioremediation by fungi. *Chemistry and Industry*,2:134-137.

Gadd, G.M. 1988. Accumulation of metal by micro-organisms and algae, 401-430: In Biotechnology:A Complete Treatise.In Rehm,H. (Ed.), *Special Microbial Processes*,vol.4,VCH,Verlagsgesellschaft, Weinheim. 6B.

Gadd, G.M. 1993. Interactions of fungi with toxic metals. *New Phytologist*, 124:25–60.

Hao,O.J.,Kim, H., Chiang and P.C. 2000. Decolorization of wastewater. *Critical Reviews in Environmental Sciences*, 30:449-505.

Hatvani, N, and Mlecs, I. 2002 Effect of the nutrient composition on dye decolorisation and extracellular enzyme production by *Lentinus edodes* on solid medium. *Enzyme Microbiology and Technology*, 30:381–386.

Hughes, M.N. and Poole, R.K. 1991. Metal speciation and microbial growth-the hard (and soft) facts. *J. Gen. Microbiol.* 137:725–734.

Hussain, J. Hussain, I. and Arif, M. 2004. Characterization of textile wastewater.*Journal of Industrial Pollution Control*, 20(1):137-144.

Inbaraj, B., Selvarani, B. and Sulochana, N. 2002. Evaluation of a carbonaceous sorbent prepared from pearl millet husk for its removal of basic dyes. *Journal of Scientific and Industrial Research*, 61:971-978.

Jarosz-Wiilkolazka, A., Kochman'nska-Redst, J., Malarczyk. E., Wardas. W. and Leonowicz, A. 2002. Fungi and their ability to decolourize azo and antraquinonic dyes. *Enzyme Microbiology and Technology*, 30:566–572.

Mandal, T.K., Baldrian, P., Gabriel, J., Nerud, F. and Zadra, F. 1998. Effect of mercury on the growth of wood-rotting basidiomycetes *Pleurotus ostreatus*, *Pycnoporus cinnabarinus* and *Serpula lacrymans*. *Chemosphere*, 36:435–440.

Mittal, A.K. and Venkobachar, C. 1989. Studies on sorption of dyes by sulfonated coal and *Ganoderma lucidum. Indian Journal of Environmental Health*, 31(2):105-111.

Mohorcic, M., Friedrich, J. and Pavko, A. 2004. Decoloration of the diazo dye reactive black 5 by immobilized *Bjerkandera adusta* in a stirred tank bioreactor. *Acta Chimica Slovenica*, 51:619-628.

Moorthi, S.P.,Selvam,S.P.,Sasikalaveni,,Murugesan, K. and Kalaichelvan, P.T.2007. Decolorization of textile dyes and their effluents using white rot fungi.*African Journal of Biotechnology*, 6(4):424-429.

Murali, S., Narayan, A.E., Vidyavate. and Sriniketan, G. 2000. Studies on colour removal by microbial means. *Journal of Industrial Pollution Control*,16(2):211-215.

Mullen, M.D., Wolf, D.C., Beveridge, T.J. and Bailey, G.W. 1992. Sorption of heavy metals by the soil fungi *Aspergillus niger* and *Mucor rouxii*. *Soil Biology and Biochemistry*, 24:129–135.

Olukanni, O.D., Osuntoki, A.A. and Gbenle, G.O. 2006. Textile effluent biodegradation potentials of textile effluent-adapted and non-adapted bacteria. *African Journal of Biotechnology*, 5(20):1980-1984.

Pinheiro, H.M., Touraud, E. and Thomas, O. 2004. Aromatic amines from azo dye reduction: status review with emphasis on direct UV spectrophotometric detection in textile industry wastewaters. *Dyes and Pigments*, 61:121-139.

Rayner, A.D.M. and Boddy, L. 1988. *Fungal decomposition of wood: its biology and ecology*, John Wiley, Chichester. 587pp.

Reddy, A. 1995. The potential for white-rot fungi in the treatment of pollutants.*Current Opinion in Biotechnology*, 6:320–328.

Swamy,J.and Ramsay,J.A.1999.The evaluation of white rot fungi in the decolorization of textile dyes.*Enzyme & Microbial Technology*,24:130–137.

Tham, L.X., Matsuhashi, S. and Kume, T. 1999. Responses of *Ganoderma lucidum* to heavy metals. *Mycoscience*, 40: 209–213.

Vanndevivera, P.C., Bianchi, R. and Verstraete, W. 1998. Treatment and Reuse of Wastewater from the Textile Wet-Processing Industry:Review of Emerging Technologies.*Jr. of Chemical*

Technology and Biotechnology,72:289-302.

Yetis,U.Özcengiz,G.,Dilek,F.B.,Ergen,N.and Dölek,A.1998.Heavy metal biosorption by white-rot fungi. *Water Science Techology*, 38:323–330.

Heavy Metal and Chemical Study of Rivers of Doon Valley

A. Kumar, B.S. * V.D. Joshi* And A.K. Singh**

Biotechnology Research Laboratory, Dept of Zoology/Entomology, H.N.Bahuguna University, SRT Campus Badshahithaul

Tehri-249199 (UK) INDIA

*Dept of Zoology, Govt. PG College Kotdwara Garhwal-246149 (UK)

** Wadia Institute of Himalayan Geology, 33, GMS Road Dehradun-248001 (UK) INDIA

Abstract

Water is a common chemical substance that is essential for the survival of all known forms of life. Industrial uses of metals such as metal plating, tanneries, industrial processes utilizing metal as catalysts, have generated large amount of aqueous effluents that contain high levels of heavy metals. Metal polluted industrial effluents discharged into rivers directly or indirectly. The discharge of waste water in river can change the chemical parameters of water and show an adverse effect on environment. Water samples were collected, from five rivers of Doon Valley: river Ganga, Alaknanda, Mandakini, Bhagirathi and Yamuna, to determine the heavy metals and other parameters like temperature, pH, TDS, BOD, COD and chloride. The toxic metals analyzed by ICP-MS. The temperature ranged between 10 – 27^{o}C, pH ranged between 7.03 – 8.16, DO ranged 6.3 – 9 mg/l, BOD ranged 1.4 – 4.7 mg/l, COD ranged between 2.9 – 34.2 mg/l, Total hardness ranged between 42 – 820 mg/l, TDS ranged between 68 – 220 mg/l and chlorides ranged between 7 – 26 mg/l. . Results showed that maximum pollutants were found in river Ganga at Missarpur Haridwar and river Yamuna at Dakpathar.

Keywords : metal pollution, heavy metals, Doon valley, ICP- MS.

Introduction

Heavy metals are natural components of the Earth's crust. They cannot be degraded or destroyed. To a small extent they enter our bodies via food, drinking water and air. As trace elements, some heavy metals are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning. The term heavy metals refer to any metallic element that has a relatively high density and is toxic or poisonous even at low concentration (Lenntech, 2004). Heavy metal poisoning could result from drinking-water contamination, high ambient air concentrations near emission sources or intake via the food chain. Heavy metals occur as natural constituents of the earth crust, and are persistent environmental contaminants since they cannot be degraded or destroyed. To a small extent, they enter the body system through food, air, and water and bioaccumulate over a period of time (Lenntech, 2004; UNEP/GPA, 2004). Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. Compounds accumulate in living things any time they are taken up and stored faster than they are broken down or excreted. Heavy metals can enter a water supply by industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers and groundwater.

Material and MethodS

Water samples were collected from five rivers of Doon valley. The rivers for this study were: Ganga (G), Alaknanda (A), Mandakini (M), Bhagirathi (B) and Yamuna (Y). Water samples were collected once in every month during April- June 2009 from two sites- middle of the river stretch and discharge point at nine monitoring stations viz.

Laxmanjhula (Rishikesh) and Missarpur (Haridwar) river Ganga, Rudrapryag river Alaknanda and Mandakini, Devprayag river Alaknanda and Bhagirathi, Dakpathar, Syanachati and Yamunotri river Yamuna and samples coded as GR, GH, AR, MR, BD, YY, YS and YD respectively. The water samples were collected in pre-rinsed clean one liter polythene bottle having double stopper facility to its full capacity without entrapping air bubbles inside it. When the water samples from all the monitoring stations were received, systematic analysis of the water samples was undertaken. For analysis of samples, methods followed were of APHA 1998. Temperature, pH and turbidity were measured by thermometer, digital pH meter (NIG 333) and UV-VIS Spectrophotometer. Total hardness, TDS, DO, BOD and COD was measured by titration method. The data were subject to statistic analysis to test the analysis of variance (ANOVA) and correlation among all the parameters using SPSS (SAS 2001, Snedecor and Cochran 1982). ICP-MS (Inductive Coupled Plasma- Mass Spectroscopy) was used for the analysis of trace elements in the samples. The concentration of Zn, Cu, Cd, Cr, As, Ni, Pb and Hg in each of the sample were determined. Blank values were negligible for all elements under consideration, which indicated the rather high purity of the reagents used. Total iron was also determined in all river samples.

Results

pH shows the acidity and basic characters of water. pH recorded for river water is ranged between 7.02 – 8.16 (Table 1). Maximum permissible limit for pH is ranged between 6.5-8.5 according to Indian standards for drinking water (ICMR 1996). The temperature of the water samples lies between 10 – 28^0C . The pH and temperature of all river samples were in desirable/permissible limit.

Heavy metals viz. As, Cd, Cu, Pb, Cr, Ni, Zn, Hg and total iron were analyzed in river water. Arsenic, Chromium and Mercury were not detected in all collected samples (Table 4). Cadmium detected in three samples GR (0.009 mg/l), GH (0.012 mg/l) and YD (0.011 mg/l) respectively. It was more than acceptable limit. The acceptable limit for heavy metals was listed in table 1 and 2. Copper was detected in AR and YD; Lead was detected in GH and YD; Nickel in GH only; Zinc in six samples GR, GH, AR, AD, BD and YD respectively . The total iron was ranged between from 0.09 – 29 mg/l (Table 2).

Table 1. pH and Temperature of River Samples

Location	**River**	**pH**	**Temperature (^{o}C)**
Laxmanjhula Rishikesh	Ganga	7.59	27
Missarpur Haridwar	Ganga	7.53	28
Rudraprayag	Alaknanda	7.35	18.2
Rudraprayag	Mandakini	7.66	18.4
Devprayag	Alaknanda	7.82	22
Devprayag	Bhagirathi	7.02	22
Yamunotri	Yamuna	7.03	10
Syanachati	Yamuna	7.08	12.7
Dakpathar	Yamuna	8.16	20

Table 2. Heavy metal Analysis in Doon Valley (mg/l)

Parameters	***GR***	***GH***	***AR***	***MR***	***AD***	***BD***	***YY***	***YS***	***YD***
Arsenic	ND	ND	ND	ND	ND	ND	ND	ND	ND

Cadmium	0.009	0.012	ND	ND	ND	ND	ND	ND	0.011
Copper	ND	ND	0.52	ND	ND	ND	ND	ND	0.004
Lead	ND	0.08	ND	ND	ND	ND	ND	ND	0.53
Chromium	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel ND	ND	0.01	ND	ND	ND	ND	ND	ND	ND
Zinc 0.25	0.06	0.84	0.5	ND	0.25	0.17	ND	ND	0.021
Mercury ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron (Total)	0.62	0.09	0.33	0.29	29	7.98	0.03	0.134	28

Abbreviations: *GR= Ganga at Rishikesh, GH=Ganga at Haridwar, AR=Alaknanda at Rudraprayag, MR=Mandakini at Rudraprayag, AD=Bhagirathi at Devprayag, BD=Bhagirathi at Devprayag, YY=Yamuna at Yamunotri, YS=Yamuna at Syanachati, YD=Yamuna at Dakpathar*

DO (Dissolved Oxygen) was ranged between 6.3– 9 mg/l. BOD or biochemical oxygen demand represents the amount of oxygen that microbes need to stabilize biologically oxidizable matter. BOD range varies from 1.4 – 4.7 mg/l in river samples (Table 3). Desirable limit for BOD is 4.0 mg/l and permissible limit is 6.0 mg/l according to Indian standards. BOD demand below 3 mg/l or less is required for the best use.

COD or chemical oxygen demand is the amount of oxygen required to oxidize all the organic material in a water sample. Thus, it is an oxygen demand by chemicals in water. The range of COD varies from 2.9 – 34.2 mg/l in river water samples.

Table 3. Chemical Parameters (mg/l)

Location	**River**	**DO**	**BOD**	**COD**	**TH**	**TDS**	**Chlorides**
Laxmanjhula Rishikesh	Ganga	8.7	2.2	11.2	158	89	10

Missarpur Haridwar	Ganga	6.3	4.7	34.2	192	220	26
Rudraprayag	Alaknanda	8.3	2.8	6	118	84	13
Rudraprayag	Mandakini	8	2.4	11.4	820	123	16
Devprayag	Alaknanda	8.3	1.4	5.8	92	96	7
Devprayag	Bhagirathi	9	2.8	4.4	162	98	11
Yamunotri	Yamuna	9	3.5	2.9	42	68	7
Syanachati	Yamuna	9	2.2	3.8	92	83	10
Dakpathar	Yamuna	8.3	4.5	28	194	133	22

According to Indian standards desirable limit is 4.0 mg/l and permissible limit is 6.0 mg/l for drinking water. High chemical oxygen demand indicates the high pollution.

Total hardness of water is due to the presence of bicarbonate, sulphates, chloride, and nitrates of Ca and Mg. Maximum permissible limit for total hardness is 600 mg/l as per Indian standards. Total hardness recorded for river water is ranged between 42 - 820 mg/l (Table3). Hardness has got no adverse effect on human health. Water with hardness above 200 mg/l may cause scale deposition in the water distribution system and more soap consumption.

Total dissolve solid consist of inorganic substances. The main constituents of TDS are calcium, sodium, magnesium, bicarbonates, chlorides, sulphates. In water samples TDS were observed between 68 - 220 mg/l . Desirable limit for TDS in drinking water is 500 mg/l and permissible limit for drinking water is 2000 mg/l as per Indian standards. Beyond desirable limit water becomes unpalatable and may cause gastrointestinal irritation.

Chloride concentration in water samples recorded is ranged between 7 – 26 mg/l (Table 3). Maximum permissible limit of chloride is 1000 mg/l and desirable limit of chloride is 250 mg/l as per Indian standards. In this study highest concentration of Chloride was 26 mg/l in Ganga River at Missarpur Haridwar.

Discussion

Pollution is the main reason because of which the rivers are getting polluted.Increased human activities near the river bodies are major factors contributing to the pollution of these rivers. The presence of heavy metals in these rivers poses a serious threat because most of these heavy metals have serious toxic effects on both humans and on plants. Directly or indirectly the water of these rivers are utilized by human, animals, and plants thus there is a great risk involved of getting contaminated. In rocks, they exist as their ores in different chemical forms, from which they are recovered as minerals. Heavy metal ores include sulphides, such as iron, arsenic, lead, lead-zinc, cobalt, gold silver and nickel sulphides; oxides such as aluminium, manganese, gold, selenium and antimony. Some exist and can be recovered as both sulphide and oxide ores such as iron, copper and cobalt. Ore minerals tend to occur in families whereby metals that exist naturally as sulphides would mostly occur together, likewise for oxides.

Generally, metals are emitted during their mining and processing activities (Lenntech, 2004). Environmental pollution by heavy metals is very prominent in areas of mining and old mine sites and pollution reduces with increasing distance away from mining sites (Peplow, 1999). These metals are leached out and in sloppy areas are carried by acid water downstream or run-off to the sea. Through mining activities, water bodies are most emphatically polluted (Garbarino *et al*., 1995; INECAR, 2000). Through rivers and streams, the metals are transported as either dissolved species in water or as an integral part of suspended sediments, dissolved species in water have the greatest potential of causing the most deleterious effects.

Most of the chemical parameters were found to be above the permissible limit as per prescribed standards. The temperature ranged between 10 – 27^{O}C, pH ranged between 7.03 – 8.16, DO ranged 6.3 – 9 mg/l, BOD ranged 1.4 – 4.7 mg/l, COD ranged between 2.9 – 34.2 mg/l, Total hardness ranged between 42 – 820 mg/l, TDS ranged between 68 – 220 mg/l and chlorides ranged between 7 – 26 mg/l. . Results showed that maximum pollutants were found in river Ganga at Missarpur Haridwar and river Yamuna at Dakpathar.

Acknowledgements

The authors are grateful to Dr. P.P. Khanna, (Scientist F, Wadia Institute of Himalayan Geology) for providing the facility to estimate the total heavy metals and Mrs. K.P. Rathoure for their valuable comments and technical support.

References

American Public Health Association 1995, Standard Methods for the Examination of Water and Sewage, APHA, Washington, 95 APHA 1998, Standard methods for the examination of water and waste water, 20th

Ed. American Public Health Association Washington.

Garbarino JR, Hayes H, Roth D, Antweider R, Brinton TI, Taylor H 1995, Contaminants in the Mississippi River, *U. S.* Geological Survey

Circular Virginia, U.S.A 1133.

ICMR (Indian Council of Medical Research), Guideline for drinking water 1996, INECAR 2000, (Institute of Environmental Conservation and Research).

Lenntech Water Treatment and Air Purification 2004, Water Treatment, Published by Lenntech, Rotterdamseweg, Netherlands (www.excelwater.com/thp/filters/Water-Purification.htm).

Peplow D 1999, Environmental Impacts of Mining in Eastern Washington, Center for Water and Watershed Studies Fact Sheet, University of Washington, Seattle. Snedecor GW, Cochran WG.1982,Statistical Methods.7th ed.he Iowa State University Press.Ames,IA.Statistical Analysis Systems 2001, SAS® User's Guide: Statistics, Version 5 Edition Cary, NC.

UNEP/GPA 2004, United Nations Environmental Protection/Global Program of Action, Why The Marine Environment Needs Protection From Heavy Metals. WHO 1999, Guidelines for Drinking water quality, Geneva, 2nd Ed.; 97-100.

Land Use Land Cover Change

Assessment of Extension of Ganga River Corridor an Indication of Soil Erosion and Biodiversity Loss Using Remote Sensing and GIS Techniques

Parth Sarathi Mahapatra, H.B.Vasistha

Ecology & environment division

Forest Research Institute,Dehradun-248006, India

Abstract

Biodiversity has become one of the central environmental issues in the framework of recent policies and international conventions for the promotion of sustainable development. In context to it the fragile ecosystem of the Himalayas has been an increasing cause of concern to the environmentalists. The steep slopes in the Himalayas, sparse forest cover, as well as high seismicity are the major factors responsible for soil erosion and sedimentation in Upper Ganges thereby encouraging habitat loss of many floral and faunal species. This problem is attributed to various developmental and anthropogenic activities such as construction of hydroelectric dam, mining, road construction, dredging, deforestation, grazing and unplanned agricultural practices in the catchments area. In general, loss of biodiversity diminishes the rate and capacity of ecosystems to produce ecosystem services; therefore conservation of the same is quiet essential.

This study was conducted in the river corridor of Ganga in between Kaudiyala and Rishikesh popularly known as 'Kaudiyala-Tapovan Ecotourism Zone' which is famous for river rafting in Uttarakhand. It is located in the district Tehri Garhwal, Uttarakhand, between 30°04′23″–30°07′34″N latitude and 78°30′13″–78°19′48″E longitude and covers a road distance of 40 km along with a river distance of 36 km from the well known religious place Rishikesh.

The techniques implied for the study includes obtaining and geo-referencing the toposheet of that study area, geo-coding of Landsat image for 1990 and Liss-III image for 2008. The command area / study area was thereafter digitized using PC- based, package, called Arc info 9.2 and ERDAS 9.1 software to generate the thematic maps. The soil erosion in the catchment area though may be accessed through various direct and indirect measures, assessment of sedimentation and beach formation along river corridor over the years can also be applied as one of the indirect measure. Subsequently field observations and survey using questionnaire were collected from more than 100 individuals and 20 camps in the study site to determine the problems relating to loss of bio-diversity.

In the present study comparative analysis of satellite imagery of downstream Ganges shows extension of sand bank/river corridor. This depicts the presence of an intense erosion activity along the upstream of Ganges; Thus posing an immediate threat to the riparian ecosystem along the upstream. Consequently the sedimentation of sand along downstream river corridor promotes bank extension and is presently encouraging the development of River Rafting and Camping Industry. However even this developmental activity is adversely affecting the forest as well as the riparian ecosystem. This is resulting in the loss of bio-diversity which is viewed by the increasing man animal conflicts arising in these regions, various adverse environmental conditions, compaction and loss of vegetation due to trekking trails amid the forest. Thus the whole belt is becoming a vulnerable destination of soil erosion and habitat loss. Therefore the paper concludes with certain recommendations which emanates from the finding of the study to check the loss of biodiversity by applying certain management practices in conjunction with planning and implementation of rules.

Keywords. Biodiversity loss, river recreation, tourism on Ganges, soil erosion, GIS.

Introduction

Forest landscapes are valuable natural resources; which have a typical structure conserving a wide variety of productive, protective, and aesthetic functions (Malanson, 1993; Boulinier et al., 2001; Thoms and Sheldon, 2000; Forman, 1997). However in recent times these ecosystems are being disturbed leading to loss of bio- diversity in many means. Nevertheless, almost all parts of the earth are associated with problems like soil erosion, movement and deposition of sediment in rivers, lakes and estuaries through the geologic ages. But in recent times the situation is aggravating with man's increasing interventions with the environment (Rinos et al.). One such means of intervention is through tourism development. For tourism especially mountains and rivers are the foundation, and the environmental resources (e.g. species habitat for ecotourism, snow cover for skiing, river for rafting, waterfalls, etc.) have a strong influence on the length and quality of tourism and recreation. On top of these factors, the peculiar conditions of mountainous areas make them more vulnerable, such as environmental fragility and tourism seasonality. High-altitude ecosystems are inherently fragile and characterised by low resiliency, and therefore they are particularly susceptible to human interference, such as soil and vegetation trampling, disturbance to native wildlife, and waste dumping (Arrowsmith and Inbakaran, 2002; Buckley et al., 2000). However, tourism has been one of the global economic success stories in the last 40 years. Apart of its bad or good effects, tourism has been increasing its profile as an industry and governments found an appropriate sector to create jobs, international income and to stimulate regional development (Hall, 1991). With the stepping of the industrialisation, agricultural societies have been transformed into urbanised landscapes. Consequences of urbanisation like habitat fragmentation and disturbance effects have been explored by for example (Bolger et al., 1997 and Sauvajot et al. 1998). Thus, biodiversity is gradually affected due to development, but the level of change is varying in different parts of an urbanising landscape. Ecological effects of infrastructure development which include habitat fragmentation and associated barrier effects on the movement of sensitive species have been studied by for instance Forman (2000), and reviewed by Trocme´ et al. (2002). Hence, the decline of habitat is globally recognized as the current main threat to the conservation of biodiversity (EPA, 1999). In general, loss of biodiversity diminishes the rate and capacity of ecosystems to produce ecosystem services (Rajvanshi et al., 2007). Therefore conservation of biological diversity (biodiversity) has recently emerged as one of the major global environmental concerns (Noss and Cooperrider, 1994; George, 1999; Diamantini and Zanon, 2000). Well any sort of tourism development carries a series of negative impacts along with it as such increased cost of living, traffic congestion, pollution, infrastructure deterioration, and an overall stress on local facilities (Hohl and Tisdell, 1995). Hence, tourism that is properly planned, developed and managed, however, can minimize the impact on the environment and even benefit the environment. This is what we call sustainable tourism development (Portfolio Marine Group, Environment Australia, 1997).

Study Area

Study area is situated along the Badrinath National Highway and is popularly known as "Kaudiyala – Tapovan Ecotourism Zone". It is located in the district Tehri Garhwal, Uttarakhand, between 30°04′23″–30°07′34″N latitude and 78°30′13″–78°19′48″E longitude and covers a road distance of 40 km along with a river distance of 36 km from the well known religious place Rishikesh(Figure 1and 2).. Emerald green dense forests with species like Sal (*Shorea robusta*), Kanju (*Holoptelea integrifolia*), Bakli (*Anogeissus latifolia*), Dhauri (*Lagerstroemia parviflora*), various Bamboo species and many others cover both sides of the highway.

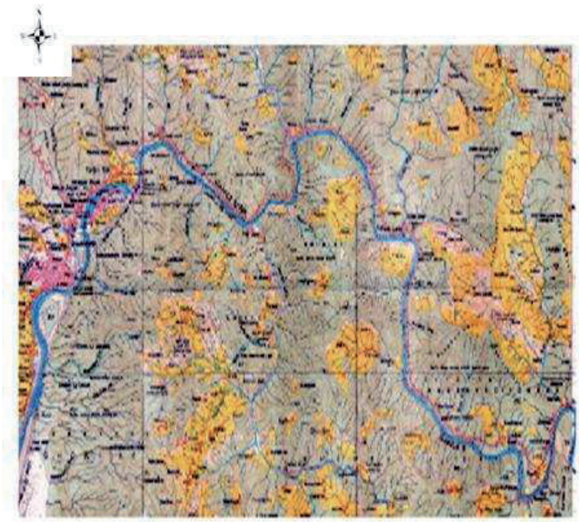


Figure1. Topsheet used for the area

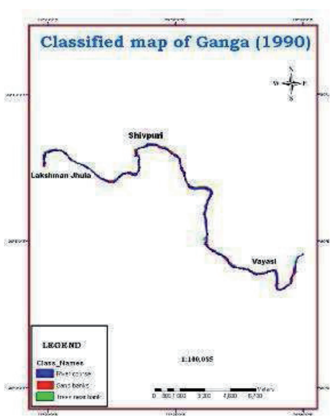


Figure 2. Classified map of Ganga 1990.

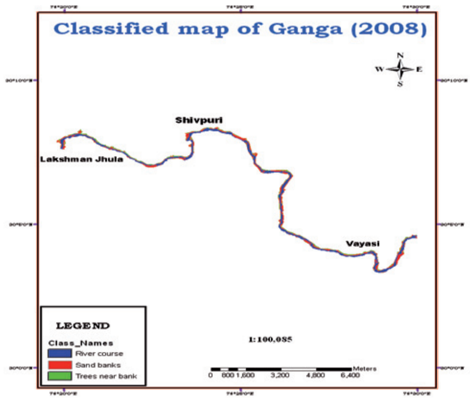


Figure 3. Classified map of Ganga 2008

Tehri Garhwal District is located at the western boundary of Uttarakhand. Located on the external range of the Middle Himalaya Mountains and comprising of Shivaliks.The mountains near and around Tehri are a big decisive factor in the weather and climate of this region. The summer temperature ranges between 9°C - 30°C and winters temperature ranges between 3°C - 15°C. The region has an average annual rainfall (though fluctuating) here remains about 70 cm (Bharatonline.com). In rainy season the climate is very cool and full of greeneries. The summers here are very pleasant with the harsh mountain sun balanced with the just nippy air. The winters are however very harsh at times with severe cold draughts all over the Tehri Garhwal region. However, Tehri Garhwal sometimes has extreme temperatures, mainly due to its changeable altitude of 1550 m to 1950 m.

Methodology

The methodology includes obtaining and geo-referencing the toposheet of that study area, geo-coding of Landsat image for 1990 and Liss-III image for 2008. The command area / study area was thereafter digitized using Arc info 9.2 and ERDAS 9.1 software to generate the thematic maps. Now the field analysis were undertaken to complete this study. It was accomplished by collecting various primary and secondary data from field surveys and government records using assorted means. With the intention of comprehending the discernment of local people about positive and negative impacts of river rafting and camping, we visited some nearby villages along this belt i.e., Byasi, Kaudiyala, Singtali, Timli, Bawani, Brahmapuri, Guller, Kathya, Bawani, Silan etc. and enquired the elderly mass, shopkeepers, children and the youth. Then we even had discussions with the camp owners, managers, workers and labours of the camp to have an unbiased knowledge of the whole state of affairs. The primary survey was conducted using a questionnaire, followed by informal and formal meetings and group discussions with the camp owners, stakeholders and villagers. Various aspects of our questionnaire acted as an indicator for generation of information associated with the camping and rafting industry and their impacts on the society, environment, wildlife and bio-diversity. Thereafter secondary data regarding the number and area of the camping sites, no. of tourists visiting and other miscellaneous information was collected from the Office of the Sub-Divisional Forest Officer, Muni-ki-Reti, as well as the Garhwal Mandal Vikas Nigam office Kaudiyala respectively.

Results

Analysis of Satellite Imagery

- From the Figures 1, 2 and 3 we find that the river water area has decreased by 28.25 Hectares from 1990 to 2008, sand / beach area has increased by 46.375 Hectares and the bank-forest transition zone has depleted by 18.125 Hectares.

- Along with it trekking is an important factor which creates trails amidst forested areas. Thereby promoting loss of biodiversity which is presently at a very small scale but if not checked may create a colossal problem.

River course between Rishikesh to Kaudiyala.	**Area in ha. during 1990**	**Area in ha. during 2008**
Water	289.625	261.375
Sand bank	115.438	161.813
Trees near bank	64.625	46.500

Growth of Camping Per Year

From the graph below we can see how the area for camping has kept on increasing with years. This signifies that the industry is increasing with leaps and bound and hence there impact on the nearby surrounding environment and society is accountable (Figure 4).

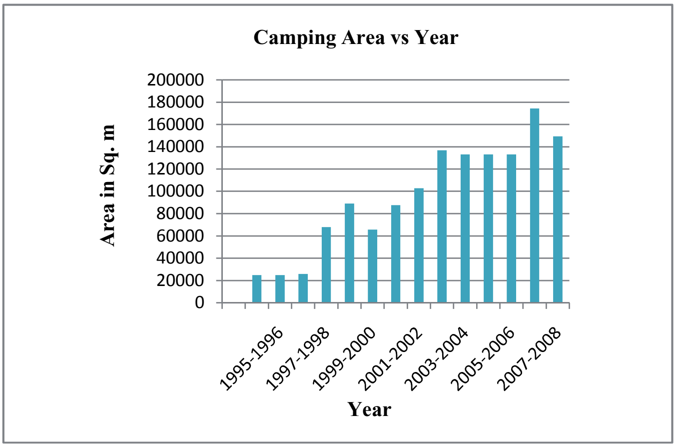


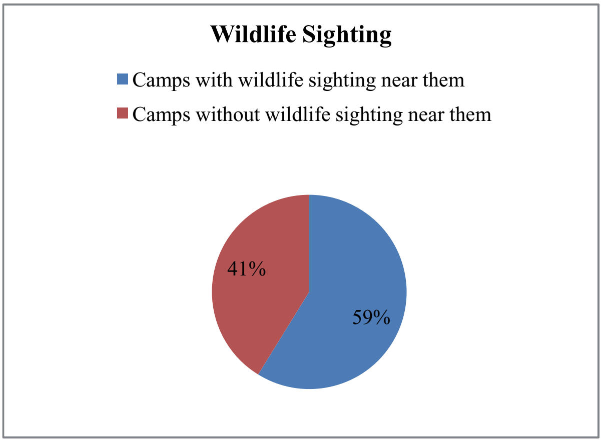
Figure 4.Graphical representation of growth of camping on the Ganges

Impacts on Bio-Diversity

From the study it was found that due to increased tourism activity amidst the forest, trails were created which keep on widening with time resulting in fragmentation, soil erosion and compaction. Some of the biological impacts as visualised include vegetation trampling and degradation (e.g., root exposure), forest thinning (e.g., use of wood for bonfire by campers), wildlife disturbance and also carry a potential threat for introduction of exotic species (Figure 5). Waste dumping in campsite areas or along the trail and even along the river corridors as well as roads may result in surface and groundwater pollution. Additionally, these activities determine a number of indirect impacts, such as increase in traffic, and therefore air and noise pollution, off-road driving, land occupation, soil loss and deforestation due to the construction of campsites, and tourism infrastructures in general.

Impacts on Wildlife

With the advent of white water tourism in Uttarakhand, some of the undisturbed ecosystems in this region were engendered. The wild life in the forest ecosystem was the first to face trouble with human intervention in their lands. As per reviews collected from the local people, camp working staff, Indo Tibetian Boder Police Camps along the river course, it was found that there was a change from diurnal habitat to nocturnal habitat in the wild animals of that region. Now these animals that are forced to move at night find livestock to be an easy prey and even destroy the agricultural lands of the villagers. Hence, in return the villagers set traps to kill the wild animals. Along with it close interaction and not exactly conflicts have been undertaken by 59% of the people in the camps surveyed (Mahapatra *et al.* 2010). However, incursions into the camps were not heard but they are not even far off distances which may thereafter pose a threat to human life.



Thus from these instances we can say that this area is approaching a considerable threat of man wildlife conflicts for which if measures not taken at an early stage, will be hard to repent.

Environmental Impacts

During our survey of the camp conditions, many discrepancies were detected with respect to the environmental conditions.

Aspects	Positive Impacts	Negative Impacts
Solid Waste	Sense of aesthetics is developed near the camp	Pile of garbage from tourist was found dumped on road, amidst the forest and in the river.
Water pollution	Not visible	Disposal of waste and open/submergence zone defecation into the river.
Trekking trails	Not visible	Waste dumping because of poor planning and no dustbins.

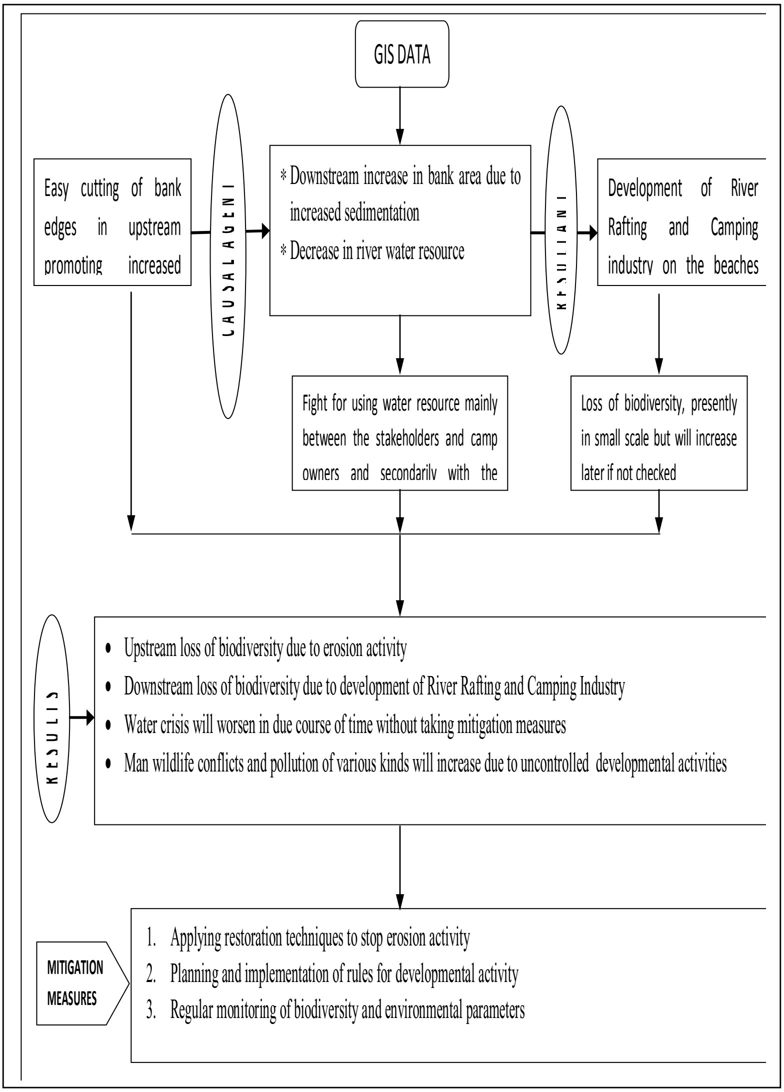


Figure 5. Model demonstrating causal agents of biodiversity loss in mountainous Regions of 'kaudiyala tapovan ecotourism zone',Its effects andmitigative measures.

Discussion and Conclusions

The study shows that in the upstream of Ganges, there is a continuous erosion activity which is resulting in enormous amount of sand deposition along the downstream every year. As a result of which the sand area is increasing which is indirectly leading for the development of the River Rafting and Camping industry in the Rishikesh-Kaudiyala Eco-tourism zone along the downstream of the Ganges. As a consequence, mountain and river tourism has become an important source of income, providing a significant contribution to the economic development of the region. However, tourism development is posing a threat to the conservation of this serene environment, due to the fragility of its ecosystems, as well as the lack of adequate infrastructures, policies and planning tools.

Therefore from the study we could find out that an intense erosion activity is constantly occurring in the upstream of Ganges which is as such posing a potential threat to the mountain as well as riparian ecosystem of that area. However, the subsequent direct and indirect impacts emanating from this activity include enormous deposition of sand in the downstream of the river. Consequently, laying a foundation for the development of "River Rafting and Camping Industry" and on the other hand reducing the river water resource and putting an adverse impact on the bio-diversity as well as the wildlife (Figure 5). Hence, a final consideration is that impacts of bio-diversity loss and tourism as a whole are difficult to estimate because they comprise a complex network of direct and indirect effects. In addition to it very little knowledge is present about biodiversity works being carried out in mountainous regions, as a result of which this work can provide a baseline for further studies.

References

Arrowsmith, C, and Inbakaran R. 2002. Estimating environmental resiliency for the Grampians National Park, Victoria, Australia: a quantitative approach. *Tour Manag*. 23:295–309.

Bolger, D.T., Scott, T.A. and Rotenberry, J.T. 1997. Breeding bird abundance in an urbanizing landscape in coastal Southern California. *Conservation Biology;* 11: 406–421.

Boulinier, T., Nichols, J.D., Hines, J.E., *et al.* 2001. Forest fragmentation and bird community dynamics: inference at regional scale. *Ecol*. 82 (4):159-169.

Buckley, R.C., Pickering, C.M., and Warnken, J., 2000. Environmental management for Alpine tourism and resorts in Australia. In: Godde P.M., Price M.F., Zimmermann F.M., editors. Tourism and development in mountain regions. Wallingford: CABI Publishing. pp. 27–45.

Diamantini, C. and Zanon, B. 2000. Planning the urban sustainable development. The case of the plan for the province of Trento, Italy. *Environmental Impact Assessment Review*; 20:299–310.

Dover, R.W., Bunce, R.G.H. (Eds.), 1998. Key Concepts in Landscape Ecology. *Proceedings of the 1998 European Congress of the International Association for Landscape Ecology*. pp. 239–244.

EPA (Environmental Protection Agency), 1999. Considering ecological processes in environmental impact assessments. U.S. Environmental Protection Agency—Office of Federal Activities.

Forman, R.T.T., 1997. Land Mosaics: The Ecology of Landscapes and Regions, Cambridge University Press, Cambridge. 213-156.

Forman, R.T.T., 2000. Estimate of the area affected ecologically by the road system in the United States. Conservation Biology 14, 31–35.

George, C., 1999. Testing for sustainable development through environmental assessment. Environmental Impact Assessment Review; 19:175–200.

Hall, C.M., 1991. *Introduction to Tourism in Australia: impacts, planning and development*. Melbourne: Longman Cheshire.

Hohl, A.E., and Tisdell, C.A., 1995. Peripheral tourism development and management. *Annals of Tourism Research*, 22: 517–533.

http://www.bharatonline.com/uttarakhand/tehri-garhwal/weather.html (Assessed on 15th May, 2010)

Mahapatra, P.S., Vasistha, H.B. and Sharma, D.K., 2010. Man Wildlife Conflict: A Case Study of Kaudiyala – Tapovan Ecotourism Zone, Uttarakhand. Proceedings of 5th Uttarakhand State Science and Technology Congress. pp. 186

Malanson, G.P., 1993. Riparian Landscapes. Cambridge University Press. Cambridge.

Noss, R.F., Cooperrider, A.Y., 1994. Saving nature's legacy. Protecting and restoring biodiversity. Washington, DC: Island Press.

Portfolio Marine Group, Environment Australia, 1997. Coastal Tourism - A Manual for Sustainable Development, Based on a draft paper prepared by Southern Cross University, ISBN 0642271291.

Rajvanshi, A., Mathur, Vinod B., Iftikhar, Usman A., 2007. Best practice guidance for biodiversity-inclusive impact assessment: A manual for practitioners and reviewers in South Asia. CBBIA-IAIA Guidance Series. Capacity Building in Biodiversity and Impact Assessment (CBBIA) Project, International Association for Impact Assessment (IAIA), North Dakota, U.S.A.

Rinos. Mohamed. M. H., Aggarwal. S. P., Silva De Ranjith Premalal., 1997. Application of Remote Sensing and GIS on soil erosion assessment at Bata River Basin, India. ACRS proceedings.

Sauvajot, R.M., Buechner, M., Kamradt, D.A., Shonewald, C.M., 1998. Patterns of human disturbance and response by small mammals and birds in chaparral near urban development. *Urban Ecosystems.* 2: 279–297.

Thoms, M.C. and Sheldon, F., 2000. Lowland rivers: an Australian introduction. *Regul River*. 16:375-383.

Trocme´, M., Cahill, S., de Vries, J.G., Farrall, H., Folkeson, L., Fry, G., Hicks, C., Peymen, J. (Eds.), 2002. Habitat fragmentation due to transportation infrastructure. The European Review. European Communities, Luxembourg. pp. 253.

Biodiversity Characterization in Marine National Park, Jamnagar, Gujarat using Remote Sensing and Geographic Information System

Ganesh Datt Bhatt

Global Open University, Nagaland

Abstract

India has a vast extent of coast line of about 8000 km spanning 13 maritime mainland states and Union Territories, which are home to a diversity of coastal and marine ecosystems, comprising nationally and globally significant biodiversity (Venkataraman and Wafar, 2005). To study the phytodiversity is very essential for conservation in a limited time and less manpower. A comprehensive methodology involving remote sensing field investigation and the Geographical Information System (GIS) has been adopted for the present study. Satellite data of MSS 4-5 is used for the present study. Supervised classification, unsupervised classification and onscreen visual interpation have been done. For supervised classification the field survey was done to become acquainted with the general patterns of vegetation of the area. Major vegetation types and a few prime localities of characteristics types were recorded. In unsupervised classification (using ISODATA) has been done with 15 classes at a 98% confidence threshold. On screen visual interpretation (1.50,000 scale) in a polygon mode using arc view has been performed with the fundamental image characteristics i.e. tone, texture, pattern, size, shape; shadow coupled with site / location and associated features.

Looking at the data generated from the three classification attempts side by side, it can easily be seen that differences in land use classes are present. Furthermore, the data generated with the unsupervised technique contains additional land use classes. By simply visually analyzing the images created using the different

classification techniques, the method of onscreen visual interpation appears to be the better choice in this example. Human error in giving iterations, lack of knowledge of study area, and other factors all contribute to inaccurate results in the supervised classification and unsupervised method. The main task of this study was to identify the proximate drivers of biodiversity loss through vegetation/forest distribution status. In the district like MNP, Jamnagar the industrial activity and infrastructural development have been identified as major driver of biodiversity loss. The secondary factors which concern the conservationists is unsustainable high rates of human population growth, natural resource consumption; inadequate knowledge and insufficient use of information and economic system and policies that fail to value the environment and its resource. With the specific needs of the district of MNP, Jamnagar there is need to build trust between development activity *viz.,* mining, dam construction, industrialization, land use conversion and conservation interests.

Keywords. Remote sensing, Biodiversity, Geographical Information System.

Introduction

India has a vast extent of coast line of about 8000 km spanning 13 maritime mainland states and Union Territories, which are home to a diversity of coastal and marine ecosystems, comprising nationally and globally significant biodiversity (Venkataraman and Wafar, 2005). It also supports almost 30% of its human population being dependent on the rich exploitable coastal and marine resources. The coastline of Bay of Bengal and Arabian Sea continues to be a rich fishing ground in the south Asian region and India is one of the world's largest marine product nations.

Marine ecosystems such as estuaries, coral reefs, marshes, lagoon, sandy and rocky beaches, mangrove forests and sea grass beds are all known for their high biological productivity, which provide a wide range of habitat for many aquatic flora and fauna. It also provides important food resources and critically major services to human beings. Therefore, sustainability of these fragile ecosystems should be our primary concern. So far, we have largely looked the marine biodiversity as a source of commercial products instead of appreciating their ecological values and services which has resulted in over exploitation and several species are now in the verge of extinction. Moreover, human activities such as destructive fishing, shipping, coastal developments, discharge of untreated effluent from industries have caused considerable damage and pose a severe threat to the coastal and marine biodiversity. In addition to that, global warming due to climate change also poses major challenges to marine biodiversity.

The Gulf of Kutch is an extension of Arabian Sea towards east and covers southern part of Kutch district and northern portion of Jamnagar district. Some portion of Rajkot district is located on the closed end of the Gulf. Total area of Gulf of Kutch is 7350 km^2. The coral reef is found on the southern part of the Gulf in Jamnagar district and it is one of the 4 major important reefs of the country. It is the northern most reef of the country located just below the Tropic of Cancer. The reef found in the Gulf of Kutch seems to be originated in the Cambrian Period thus it is a very ancient reef and many fossils of molluscs are found on the shore. The water current is very fast and studies done by NIO suggests that silt from river Indus which meets the sea near Karachi flows into the Gulf and it affects the coral reef. Ecologically the reef in the Gulf of

Kutch has great significance as it is having different types of ecosystems like Coral reef ecosystem; Sea grass and Sea weed ecosystem, Mangrove ecosystem, Coastal sandy ecosystem, Barren mudflat, Rocky shore etc. Because of the diversity in ecosystem the biological diversity in this area is very high. Therefore, in one of the seminars at Sasan Gir in 1980 it was decided to protect and develop this area for preservation of Marine life.Most importantly, coordination among all organizations/institutions who works for conservation of coastal and marine biodiversity and social welfare of coastal communities is required. Moreover, documentation and data base of research information on marine biodiversity is also urgently required. It is also important to develop a specialized higher educational field based programme in marine ecosystem ecology with an emphasis on rigorous scientific research, hypothesis testing, taxonomy and conservation. Human resource development to manage the Marine Protected Areas of India is also required immediately.

Methodology

A comprehensive methodology involving remote sensing field investigation and the Geographical Information System (GIS) has been adopted or the present study (Figure 1). The raw digital data was enhanced using contrast stretching techniques to facilitate better differentiation among vegetation types. The field survey was done to become acquainted with the general patterns of vegetation of the area. Major vegetation types and a few prime localities of characteristics types were recorded. The variation and tonal patterns were observed on existing map/images. The spectral pattern observed on satellite image has been compared with the ground situation in the field with respect to each forest types under different phonological appearance.

The first attempt was made to classify the various land uses in erdas GIS and image processing software using supervised classification techniques. In supervised classification, spectral signatures are developed from specified locations in the image.

These specified locations are given the generic name 'training sites' and are defined by the user generally a vector layer is digitized over the raster scene. The vector layer consists of various polygons overlaying different land use types. The image shows the raster image seen earlier with the addition of several training sites outlined on top of it. The training sites will help erdas develop spectral signatures for the outlined areas. The land use categories of interest in this example are water, agriculture, grassland, and forest. Multiple polygons are created for each land use category to help ensure that erdas has sufficient information to create the spectral signatures. Once the training sites are developed erdas can use this information, along with the various images of different bandwidths, to create spectral signatures from the specified areas. These signatures will then be used to classify all pixels in the scene. There are two basic groups of classifiers that are used in erdas supervised classification module. They are called hard classifiers and soft classifiers. Hard classifiers assign each pixel in the scene a discrete value or category based on the training sites in the vector layer. For example, if four different land use types were identified with the training sites, each pixel in the scene will take on the value of one of those four land uses. If soft classifiers are used, probabilities may be listed as to which category each pixel may or may not belong to. In other words, definitive decisions about land categories are not made. The hard classifier called MAXLIKE was used to re-classify each pixel. MAXLIKE assigns each pixel in the image to the class that it has the maximum likelihood of belonging to. Other hard classifiers may use statistics such as pixel location and proximity of other features to help make classification decisions. The AREA module in erdas was then used to view the statistics concerning each land cover group. This information will later be compared to data generated from the unsupervised classification example. Zooming in on the dam and outlet area of Perry Reservoir, it is evident that the classification technique used has some error in classifying. This image identifies areas on the dam of the reservoir as agricultural areas. This area is most likely made up of riprap or other non-vegetative materials and fall in the same category as the bare soil. This is a common problem and is most likely due to the similar reflectance properties held by non-vegetative surfaces. The spectral reflectance properties of these surfaces, such as rock and concrete, were classified in the same category as bare soil (Figure 2).

Unsupervised classification is a method in which the computer searches for natural groupings of similar pixels called clusters (Jensen 231). Fewer clusters exist; more pixels within each cluster exist and will vary in terms of spectral signature, and vice versa. In ERDAS unsupervised classification is performed using an algorithm called the Iterative Self-Organizing Data Analysis Technique (ISODATA). Using this algorithm, the analyst input the number of clusters desired and a confidence threshold. The computer will then build clusters iteratively, meaning that with each new iteration the clusters become more and more refined. The iterations stop when the confidence level (or a maximum number of iterations specified by the user) is reached (Jensen 238). For example, if the user wants 30 clusters at 95% confidence, the computer will filter actively build the clusters until it is 95% confident has attained the best distribution of pixels into 30 clusters. After the clusters are built, the analyst must select the land cover classes (water, forest, etc.), then assign each cluster to the appropriate class. For this step, it is important user has a good knowledge of the region being mapped, since he or she must decide what land cover the pixels of each cluster represent. Once all clusters have been assigned to a class, the image of clusters can be recoded into a GIS layer which displays each land cover class with a different color. Once the spectral enhancements were completed on my image, I performed an unsupervised classification (using ISODATA) with 15 classes respectively and a 98% confidence threshold. I set the maximum number of iterations at 15. The final result was an image with 15 groups of pixels each represented by a different color. I was able to highlight each class one at a time and then determine which of the classes it belonged to by interpreting the original multispectral image. Then I changed the cluster color to an appropriate one, for example, I made the water cluster blue (Figure 3).

In on screen visual interpretation method identification of objects and classification, visually from the hard copy photographic prints or on screen digitization using digital image is known as visual interpretation. There are certain fundamental photo/image characteristics, which help in interpretation of earth features. They are tone, texture, pattern, size, shape; shadow coupled with site / location and associated features. Most of these image characteristics depend on the spectral, spatial, temporal and radiometric resolution of the sensor and the ability of an imaging system to record finer details in a distinguishable manner. Prior to visual interpretation optimal band requirements, template depicting .different vegetation types and class codes need to be finalized (Class codes will be finalized in the review meeting) Thereafter on screen interpretation of the vegetation should be done on (1.50,000 scale) in a polygon mode using arc view.In on-screen visual interpretation the imagery is displayed onto a computer screen (normally as FCC) and intended classes are delineated based on image interpretation elements and ancillary and legacy data. Resultant output from this will be vector format, which supports complex GIS analysis and has smaller file size (Figure 4).

Study Area

The area is described as Marine National Park, Jamnagar (MNP) located in the Gulf of Kutch. The Gulf of Kutch is an inundation in the Saurashtra peninsula of the west coast, aligned approximately in the east-west direction. The water depth in the Gulf varies from 15m to 55m. The Marine National Park is located on southern coast of the Gulf between 22 15' N to 23 N latitudes and 68 E to 70 35' E longitude. The Marine National Park was constituted in an area of 162.89 km^2 and Marine Sanctuary was constituted in an area of 220.71 km^2 and 237.21 km^2 respectively.The total area of the Gulf of Kutch is 7350 km^2. On the southern coast of Gulf of Kutch in Jamnagar district 457.92 km^2 areas is declared as Marine Sanctuary and 162.89 km^2 is declared as Marine National Park. The underground rock is sedimentary formed by the deposition of sands and silt floating by various rivers.

The mangrove swamps are covered with sand and soft mud varying in depth from 30 cm to 3 m the islands and shoreline are covered with clumps of grasses creepers etc. because of the continuous and prolong exposure of upper intertial zone mud fragment on the shoreline gets harder and harder resulting into the rock formation. At some places few boulders are also formed. These boulders are very small in size and may be the extension of the Deccan trap. The soil is very fertile as it is enriched by the silt and organic material brought by the seven intermediate rivers flowing into the Gulf of Kutch.

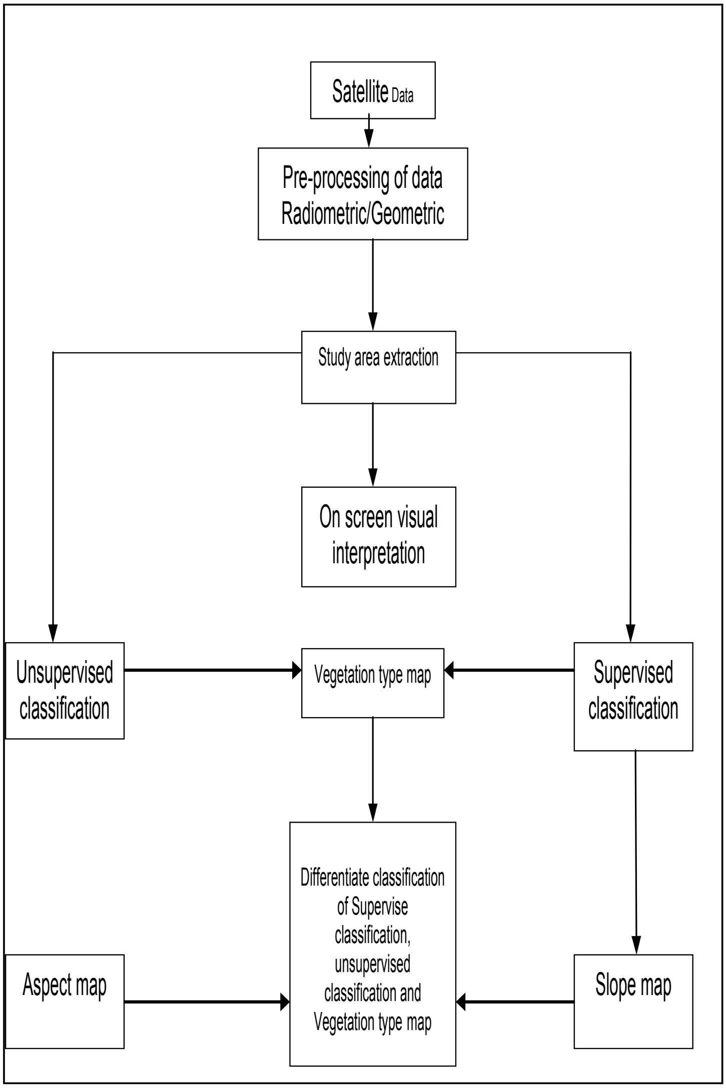


Figure 1. Paradigm of the study Area.

The river Aji, Und and Kankavati meets the Gulf of Kutch in Jodiya taluka.Rivers Ruparel, Rangmati, Hathmati meets the Gulf of Kutch in Jamnagar taluka. Rivers Ghee, Sani meets the Gulf of Kutch in Khambhalia and Kalyanpur taluka. River Gomati meets the Gulf of Kutch in Okhamandal taluka. However, at some places the sand overtakes the soil; the sand particles come along with the tidal waves and get deposited over the top soil. The terrain is generally gently and having slopes toward the Gulf of Kutch.. The Gulf of Kutch is very rich in biological resources. It has thick mangrove forests, mangrove swamps, and inland vegetation on island. The grasses, herbs and shrubs grow on the islands. The grasses and herbs grow along with mangroves, rich algal resources, sea grasses and a number of marine fauna representing almost all phyla. The area is having very rich population of aquatic as well as terrestrial birds. The climate of the Jamnagar district is generally moderate. Along the coast it is slightly humid with average temperature of 33^0 C. The minimum average temperature is 8^0 C during winter and maximum average temperature is 44^0 C in May and June. The month of May and June are the hottest whereas December and January are the coldest months. In Gulf area the maximum temperature recorded was 39.8^0 C and the minimum temperature recorded was 6^0 C in 1985. During monsoon the approach to the island also becomes difficult. The dew is common up to February. The south west monsoon generally sets on the Gulf in the beginning of July and continues till the end of September. Sometimes it starts by middle of June also. The average annual rainfall is 500mm. The rainfall is very erratic and numbers of rainy days are very few. There is always a very long dry spell between the two rains. The Jamnagar district is a drought prone area and almost every third or fourth year is a drought year. There are 57 villages located on the periphery of Marine Protected area. Before countries independence most of the coastal villages were totally dependent on Gulf of Kutch for livelihood and for feeding their cattle. Collection of windowpane oyster, sacred chank and Pearl oyster were the main activities. The villagers of Poshitra, Mulvel, Samlasar, Rajpat, Nana and Mota Asota and Pindhara were dependent on collection of windowpane oyster. After formation of Marine Protected Area, the Government has put the ban on the collection of windowpane oyster. The Jam Saheb of Navanagar state, the erstwhile ruler before the independence, encouraged the collection of pearls and the Navanagar state maintained the separate department known as Motikhata for this purpose. The fishermen used to sell these pearls. There has been population explosion after independence and it has also played an important role in increasing anthropogenic pressure on Marine Protected Area. Some villages like Jodiya, Navagam ghed, Salaya, Sikka and Okha are urbanized towns having a population over 10,000 people. Therefore, there is a density of 200 people per km^2 in these 57 villages. The collection of crabs and other small fishes is their day to day routine. Some of the people work on Cargo ships also and visits far off African countries.

Results

Looking at the data generated from the three classification attempts side by side, it can easily be seen that differences in land use areas are present. Furthermore, the data generated with the unsupervised technique contains additional land use classes. The reason that additional classes are present in the unsupervised method is due to the many classes created (16) and the fact that they did not fall into one of the classes used in the first example. By simply visually analyzing the images created using the different classification techniques, the method of onscreen visual interpation appears to be the better choice in this example. Human error in giving iterations, lack of knowledge of study area, and other factors all contribute to inaccurate results in the supervised classification and unsupervised method. The use of USGS Digital Line Graphs (DLG) (line map data in digital form) would be helpful in isolating out features such as asphalt and concrete. DLG hydrological maps contain information on transportation, flowing water, standing water, and wetlands further easing the job of classification. Also available from the USGS are Multi-resolution Land Classification (MRLC) maps. MRLC data are derived from Landsat 7 TM data. Landsat 7 TM has several advantages over pervious Landsat satellites including better resolution and an additional thermal band.

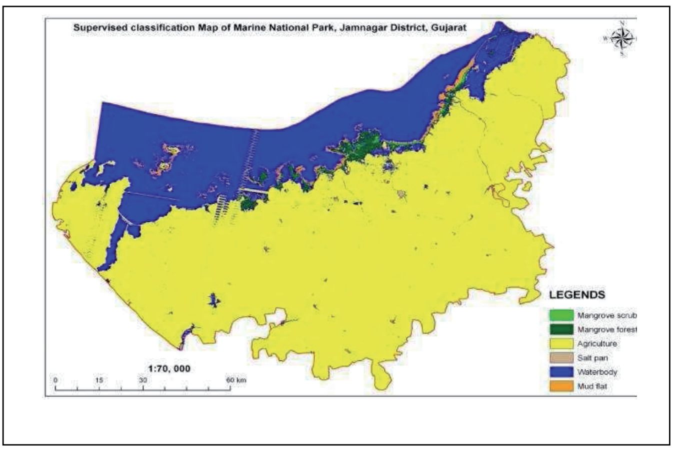


Figure 2. Supervised classification map of MNP, Jamnagar, and Gujarat.

These maps are available at reasonable price and already have land use classified into 21 different land use classes. Deforestation and subsequent loss in biodiversity has raised concern among conservationists in the recent past.

The supervised, unsupervised and onscreen visual interpretation technique has been used to map these features in a consistent scale and classification scheme incorporating the knowledge base. The use of biodiversity indices appears to be a viable approach for establishing environmental thresholds and evaluating ecological impacts of development. The temporal remote sensing data has been found very effective to map and monitor the impact of drivers of biodiversity loss over the natural resource.

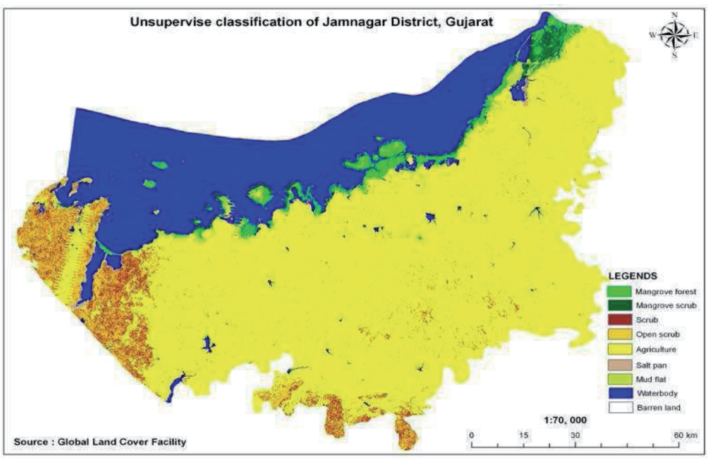


Figure 3. Unsupervised classification map of MNP, Jamnagar, Gujarat.

The economic and social drivers of habitat loss and related biodiversity threats, the human ecological analysis provides a most useful complement to the biological analysis of the biodiversity problem. Although there is ample evidence for the theoretical background behind the policy, economic and social drivers of biodiversity loss, experimental evidence for most of the causes of this loss is fragmented, meager or non-existent.

Although many of these relationships are complex, it is imperative to enhance research on the causal links between biodiversity losses on the one hand and economic policy, production and consumption patterns, culture, internalization of environmental costs, globalization of the economy and poverty and inequality on the other hand. Theory alone offers insufficient arguments to tackle the current root drivers of biodiversity loss. Forest lands with high resource values of regional and national significance, are under a threat of being utilized for timber and non-forest purposes. The main task of this study was to identify the proximate drivers of biodiversity loss through vegetation/forest distribution status. In the district like MNP, Jamnagar the industrial activity and infrastructural development have been identified as major driver of biodiversity loss.

The secondary factors which concern the conservationists is unsustainable high rates of human population growth, natural resource consumption; inadequate knowledge and insufficient use of information and economic system and policies that fail to value the environment and its resource. Of core importance in this discussion is the question as to whether conservation policies will be able to compensate for the current fundamental root causes of biodiversity loss. With the specific needs of the district of MNP, Jamnagar there is need to build trust between development activity *viz.,* mining, dam construction, industrialization, land use conversion and conservation interests.

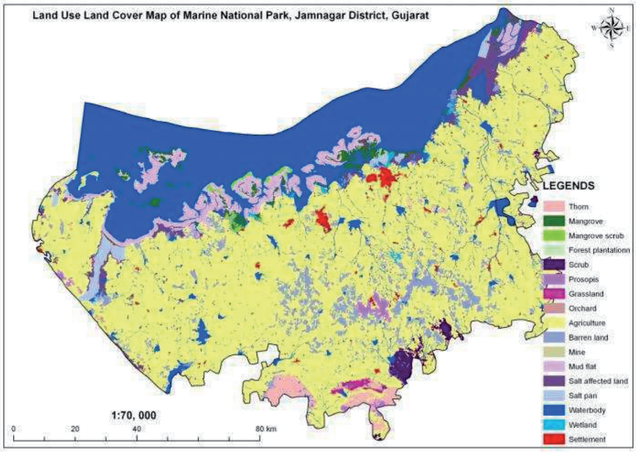


Figure 4.Vegetation type/land use map of MNP Jamnagar district, Gujarat.

The observed results will contribute to our understanding of species composition; structure and ecology of spatially distributed vegetation classes and will facilitate sustainable forest management. Increased awareness and ecological concern, to determine the forest types and the land cover pattern of the magnificent house of diversity and endemic will there by generate an outlook for forest management and will successfully meet the challenge of biodiversity conservation in the new millennium. Effective use of knowledge of species composition and their habitat assessment will create a structure to combine biological assessment, with an awareness of the socio-economic context and ecological knowledge as well as the support of the surrounding community.

References

Anonymous 2005-2014. *Working Plan for Marine National Park, Jamnagar,Gujarat*.

Anonymous 2008. State of Forest Report 2005. Forest Survey of India, Dehradun.

Champion, H.G. and Seth, S.K. 1968. A Revised Survey of the Forest Types of India, Govt. of India, Publications, New Delhi, 404p.

Morrison, Current Projects. new wcpa. MPA_WCPA India.doc 31/22/02.

Pernetta**,** J.C. (Ed). 1993**.** Marine Protected Area Needs in the South Asian Seas Region. Volume 2. India. A Marine Conservation and Development Report.Sabins, Floyd F. Remote Sensing. Principles and Interpretation. 3rd edition.The wildlife protection act, 1972. (No. 53 of 1972).

Vasanthakumari V; Devaraj S N; Devaraj H.1997. Methacrylonitrile induced oxidative stress in rat liver. Indian journal of biochemistry & biophysics**.**

Venkataraman et., S. al. E. Stringer, B. S. Kandola, D. A. Pye, and J. T. Gallagher 2003. 537 – 542.

Kannan AT, and Mohan V. 2005 Challenges in diabetes management with, Ministry of Health and Family Welfare. Government of India; 43-64.

NRSC, 2008. Biodiversity characterization at landscape level using remote sensing and Geographic information system. Manual, National Remote Sensing Centre, Hyderabad.

Seismic Vulnerability Mapping Using Geospatial Technology

Peeyush

Disaster Mitigation & Management Center-Dehradun

Abstract

This research presents a framework to integrate several sources of spatial information to derive a map of seismic vulnerability for the city of Dehradun which is under Earthquake Zone V. The proposed method is based on generating a geographical database with different variables. In this case study, seismic vulnerability assessment of buildings and population is carried out for one municipal wards of Dehradun City. Parameters considered for the generation of compatible building type classifications are roof type, structures, presence of cracks, maintenance, building shape, number of stories, year of construction etc. The spatial information will obtained from different sources, mainly Iknos images, ground truth data collection. The map of seismic vulnerability will be based on the estimated location of population, as well as the situation of critical installations and a map of construction fragility. Since population activity changes through the day, a dynamic cartography of vulnerability will produce, based on population density levels for different time periods. Seismic Analysis is a subset of structural analysis and is the calculation of the response of a building structure to earthquakes. It is part of the process of structural design, earthquake engineering or structural assessment and retrofit in regions where earthquakes are prevalent. Seismic vulnerability analysis of existing buildings requires basic information of their structural behavior. This research presents a methodology to predict the seismic vulnerability of buildings by geostatistical analysis using geoinformatics on a number of structural parameters determined on the basis of engineering knowledge and observations. It’s better to evaluate earthquake damage in a probabilistic way due to the uncertainty in occurrence of earthquake and respective structural response. In this case study, seismic vulnerability assessment of buildings and population is carried out for one municipal wards of Dehradun City. Parameters considered for the generation of compatible building type classifications are roof type, structures, presence of cracks, maintenance, building shape, number of stories, year of construction etc. To estimate risk of population, social vulnerability parameters like utilities, facilities, day and night time population, population at various age groups are taken. Finally, amount of vulnerability related to various buildings are calculated and its impact on population is shown.

Keywords: Seismic vulnerability, geostatistics, geoinformatics, Seismic vulnerability.

Introduction

Indian landmass was once a part of the conglomerate of continental plates located in southern hemisphere, around the South Pole, and evolutionary history of Himalaya is interwoven intricately with the separation of these plates and northward drift of the Indian landmass. Continued subduction of the Indian Plate beneath the Eurasian Plate consumed the intervening oceanic plate and led to the collision of the alien landmasses. This caused upliftment, deformation, metamorphism and shearing of the sediments deposited in the hitherto intervening ocean basin, along with the rock mass of the two Plates involved in orogeny. This sums up the evolutionary history of the Himalayan mountain chain which is a product of continent – continent collision that has rendered the terrain highly fragile and prone to disasters.

Earthquake hazard potential is evaluated to be particularly high in the entire Himalayan terrain and in the past the region has been jolted by four Great Earthquakes, apart from Kumaun Earthquake of 1720 and Garhwal Earthquake of 1803. The peak ground acceleration (PGA) in Western Assam Earthquake of 1897 is estimated to have exceeded 1 g (Oldham, 1899), while around 18,000 persons were reportedly killed in 1905 Kangara Earthquake (Middlemiss, 1910). Arya (1990) has indicated possibility of around 80,000 persons being killed if the 1905 event repeats during the daytime. This projection is verified by the toll of 2005 Muzaffarabad Earthquake. Wyss (2005) carried out loss estimation simulations for Great Earthquakes in the Himalaya and has estimated the fatalities to exceed 2,000 in the townships of Almora, Ranikhet, Chaubatiya, Nainital, Pithoragarh, Champawat, Kotabag, Lansdowne and Ramnagar in the simulated Garhwal Earthquake. Entire State of Uttarakhand is categorized as falling in Zone IV and V of the Earthquake Zoning Map of India (IS 1893 Part 1, 2002) and is interpreted to have accumulated potential slip for generating future Great Earthquakes (Khattri, 1987).

Most earthquakes in the State of Uttarakhand are concentrated in close proximity of the Main Central Thrust (MCT) and not many earthquakes have their epicenters in the proximity of both Main Boundary Thrust (MBT) and Himalayan Frontal Fault. This however does not rule out possibility of a major earthquake along the latter tectonic boundaries but is certainly indicative of relatively higher risk in the areas around MCT. It is important to note that a number of urban centres in the State are located in close proximity of these tectonic discontinuities and this is a cause of concern.

Seismic risk is a direct function of the state of built environment or vulnerability of the building stock. Assessment of the building condition is therefore central to any seismic risk evaluation exercise because it forms the basis for realistic risk reduction efforts. This exercise is all the more important for urban areas that have concentration of both infrastructure and population.

Scenario is really grim in the urban areas in the hilly terrain that are faced with severe constraints on horizontal expansion and people are forced to add storeys to the existing structures in order to meet the growing demand. Due to the lack of suitably qualified technical manpower in these areas most structures are however constructed without due regard to seismic safety related features. Lack of awareness regarding seismic threat in the region, as also on the seismic safety related measures is often cited as being the main causes of non – compliance of appropriate seismic safety measures. Inappropriate techno-legal regime, non – existence of suitable mechanism for their compliance and lack of stern action against the defaulters are however important issues related to this important problem.

Objectives

The research aims at precisely ascertaining the population group prone to high seismic risk in the Chukhuwala ward (Ward No. 13) of Dehradun city. This would help in highlighting the seriousness of the issue and is intended to pave way for corrective measures, suggestions for which would form a part of the research. The research is intended to bring forth the following that could subsequently be utilized for formulation of an effective risk reduction strategy:

1. Evaluation of differential seismic vulnerability of the building stock.
2. Risk assessment.
3. Estimation of casualties and direct losses due to seismogenic damage to the building stock.

Study Area

Though the study focuses on Dehradun city the limitations imposed by available time do not allow this study to cover the entire city and one highly vulnerable ward (Chukhuwala) of the city is therefore covered under the present investigations. Located in the heart of the city the Chukhuwala ward represents old constructed area of the city. This area is highly congested, has preponderance of age- old buildings and has numerous problems relating to access. Bindal River is located to the northwest of the ward and in the vicinity of the river there is preponderance of slums and squatters. The residential population of the Chukhuwala ward is 12000. The study area Dehradun according to seismic zoning map of India (IS-1893-2002) lies in seismic zone IV, having expected MSK intensity VIII.

Methodology

Detailed seismic vulnerability evaluation is a technically complex and expensive procedure and can only be performed on a limited number of buildings. It is therefore important to use simpler procedures that help in rapid evaluation of the vulnerability profile of different type of buildings. More complex evaluation procedures can thus be limited to the most critical buildings (Sinha and Goyal, 2004).

Rapid Visual Screening (RVS) is one such cost effective tool for identifying highly vulnerable structures that can subsequently be surveyed in detail for appropriate mitigative action. RVS was first proposed in the United States (US) in 1988 and was further modified in 2002 to incorporate latest technological advancements and lessons from earthquake disasters in the 1990s. Though originally developed for typical constructions in the US this procedure has been widely used in many other countries after suitable modifications. The most important feature of this procedure is that it permits vulnerability assessment based on walk-around of the building by a trained evaluator. The evaluation procedure and system is compatible with GIS-based city database and also permits use of the collected building information for a variety of other planning and mitigation purposes.

The RVS method is designed to be implemented without performing any structural calculations and utilises a scoring system that requires the evaluator to identify the primary structural lateral load-resisting system together with the building attributes that modify the seismic performance expected for this lateral load-resisting system. The inspection, data collection and decision making process typically takes place at the building site.

Data Collection

Modified version of the FEMA-154/ATC-21 based data collection form was used for collecting information in the field. Taking note of seasonal variation in occupancy provision was made for recording the peak and lean occupancy of the buildings. In order to take the relief of the area into account provision of broad estimation of the slope into three categories (<15°, 15° - 30° and >30°) was also included. Some parameters that include building identification number, ward number, owner's name, roof type, accessibility were also added for a broader information spectrum and to make analysis easier to perform. Provision was also made for including the subjective remarks of the field surveyor. IKONOS imagery was utilised for mapping the structures while the database was prepared using ARC INFO GIS software (version 9.3) that was also used for analysis and correlation. For assessing the seismic vulnerability of the structures in the Chukhuwala Ward detailed investigation of the individual buildings was undertaken in the field. The format utilized for the surveys is Type of construction, Age of construction, Number of stories, Plan, Occupancy Type, Quality of building, Number of occupants during day time, Number of occupants at night time.

Expected earthquake induced damage to structures. When exposed to a particular intensity of ground shaking, different building types experience different levels of damage depending on their inherent characteristics. Damageability is thus defined as the level of damage that is likely to be incurred in a seismic event. Sinha and Goyal (2004) have developed a methodology of correlating RVS scores of the surveyed structures in different seismic zones with probable seismic losses using European Macroseismic Scale (EMS-98) damage grades. Sinha and Goyal (2004) suggest only three hazard zones for RVS studies. These correspond to low (Zone II), moderate (Zone III) and high seismic risk (Zones IV and V) as more precise categorisation between Zone IV and Zone V is not envisaged to enable better assessment of structural vulnerability using RVS procedure due to the influence of a large number of other factors on the building performance in intense ground shaking conditions. This methodology has been used in the present study to assess the likely earthquake induced damages.

EMS-98 recommends five damage grades. Of these Grade 4 and Grade 5 are important for vulnerability and risk assessment as these have the potential of threatening the lives of the occupants as also causing damage to the contents therein. Grade 4 or very heavy damage grade denotes heavy structural damage and very heavy non-structural damage and is characterised by serious failure of walls (gaps in walls) and partial structural failure of roofs and floors. Grade 5 or destruction denotes very heavy structural damage and is characterised by total or near total collapse of the structure.

Results

Most of the buildings in study area are of building structure type 9 (burnt brick in cement mortar) while other type of building structure are also observed. After that earthen buildings and random rubble in lime surkhi type of buildings are found (Figure 1).

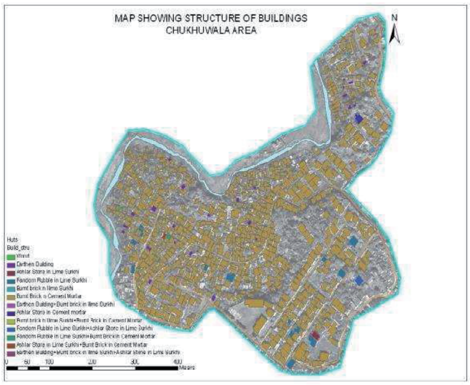


Figure 1.Map showing structure of buildings

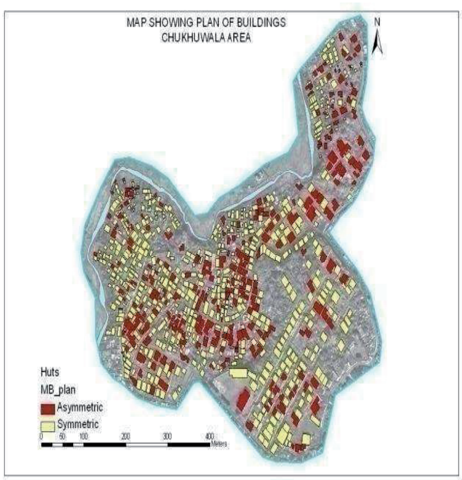


Figure 2.Map showing plan of buildings

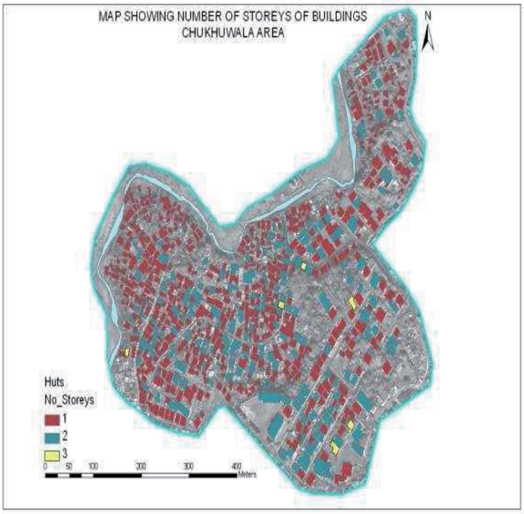


Figure 3.Map showing number of storeys of buildings

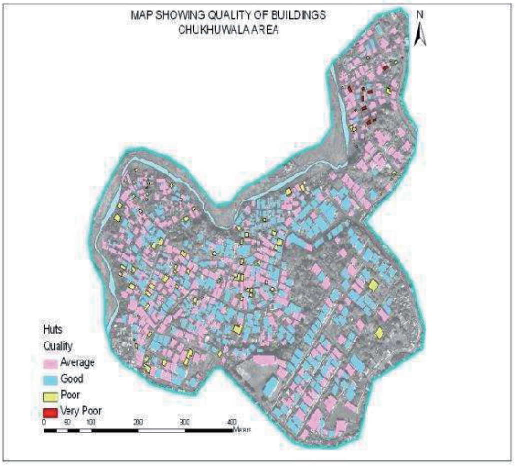


Figure 4.Map showing quality/condition of buildings

Symmetric and non-symmetric type huts are randomly distributed. Symmetric structures are considered to be the safe structures than non symmetrical ones and are outnumbering the later ones.Due to the impending earthquake possibilities the most of the buildings are one storey. Some are two storey and very few buildings are three storeys (Figure 2 and 3).Most of the buildings are of good and average quality. Some are of poor Quality and very few are of very poor quality(Figure 4).

Data Analysis

Vulnerability can be briefly defined as “being prone to or susceptible to damage or injury” (Blaikie 1994). To determine vulnerability a long chain of causes or factors can be analysed including natural, technological, social and political factors. The assessment of vulnerability to seismic risk requires particular information on each one of the factors and elements at risk. All items, like geologic evolution, urban development, strength of structures, and possible collateral effects, have to be considered carefully to assess the seismic vulnerability as accurately as possible.

Vulnerability of buildings in the ward is derived on the multi criteria analysis, which is based on the building type (Structure).

Table 1. Vulnerability class of the structures.

Final Score	**Vulnerability Class**
<40	Grade 5
41-50	Grade 4
51- 60	Grade 3
61-70	Grade 2
>70	Grade 1

Depending upon the various parameters scores are assigned to each individual building, i.e., each type has a basic score that is calculated on the basis of different structural parameters that highly influence the vulnerability of the building (number of stories, plan and irregularities, quality of building).

Risk

Risk is a concept that denotes the precise probability of specific eventualities. Technically, the notion of risk is independent from the notion of value and, as such, eventualities may have both beneficial and adverse consequences. However, in general usage the convention is to focus only on potential negative impact to some characteristic of value that may arise from a future event.

Risk can be defined as "the threat or probability that an action or event, will adversely or beneficially affect an organization's ability to achieve its objectives. In simple terms risk is 'Uncertainty of Outcome', either from pursuing a future positive opportunity, or an existing negative threat in trying to achieve a current objective.

Risk is described both qualitatively and quantitatively. Qualitatively, risk is proportional to both the expected losses, which may be caused by an event, and to the probability of this event. Greater loss and greater event likelihood result in a greater overall risk.

Frequently in the subject matter literature, risk is defined in pseudo-formal forms where the components of the definition are vague and ill defined, for example, risk is considered as an indicator of threat, or depends on threats, vulnerability, impact and uncertainty.

Measuring risk is often difficult. Often, the probability of a negative event is estimated by using the frequency of past similar events or by event-tree methods, but probabilities for rare failures may be difficult to estimate if an event tree cannot be formulated. Methods to calculate the cost of the loss of human life vary depending on the purpose of the calculation. Specific methods include what people are willing to pay to insure against death, and radiological release (e.g., GBq of radio-iodine). There are many formal methods used to assess or to "measure" risk, considered as one of the critical indicators important for human decision making.

Since the city has buildings, ranging from very old and vulnerable stone/adobe buildings to the newly constructed masonry/ RC buildings, generally without provisions for seismic loads transfer mechanisms and city has been a very important center of the northern academies, institutes and research centers so this has made the earthquake risk assessment of the city very urgent.

Vulnerability Assessment

Out of the total buildings surveyed 17 buildings were found under Grade 5 vulnerable conditions. The tabular representation of the seismic vulnerability assessment is shown in Table 2 Figure 5.

Table 2. Vulnerability assessment for different building structure type.

Vulnerability Class	**Number of Buildings**
Grade 1	20
Grade 2	277
Grade 3	404
Grade 4	205
Grade 5	17

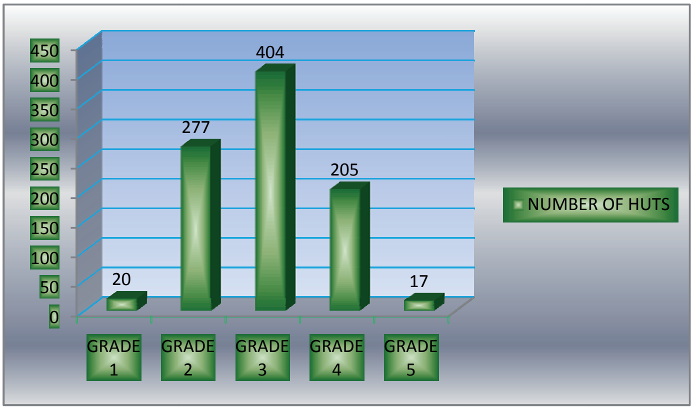


Figure 5.Bar Chart Showing No. of Grade 5 Huts in Two Different Occupancy types.

Chukhuwala is considered to be vulnerable being highly congested. The following graph shows the vulnerability class for different building structure type. Out of 923 buildings 17 buildings fall under Grade 5 vulnerable conditions. Buildings, which fall under extreme to high vulnerability conditions, may result into total collapse there by causing damage to building stock and causalities. 20, 277, 404 and 205 buildings fall under Grade 1, Grade 2, Grade 3 and Grade 4 vulnerable conditions respectively. In the Grade 5 huts,16 are of residential type and 1 is of residential cum commercial type.

Risk assessment: Records from past earthquakes show that for different regions in the world with different kinds of construction there are different threshold intensities at which the first term begins to dominate. For intensities below that shaking level, casualties are primarily damage or non-collapse related. For intensities above that level, the collapse, often of only a few structures, may control the casualty pattern. The number of occupants during day and night time for different occupancy type is already surveyed and is then plotted.

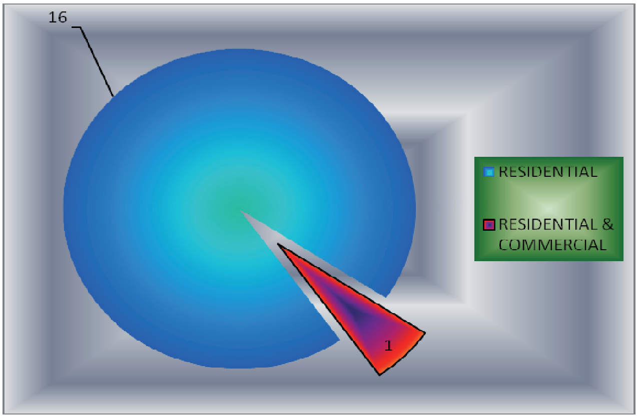


Figure 6 .Distribution of buildings under different vulnerabilitty classes

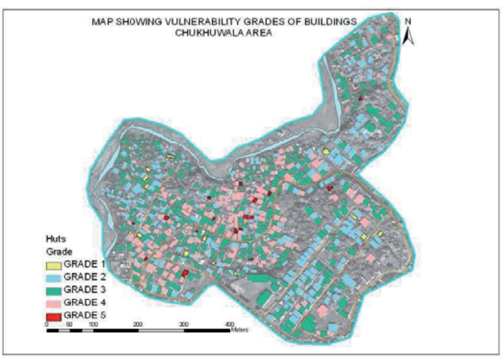


Figure 7. Map showing vulnerability category of buildings

The replacement value of damaged structures is calculated by using the following formulae:

replacement value = Total Floor Area*10.7639*500

10.7639 is a factor for converting Square meter into Square feet. Rs.500 is hypothetical cost considered for per square feet of the total floor area.For residential area, non-structural damage is considered to be half of replacement value.For residential cum commercial area, non-structural damage is considered to be same as replacement value.

Damage(in Rs.)	**Residential**	**Resi.+Commercial**	**Total**
Structural	7472371	3736185	7567554
Non-Structural	95183	95183	3831268
		Overall Damage	11398822

It is observed that the total structural damage in the residential huts is Rs. 7472371. The total non-structural damage in the residential huts is Rs. 3736185. The total structural damage in the residential cum commercial huts is Rs. 95183. The total non-structural damage in the residential cum commercial huts is Rs. 95183. The total structural damage in the whole area is Rs. 7567554. The total non-structural damage in the whole area is Rs. 3831268. The overall damage that will be caused within this area is Rs. 11398822.

The casualty patterns for people, who evacuate collapsed buildings, either before or immediately after the collapse, are more difficult to quantify. Statistical data on these casualty patterns is lacking, since in most post-earthquake reconnaissance efforts these injuries are not distinguished from other causes of injuries. In some cases, the lighter injuries may not be reported. An assumption may be applied that those who manage to evacuate are neither killed nor receive life threatening injuries. Often it is assumed that 50% of the occupants manage to evacuate.The output from the above model consists of a casualty breakdown by injury severity level, defined by a four level injury severity scale (Durkin and Thiel, 1991; Coburn, 1992; Cheu, 1994).

Indoor causalities for complete structural damage .

Occupancy Type	**Day Time Occupants**	**Night Time Occupants**	**Total No. of Occupants**	**Total Probable causalities Total No./2**
Residential/Residential & Commercial	61	107	168	84

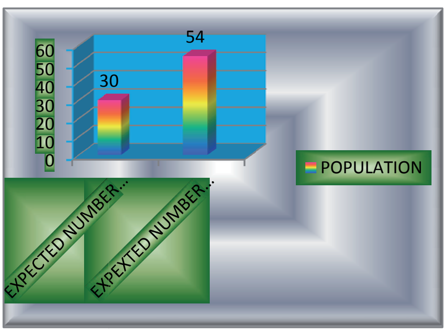


Figure 8. Expected number of people killed under different Occupancy Types.

The total number of indoor casualties is 168. Out of these 161 arise from residential area and 7 arise from residential cum commercial area. Expected number of occupants killed at day time is 61 whereas expected number of occupants killed at night time is 104. Same statistics can be presented in the form of bar graph (Figure 8).

References

Arya, A.S., 1990, Damage scenario of a hypothetical 8.0 magnitude earthquake in Kangra region of Himachal Pradesh, Bull. Ind. Soc., Earthquake Tech. Paper,297 (3), 121 –132.

FEMA 154, Rapid Visual Screening of Buildings for Potential Seismic Hazards,(ATC, 1988, updated 2002).Indian Standard (IS).1893, Part 1,2002, Criteria for earthquake Resistant Design of Structures, Bureau of Indian Standards, New Delhi.

Khattri, K.N., 1987. Great earthquakes, seismicity gaps and potential for earthquake disaster along the Himalayan plate boundary, Tectonophysics, 138. 79-92.

Oldham, R.D., 1899. Report on the great earthquake of 12th June, 1897, Memoirs of the Geological Survey of India, Vol. XXIX, Geological Survey of India, Calcutta.

Population profiles (India, States and Union Territories), 2004, Office of the Registrar General, India, New Delhi.

Sinha, R., and Goyal, A., 2004, A National Policy for Seismic Vulnerability Assessment of Buildings and Procedure for Rapid Visual Screening of Buildings for Potential Seismic Vulnerability, Report of the Department of Civil Engineering, Indian Institute of echnology,Bombay,12pp., (http.//www.civil.iitb.ac.in/~rsinha/Vulnerability_Assessment.pdf)

Wyss, M., 2005, Human losses expected in Himalayan earthquakes, Natural Hazards,34, 305-314.

Land Use Practices for Flood Risk Reduction

Richa Arya, Mohd. Muzamil Bhat, A.K. Gupta*and M. Yunus
Department of Environmental Science,
Babasaheb Bhimrao Ambedkar University, Lucknow (U.P.)
*National Institute of Disaster management (GOI), New Delhi

Abstract

The Indian sub-continent has an area of 3.28 million sq. km (329 million hectares). It is the second largest country in Asia and the seventh in the world. Because of its unique geography, India is always prone to several disasters. Flood is one of them and it has the greatest potential of all natural disasters and affects the greatest number of people physically and economically. In India, human interference becomes very high in the flood plain areas and the land use patterns gradually changed. Besides, the runoff generation process is changed, especially by decreasing the infiltration capacity of the soil and the change of soil cover. High population density increases the risk of flood hazard. The per capita availability of land has declined from 0.89 hectare in 1951 to 0.37 hectare in 1991 and is expected to slide down to 0.20 hectare in 2035. Flood risk can be mitigated by land use planning, which includes many aspects and is a beneficial tool for all levels (large scale and community based).

Key words. Disaster, flood, land use, population density etc.

Introduction

In India flood problems are occurring to areas on the northern of Ganga River,eastern of Brahmaputra and Barak rivers. These rivers having large number of tributaries are the main root cause of flood problem in our country. The flood plains of the Ganga, Brahmaputra and Barak rivers in the region have large area used for agriculture. The agricultural productivity on these flood plains is partly influenced by the supply of nutrients and minerals during periods of inundation. The physical and chemical properties of the flood plain soils and the temporary water storages located on the flood plains change as a result of floods and this influences crop growth. The Ganga, Brahmaputra and Barak rivers are fed by water from the Himalayas.

The flood plains of the north-eastern region of India receive heavy rainfall during the monsoon season. The unplanned land use increases the flood risk and about 40 mh land is prone to floods in India. Flooding produces a variety of negative impacts. The magnitude of adverse impacts depends on the vulnerability of the activities and population and the frequency, intensity and extent of flooding. The major impact is l**oss** of lives and property. As communication links and infrastructure such as power plants, roads and bridges are damaged and disrupted, economic activities come to a standstill, resulting in dislocation and the dysfunction of normal life for a period much beyond the duration of the flooding. Similarly, the direct effect on production assets be it in agriculture or industry, can inhibit regular activity and lead to loss of livelihoods. Damage to infrastructure also causes long-term impacts, such as disruptions to clean water and electricity, transport, communication, education and health care. The additional cost of rehabilitation, relocation of people and removal of property from flood-affected areas can divert the capital required for maintaining production.

Migration to developed urban areas contributes to the overcrowding in the cities. These migrants swell the ranks of the urban poor and end up living in marginal lands in cities that are prone to floods or other risks. Selective out-migration of the workforce sometimes creates complex social problems. The high cost of relief and recovery may adversely impact investment in infrastructure and other development activities in the area and in certain cases may cripple the frail economy of the region. Recurrent flooding in a region may discourage long-term investments by the government and private sector alike. Lack of livelihoods, combined with migration of skilled labour and inflation may have a negative impact on aregion's economic growth. Loss of resources can lead to high costs of goods and services.

Flood

Flood is a natural phenomenon, sometimes it is also influenced by human activity. There were several definitions given by many workers/organization. Flood is a body of water rises to overflow the land which is not normally submerged (Ward,1978). Flood is a relatively high flow which overtakes the natural channel provided for the runoff (Chow, 1956). According to World Meteorological Organization (1974), a flood is a rise usually brief, in the water in a river to a peak, from which the water level recedes at a slower rate. There are various categories of floods as river flood, single event flood, multiple event flood, flash flood, urban flood, flood due to dam breakage, Predictable-regular flooding etc.

Flood risk in India

The problem related to flood in India may be categorized on regional basis as Brahmaputra river region, Ganga river region, North-West river region and Central India Deccan rivers regions. Flood risk is increasing gradually from several decades. Heavy rainfall is the main reason behind the flood in these regions in India but another most common reason is unplanned drainage system. The north western parts and southern parts of west Bengal severely faced the problem of drainage congestion.

These factors including high population density play crucial role to increase the flood risk. Different regions of the country have different climates and rainfall patterns and, as such, it is also experienced that while some parts are suffering under devastating floods, another part is suffering under drought. With the increase in population and developmental activity, there has been tendency to occupy the flood plains which has resulted in more serious nature of damages over the years. Because of the varying rainfall distribution, many a times, areas which are not traditionally prone to floods also experience severe inundation. Most of the states are prone to floods in India. Some states also experience severe inundation. Most of the states are prone to floods in India. Some states which annually face flood problems are Uttarakahnd, Uttar Pradesh, Bihar, West Bengal, Arunachal Pradesh, Assam and Orissa.

Flash floods are more common in India, produced by intense rainfall over a small area and the infiltration rate is much lower than the rainfall rate. Flash floods are characterized by very fast rise and recession of flow of small volume and high discharge, which causes high damages because of suddenness. This occurs in hilly and not too hilly regions and slopping lands where heavy rainfall and thunderstorms or cloudbursts are common. Depression and cyclonic storms in the coastal areas of Orissa, West Bengal, Andhra Pradesh, Karnataka and Tamil Nadu also cause flash floods.Arunachal Pradesh, Assam, Orissa, Himachal Pradesh, Uttarakhand, the Western Ghats in Maharashtra and Kerala are more vulnerable to flash floods caused by cloud bursts. Sudden release of waters from upstream reservoirs, breaches in landslide dams and embankments on the banks of the rivers leads to disastrous floods.

Departmental/Institutional Framework

Both State and Central level organizations are involved in flood executive schemes.The States have to investigate, plan, construct, maintain and operate all flood works. Flood Control Boards were concurrently set up in some of the States, later followed by some others. The functions of the State Flood Control Boards are to assess the flood problem in the States, deal with questions of policy and over-see the planning and implementation of flood schemes. In the discharge of their functions, the Boards are assisted by Technical Advisory Committee. The role of Central Government is advisory, catalytic and promotional in nature.

Various Departments and Organizations dealing with Flood Management at State level are Irrigation & Waterways (I&W) Department, Water Resources Department, Public Works Department (Water Resources), Irrigation & Flood Control Department, Agricultural and Minor Irrigation, Narmada & Water Resources Department and Power & Irrigation Department. Similarly Central Organizations involved are

Central Water Commission, Ganga Flood Control Commission, Brahmaputra Board, India Meteorological Department (IMD), National Centre for Medium Range Weather Forecasting (NCMRWF), National Disaster Management Division of Ministry of Home Affairs, National Institute of Disaster Management (NIDM) and National Disaster Management Authority (NDMA).

Protection against Floods

Safety against floods had received considerable attention during the last four decades. Different measures have been adopted to reduce flood losses and protect the flood plains but with limited success. Absolute flood control and protection to all flood prone areas in the country for all magnitude of floods of different probability of recurrence is not possible to be achieved due to various reasons. Nevertheless, flood management measures to give a reasonable degree of protection form flood losses at economic costs, would be necessary. As the flood disaster of varying degree may continue to occur every year in various parts of the country, an integrated approach to manage flood disaster for its different phases as given below should be part of the future programme.

1. Pre-disaster Phase
2. Disaster/Impact phase
3. Post-disaster Phase.

The pre disaster phase includes prevention, mitigation and preparedness activities. These activities involve extensive data collection, maintaining directories of resources, developing action plans, capacity building, training and community awareness activities among others. Government departments, district administration, local authorities and other relevant agencies will develop plans for prevention and mitigation of disasters and will build capacity and ensure preparedness in the event of a flood disaster actually taking place. The disaster phase includes all measures that are taken immediately aftermath disaster. The speed and efficiency of the response in this phase will crucially determine the loss to life and property. The revenue department, in conjunction with other relevant Government departments would carry out activities in this phase. In the post-disaster phase, the thrust of Government policy will be to ensure a speedy return to normalcy and mitigation of long term consequences of the disaster. The policy objective of the Government in this phase will be to focus on economic and social consequences of the disaster and directing efforts to improve the same. The post-disaster phase will mainly comprise reconstruction and rehabilitation activities. From the foregoing statement, it can be seen that concerted effort and coordination amongst different department of Central and State Governments, NGOs etc., are required to bring about appropriate disaster Management system into place to reduce the losses and suffering of the people when faced with such disasters.

Land Use and Flood

Due to increasing human interference and development of the catchment area,the runoff generation process is changed, especially through decreasing the infiltration capacity of the soil and the change of soil cover. Hydrological responses to rainfall strongly depend on local characteristics of soil, such as water storage capacity and infiltration rates of that particular area. The types and density of vegetation cover and land-use characteristics are also important to understand hydrologic response to rainfall. Environmental degradation is the result of uncontrolled urban development in high-risk zones. Large-scale constructions within the floodplain can result in obstruction to flood flows. Such construction can be undertaken as part of developing new buildings, roads, industrial and residential areas. For water resources development barrages or dams may be constructed in the upper reaches of a water course. Depending on the topography of the area this in case leads to the diversion of water into a neighbouring catchment and may increase the flood risk in these regions.

The construction of transport infrastructure such as highways and railroads ideally requires open flat land. Such conditions can be found on floodplains and the floodplains are used to develop such infrastructure. Human activities gradually encroach on the natural environment altering the dynamic equilibrium of the hydrologic cycle and initiating new processes during rainfall events. It is now well accepted that there exists causal links between environmental degradation, land-use and vulnerability to disaster. In physical terms, for instance, flash floods are considered to be fast onset disasters, but the root cause may reside in a historically progressive process of environmental degradation and unsustainable land-use that affects the hydrological response and the impact of the flood. Urbanisation disrupts natural drainage patterns. Natural watercourses are destroyed and the natural retention of runoff by plants and soil is removed. By changing pervious natural surfaces to less or non-pervious artificial surfaces, the storm water runoff rates and the total runoff volumes will increase as a result of a declining natural water storage capacity of the soil. All these factors are leading to an increased risk of urban flooding. Change of natural water storage as a consequence of urbanisation also causes significant changes to the temporal characteristics of runoff from an urbanised area, such as shortening the runoff travel time and giving to the event a flashing appearance.

Land use Planning

Flood management plans are developed at different levels as part of sectoral planning. These include Basin or Catchment Flood Management Strategy, Basin or Catchment Flood Management Plan, Local Floodplain Management Plan and Project Plan. The different plans largely vary on spatial and temporal scales. The first two are prepared for comparably large areas and partly with substantial time horizons (reaching up to several decades). The latter two types of flood management plans are prepared on rather small spatial scales and time scales of months or a few years. Spatial planning can be seen as one of the means to prevent and mitigate man-made and natural risks (Burby, 2006; Burby et al., 2000; Cutter, 1993; Godschalk et al.,1999; Immink, 2005; Mileti, 1999).

All structural flood management interventions need to be incorporated into the land use planning process to safeguard spatial requirements of those measures now and in the future. This proves in practice a challenging task as spatial requirements can be substantial with limited available land resources e.g., for a dam or reservoir but similarly for levees and diversion channels. Further our knowledge of the future is inherently limited. This particularly concerns future economic drivers, as well as future rainfall patterns and other climatic factors which form the basis of planning the location and spatial requirements of hydraulic works in general and structural flood management measures in particular. Another option under this strategy refers to measures taken over the whole catchment area (not only the water system) to optimize the functioning of the catchment for flood management. Another consideration taken refers to where flooding causes least harm and where it should occur to protect other crucial areas such as cities and industrial centres with high potential for damage. Those high risk areas need to be identified and made part of the land-use planning and regulation process, in order to be kept free from high risk uses.

Flood Management Planning Processes

Information on land use/land cover in the form of maps and statistical data is very vital for spatial planning, management and utilisation of land for agriculture, forestry, pasture, urban-industrial, environmental studies, economic production etc. Today, with the growing population pressure, low man-land ratio and increasing land degradation, the need for optimum utilization of land assumes much greater relevance. The draft outline on the National Land Use Policy and strategy on Optimum Land Use Planning and the creation of National Land Use Conservation Board (NLUCB) in 1985 clearly indicate the serious concern of the Government in this regard. Flood risk management involves a suite of management plans which fall into the three categories of prevention, protection and preparedness. The first category can also be subdivided into those actions which address the cause and those which address the effect of flooding. Dealing with the cause is fundamental in a long term solution to any environmental, social or economic issue. In terms of flooding it is identifying where the floodwaters originate, investigating runoff rates in headwater catchments, looking at how river channels convey floods and dealing with the rivers before they become too big to be managed. Dealing with the cause of the floods is therefore looking at the whole catchment and the management technique which can best address the cause is catchment land use planning.

Land use can be planned on a catchment scale to target the causes of flooding by distributing certain land uses in key areas within the catchment. The land uses to be considered include the catchment's vegetation cover, soil cover, river channels and related aspects such as ground drainage, access roads and river morphology. For flood management these land uses need to be distributed to control the rate of runoff during storm conditions and the rate of flow down the watercourses. To plan the distribution of land uses over a catchment the full range of catchment characteristics need to be linked to the hydrological characteristics of the land use type. The identification of key flood control areas within a catchment highlights other areas in the catchment which will have little control on flood generation. These areas could be a significant proportion of the catchment enabling land owners and local communities to use this land for agriculture, forestry, recreation and small scale infrastructure. This integrated approach on the whole catchment scale, involving communities, is therefore land use planning on a sustainable level. Sustainability has to involve the economics of a scheme, good planning, understanding flood generation processes, protecting natural environments and working with communities. This has led to the suggestion that sustainable flood risk management includes the following components:

1. Floods legislation driven by good policy and planning;
2. Flood monitoring networks and warning systems;
3. Flood data for trend analysis and investigating flood generation processes;
4. Protecting, benefiting and involving communities;
5. Engineered flood protection schemes
6. Economics including capital costs, maintenance costs
7. Protecting and enhancing the natural environment;
8. Natural flood management in functional flood control areas involving river restoration and catchment land use planning.

Natural flood management deals with the causes of flooding by slowing down runoff rates in the upper catchment and reducing flow rates down watercourses. Fundamental to this is that there are key areas in a catchment where floods are generated and where flood flows should be slowed down. In a catchment there are natural systems such as soils and river meanders which provide this function. If these systems at the key points have been degraded then there is a high risk of increased runoff rates and more rapid flow rates in rivers. These areas are therefore keys in the success of natural flood management and can be termed functional flood control areas. The techniques which are used in natural flood management include:

- Reforestation of hill slopes
- Planting dense woodlands in gullies
- Blocking artificial drains
- Restoring wetland features
- Restoring river channel meanders
- Controlling excessive erosion
- Management of large woody debris in watercourses

One approach to the mitigation of the severity of floods is to retard the rate of run-off from natural watersheds. In rural areas, this can be accomplished by adopting conservation practices directed towards the increased infiltration of storm rainfall and the surface detention of flood run-off. In small urban watersheds, run-off can be retarded by providing onsite detention storage facilities, using such techniques as the provision of lot storage and the use of parking areas and sporting fields to detain storm run-off. Land-use regulations can be used as an effective means of reducing the damage associated with natural disasters. In the context of floodplain occupation, land-use regulations attempt to minimize the effect of flood disasters by balancing land uses with flood risk. Restrictions are placed on the nature and location of urban and industrial development and the type and extent of agricultural activity. To be fully effective, such land-use control measures should be introduced in combination with other forms of disaster reduction drawn from the range of available structural and non-structural measures. Although it is not possible to avoid the occurrence of natural disasters, their physical impacts can be reduced through appropriate mitigation strategies. In many circumstances, wise land-use planning and management can be effective in reducing the adverse consequences of water-related natural disasters. On the other hand, the vulnerability of land to such hazards as flooding or landslip can be increased as a consequence of environmental degradation resulting from unwise land use and the uncontrolled exploitation of natural resources.

Conclusions

All structural flood management interventions need to be incorporated into the land use planning process to safeguard spatial requirements of those measures now and in the future. The assessment of the influence of human activities on the global environment needs spatially explicit data sets describing changes in land use and land cover and their associated biophysical and socioeconomic drivers. One of the most obvious manifestations of human activity in the terrestrial biosphere is the extent of land use and land cover change. Flood risks can be reduced and mitigated by better land use planning and is a beneficial tool for all levels.

References

Burby, R.J.2006. Hurricane Katrina and the paradoxes of government disaster policy. Bringing about wise governmental decisions for hazardous areas.*Annals of the American Academy of Political and Social Science* 604, 171-191.

Burby, R.J., Deyle, R.E., Godschalk, D.R., and Olshansky, R.B. (2000).

Creating Hazard Resilient Communities through Land-Use Planning. *Natural Hazards Review*, 1, 99-106.

Chow, V.T. (1956). Hydrologic studies of floods in the United States, *International Association of Hydrological Sciences*, 42,134–170.

Cutter, S.L.1993. Living with risk . the geography of technological hazards, Arnold, London. 71-73.

Godschalk, D.R., Beatly, T., Berke, P., Brower, D.J., Kaiser, E.J., Bowl, C.C. and Goebel, R.M.1999. Natural Hazard Mitigation. Recasting Disaster Policy and Planning, Island Press, Washington D.C. 233-234.

Immink, I. 005). Established and recent policy arrangements for river management in The Netherlands. an analysis of discourses. From Landscape research to Landscape Planning. Aspects of Integration, Education and Application, B. Tress, G. , G. Tress, G. Fry and P. Opdam, eds., *Springer*, Dordrecht. 387-404.

Mileti, D. S. 1999. Disasters by design . a reassessment of natural hazards in the United States, Joseph Henry Press, Washington, D.C. 133-135.

Ward, R. 1978. Floods. A Gcographirol Perrpccfiuc. London Macmillan Press Ltd.55-58.

WMO (World Meteorological Organization). (1974). WMO/UNESCO International Glossary of Hydrology, WMO Publication No. 385, WMO, Geneva.

WMO (World Meteorological Organization). 2007. The role of land-use planning in flood management- A tool for integrated flood management. 10-15.

Combating Desertification Programmes in Western Rajasthan –Issues and Constraints

N.K.Bohra ,J.K.Shukla and D.K.Mishra

Arid Forest Research Institute, Jodhpur (Rajasthan)

Abstract

In Western Rajasthan the climate is very harsh and rainfall is irregular .The temperature reaches to 50 degree in summer and drops to 0 degree in winter. The Forest area is very limited and rainfed agriculture is the only system for their survival. The huge barren land patches along with moving sand dunes and rocky area are really a challenge for the forester and researcher. Government of India started a massive programme in western Rajasthan named as Combating Dsrtification Programme (CDP). The programme aimed to establish sand dunes, increase in forest area along with providing fuel wood, fodder, and increase in pasture lands, employment generation and other local requirements. However during implementation there are several constraints appear with respect to land ownership, types of plantation, local factors etc. There is need to find out solutions well as to modified programme with respect to changing climate and local demand .During evaluation work of these area several good things also comes out like increase in forest area ,increase in awareness and at the same time increase in Biodiversity in the programme area. However there are some lacunae are also there which should be solved and in future such programmes can be organized and develop after learning from these programmes stories. The paper will be presented with respect to study undertaken in Jodhpur, Sikar, Nagaur and Barmer region of western Rajasthan.

Keywords: CDP, pasture lands, biodiversity

Introduction

Rajasthan is the largest state of India, having 10.5% area of the country and covers two-third area of Thar Desert. It Supports 5.5% of human population, 10% of cattle, with 0.5% Pastureland and 1.15% water resources of the country. In this region droughts recur almost every year in one or the other part of the State. The total area affected by sand drift in India is about 88,000 km^2. Thar Desert in Rajasthan is characterized by low and erratic rainfall, monsoon variability, high air temperatures and intense solar radiation coupled with high wind velocity. Thus, there is a random recurrence of drought and famines making local livelihoods highly vulnerable.

With increase in human and livestock population over the years, the natural resources in the drought prone and desert areas have been under great stress resulting in continuous depletion of vegetative cover, increase in soil erosion and fall in ground water levels due to continuous exploitation. All these factors contribute to diminishing productivity of land and loss of natural resources. Department of Land Resources have been addressing these problems on a regular basis through the highly focused, specific area development programme i.e., Desert Development Programme (DDP) in dry regions of India in 1977-78. From 1995-96, the coverage has been extended to a few more districts. Desert Development Programme (DPP) was launched as a centrally sponsored scheme in 1977-78 with the prime objective of controlling desertification and restoration of ecological balance in dry region. In Rajasthan, various schemes taken-up under this programme are, shelterbelt plantations, rehabilitation of degraded forests, village fuel wood and fodder plantation, farm forestry, sand dune stabilization, pasture development and establishment of nurseries.

In absence of watershed in arid districts of Rajasthan, the recommendation of Hanumanta Rao committee was relaxed in 10 arid districts. Fifty percent of funds allocated to a district were suggested for its use as per the normal guidelines for watershed development and the remaining 50% of the fund was earmarked for sand dune stabilization, shelterbelt creation and afforestation. In Rajasthan, various schemes taken-up under this programme are afforestation, shelterbelt plantations, sand dune stabilization and plantation. To involve village communities in the implementation of this project and also involve the Panchayat Raj Institutions (PRIs) for management of economic development activities in rural areas, GOI has issued Guidelines called Guidelines for Naveen Hariyali. These new guidelines under the area development programmes were implemented in accordance with the Guidelines for Naveen Hariyali with effect from 1.4.2003.

Comabating Desertificaton Programme

The Combating Desertification Project is a centrally sponsored project in which project cost is shared by the Central and State Governments in the ratio of 75.25. The work is carried out in accordance with project profile by the agency i.e. Forest department and include objectives such as:

1. Combating desertification
2. Increasing supply of fuel wood, fodder and generating employment through environmental improvement of degraded community and forestland by afforestation.
3. Sand dune stabilization work to control shifting of sand dune and to check further extension of desert.
4. Increasing productivity of existing vegetation through proper

treatment in addition to the planted seedlings.

5. Improvement in climatic condition through afforestation activities.
6. Supply of quality planting stock on local demands.
7. Ensuring people participation in afforestation activities.

Plantation activities covered in the model were defined for growing tree and grasses under the project and the provision has been made for their maintenance for five years. In order to protect the plants raised under the project, provision has been made for the enclosure of the plantation sites by trench- cum-mound fencing in the areas having hard soil and by 3/4 strand Iron barbed wire fencing in the areas having loose sandy soil. Some sites have protected by both ditch and barbed wire fencing.

By clubbing together different activities a decrease in demand and supply gap of fuel wood, fodder and other forest products has been observed, thereby fulfilling the local needs viz. fuel wood, fodder, NTFP and timber.

Selection of Place

The decision regarding selection of village panchayats under which plantation has to be raised is taken in the meeting of Zila Parishad after thorough discussion. The community organization represented by village panchayats and VFPMCs were involved in selection of suitable site and allotment through the approval of Gramsabha, mode of operation & treatment plan of the proposed area. VLOs were involved in execution of the afforestation work through fencing, vegetative interlacing, erection of micro windbreaks, mulching, formation of V-ditches, contour trenches, planting, seed sowing & its protection. For each plantation site, forest department has been formally allowed to raise plantation by a resolution passed by the concerned Gramsabha.

Under this project various models are proposed depending on site types and an estimated unit cost is also prepared to carry out these works.

Working Plan

The forest department prepared afforestation project in the district, which after approval by the Govt. has been implemented under special project "Combating Desertification Project- *Hariyali*" involving the local people and the VFPMCs.

Table 1.Various types of afforestation models being implemented under the project.

S. No.	Afforestation model	Estimated Unit Cost(Rs./ha.)
1.	Sand dune Stabilization Plantation (unit size 50 ha.)	33,053
2.	Sand dune Stabilization Plantation (unit size 25 ha.)	41,737
3.	Afforestation Plantation Scheme –I (unit size-15 ha.)(Panchayat wastelands)	60,271
4.	Afforestation Plantation Scheme –I (unit size-25 ha.)(Treeless rocky wastelands)	29,204
5.	Afforestation Plantation Scheme –I (unit size-100 ha.) (Degraded natural rangelands)	13,270
6.	Shelter Plantation –I (unit size-4.8 ha. or 12 row kilometer)(Roadside plantations)	2,19,262
7.	Shelter Plantation –II (unit size-10 ha.) (Protection of agriculture lands and habitations)	69,075
8.	Raising & maintenance of plants in nursery for one year (unit size. 1.00 lakh plants)	1,83,751
9.	Maintenance of plants during the second year for 6 months (unit size. 1.00 lakh plants)	78,187

Constitution of Wc/Wa and Related Training

As per the guidelines issued by Ministry of rural development, Govt. of India, vide letter No.S-11033/3/98-DDP, dated. 10th December, 1998 – Para 5, constitution of village forests protection and Management Committee (VFPMC) in the form of village level organizations (VLO's) have been registered and they are functioning as watershed associations. Training and entry point activities were clubbed with actual work of sand dunes stabilization, shelterbelt plantation and afforestation activities, though some of the activities related to plantation have been demonstrated by the project implementing agency like :

1. Training on collection, belling and storage of grasses.
2. Training on nursery development and tree planting techniques through village nurseries.
3. Training on silviculture operations like pruning, weed removal

These training were organized at range levels and the details and actual dates were not available with them and/or not made available.

Role of Women in the Execution of Project

Major afforestation activities are executed through women as laborers (varying from 60 to 80 per cent). However, efforts are being made to give them more representation in VFPMCs and involve them in decision-making processes. Representation of women in decision making process has been negligible. This may be because of low literacy and prevailing traditional *Purda* system among the women, who generally avoid coming in the meetings and expressing themselves. Plantations are being raised on different types of types of wastelands available. Types of available wasteland are.

1. Degraded Gaucher and Orans

2. Saline –alkaline area
3. Barren rocky slops.
4. Active sand dunes with interdunal spaces.

These include village common land (*Oran* and *Gaucher*), bare sand dunes, panchayats wastelands, treeless rocky wastelands; heavy gully eroded areas and degraded village rangeland except some portion on forest land. There is a scarcity of water, shelter, fodder etc.

Compatible Methodology / Technique Used

The methodology adopted for soil and water conservation work is suitably laid at the site to manage the existing natural resources. Digging of contour or staggered trenches in the hilly tracts and V-ditches in the flatland are the measures adopted in the form of earthwork to improve soil and water status. The methodology adopted for the execution of work is based on the demand of local people, cost-effective technology and suitably matching with the topography of land.

On shifting sand dunes, soil conservation works against wind erosion are done through micro windbreaks of locally available dry materials of Kheemp (*Leptadenia pyrotechnica*), Bui (*Aerva persica*), Sinia (*Crotolaria burhia*), termed as mulching and also through live vegetative means like sowing of seeds of Phog (*Calligonum polygonoides*), Kheemp (*Laptadenia pyrotechnica*), Sewan (*Lasiurus sindicus*), Sonamukhi (*Cassia angustifolia*) etc. along the contour against the wind direction. Construction of wide trench-cum-bund enclosure (in hard soil only) is made to protect the plantations from the biotic interference. Digging of pits for planting of the seedlings and making of saucer (*thavla*) around the seedling are the other soil working done under the CDP. Construction of contour trenches in the areas having higher slope and hard surface for moisture conservation (wherever required),Gully plugging and construction of check dams wherever required, Construction of V–ditches on lands with gentle slopes as a moisture conservation measure (wherever required) with regular soil working in the saucer (*thavla*) are also made mandatory under this project. For creating awareness among the villagers and to ensure people's participation in the project, trainings have been organized both at Range and Division levels. In all the field offices viz. Range offices, the plantation records like survey maps, plantation journals, plantation schedule etc. were prepared and maintained properly.

Usefulness

The project was successful in following ways:

- There is increase in biological diversity after project implementation and protection of the area. Some indigenous species sprouted/regenerated after protection of the area even during failure of monsoon when most of the plantation activities in dry areas ceased. Some of the species may be endangered and/or of high value either in the term of gene bank or of medicinal in nature.
- Sand dune stabilization work under the project has benefited some of the farmers in the area. At sum range areas where earlier roads are blocked during summer region are now having clear roads due to stabilization of sand dunes on both sides of roads. Establishment of shelterbelt will be beneficial in improving microclimate and proving shade in the vicinity of the habitations. Adoption of different afforestation models increased the grass productivity particularly when the grass seed sown after deep plough in between the two rows of the planted seedlings as well as on the V-ditches.
- The poor villagers got the employment in afforestation works. They

collect the grass free of cost from the plantation areas and their requirement for cattle stall-feeding is met to some extent.

However there are still some constraints which owing to harsh conditions cannot be removed, however during execution of new programme for afforestation in desert, these should be kept in mind.

Constraints

- Because of extreme climatic conditions, raising of successful plantation is a difficult task in the district. The Scarcity of water along with uncertainty of employment and poor socio-economic condition prevailing in the region makes the area very harsh. The sand storms due to high winds in the summer drift the loose sand exposing the roots of planted seedlings and depositing the same on the young seedlings in adjoining areas. Successive droughts further aggravate the problem.
- *Citrullus colocynthis* (Tumba) and other cucurbits plants were found to grow naturally in most of the sites with sandy soils. But it provided a good shelter to the rodents, whose number multiplied enormously and have damaged the plantations (peeling A*cacia tortilis* as well as other plants shoots).
- The people's involvement is mainly limited up to execution of development works in the form of labour and initial planning as micro plan. Special emphasis needs to be given on involvement of women in afforestation and soil conservation works.
- The plantations are well protected from cattle through fencing / social fencing.
- However, three strand barbed wire fencing was not found effective against Chinkara and Blue bull.

- In some of the sites, the problem of rodent and termite both have affected the site too much, which have affected the growth and survival both .The plantation may be better protected with active involvement of VFPMCs and the villagers.
- The frequency of irrigation was less which may be one of the causes of mortality in the initial period of one to two year..
- The performance of *A.tortilis* in the project is found more satisfactory as compare to other tree species but the composition of other species specially the indigenous tree species like *T.undulata*, *P. cineraria* and *A.senegal etc* should be increased. Presently, the twigs or cutting material is being used for erection of micro windbreaks; it can be improved through live hedge windbreaks by seed sowing of *Cassia angustifolia, bui/sevan etc* in checkerboard design. The silvipastoral system and live hedge plantation of Euphorbia species and Acacia Senegal should also be increased.

Conclusions

The combating desertification programme has improved the desertic conditionand life .It was also useful in creating awareness and also generating employment to improve the economic condition of the harsh region. It is essential to utilize its fruit in sustainable way and by conserving the plantation so that our future generation can also reap its fruit.

Bio-economic analysis of soil and forest degradation processes in Arnigad micro watershed of Mussoorie-Dehradun, Uttarakhand (India)

Ram Chandra and Prafulla Soni*

Progressive Research Organization for Welfare (PROW),

Vishwakarma Colony,M.B. Road,New Delhi (India) -110044

* Advisor Restoration ecology & Biodiversity Conservation,Dehradun

Abstract

The Himalayas present a storehouse of biodiversity, where flora and fauna vary extensively with climate diversity from one region to the other. However, extensive commercial felling of forest for timber has been reported in the region, especially in the last few decades when urban centers began to grow in areas near the forests.

One of the big challenges is the natural resource dependence of the native population of the region, who are primarily agro-pastoral. The bulk of the region has dependence on livestock. The potential impacts of excessive grazing include depletion of the scarce forage for wildlife, habitat degradation and soil and forest degradation. The livestock population in the region has also increased during the recent past and problem of grazing in the high altitudes has acquired serious dimension, as a result the vegetative cover is decreasing which has resulted in the loss of top soil due to excessive erosion. Fuel wood and fodder constitutes the dominant source of energy and feed for livestock respectively in the region and population growth has contributed to increased exploitation of forests for meeting growing energy demands.To see the effects of human, livestock, grazing, fuel wood and fodder collection activities on absolute change in selected land use categories of forest i.e. dense forest, scrub forest and degraded forest during 1985-86 to 2005-06, a study was conducted in Arnigad micro watershed of Mussorie-Dehradun, Uttarakhand and hypotheses were developed; collected primary data was processed and analyzed through the linear and multiple regression models to predict the directional results of research indicating the impacts of demographic activities on the soil and forest ecosystems leading to their degradation.

Results of the study showed that at the difference of 20 years period from 1985-86 to 2005-06 developed hypotheses were found true in case of scrub and degraded forest. As the activities of grazing, fuel wood and fodder collection got increased then increase in forest degradation of the category degraded forest and scrub forest took place in Arnigad watershed. Increase in human as well as livestock population caused change in the land use categories and the forest degradation increased when the human and livestock population went on increasing. Increase in income from different sources of fodder, crop and animal husbandry caused the continuation of the use of resources and ultimately led to forest degradation. Soil degradation is aggravated by increased demographic pressure as well as grazing, fuel wood and fodder collection activities. It is inferred that when livestock population increases the extent of area under soil erosion also increases with the degree of increase in livestock population.

Keywords: Regression models, hypotheses, soil,forest degradation, micro watershed.

Introduction

The Himalayas present a storehouse of biodiversity, where flora and fauna vary extensively with climate diversity from one region to the other. If an attempt is made to divide the forests types based on the standard classification of tropical, sub-tropical, temperate and alpine, it becomes difficult to describe the rich diversity of the Himalayan forests. One-tenth of the world's known species of higher altitude plants and animals occur in the Himalayas (IPCC, 2001). However the rich diversity of Himalayas is now severely threatened and many species have become endangered on account of a variety of physical, biotic and strategic factors unique to the region. The loss in biodiversity has been largely on account of habitat losses, which in turn have happened due to deforestation, over-exploitation of resources, wetland drainage and filling, human settlements/encroachments, population growth, and species introduction. The rich endemic flora of the Himalayan region faces the threat of extinction due to degradation of forests and natural habitats for expansion of agriculture, river valley projects, industrial and urban development (MoEF, 1999).

The Himalayan region is characterized not only by ecological fragility but also by a deep and historical geopolitical sensitivity (Stone, 1992). An ecosystem based natural resource management approach is difficult to achieve as many countries share the resources of this mountain system. One of the big challenges is the natural resource dependence of the native population of the region, who are primarily agro-pastoral. The bulk of the region has dependence on livestock. The potential impacts of excessive grazing include depletion of the scarce forage for wildlife, habitat degradation, disease transfer and reduction in the breeding performance of both wildlife and domestic stock. This leads to livestock depredation by wild carnivores, which is a serious conservation issue in the Himalayan region. Land degradation in the Himalayas has also been caused by instabilities arising from the large-scale expansion of new roads and open cast mining (Stone, 1992). Soil erosion, especially the loss of fertile topsoil either by gully, rill or sheet erosion, formation of hardpans and the exposure to indurated horizons has led to large-scale deterioration of the resource base of mountain agriculture. This is manifested in the decline in the per capita availability of cropland, reduced availability of village commons (also called support land), fall in soil fertility and a decline in the carrying capacity of these areas. Large portions of arable land in the northern Himalayan states of Jammu & Kashmir and Himachal Pradesh have been rendered infertile and are in need of contingent soil and water conservation measures like contour farming, terracing, strip cropping, mulching, crop rotations, organic manuring, shallow ploughing etc. (Gupta and Banerjee, 1991). The prime cause for these can be attributed to the rate of exploitation of land resources, which has been higher than the rate of replenishment.

Forest areas in the proximity of population centres and villages are reported to be degrading faster due to collection of fuel wood and cattle grazing, as compared to forests away from population centres and located in inaccessible areas (FSI, 2000). Deforestation and degradation has been caused by commercial logging; clearing of forestland for settlements and agriculture; excessive exploitation of forests for fuel wood and food; and overgrazing. The denudation of fir and spruce forests in Himachal Pradesh and Jammu and Kashmir for making package cartons for apples is an example of the commercial exploitation of forests taking place in the region (TERI,1992). Fuel wood constitutes the dominant source of energy in the region and population growth has contributed to increased exploitation of forests for meeting growing energy demands.

Degradation of natural forests is a global problem (Guppy, 1984; Sayer and Whitmore, 1991). Mankind has been destroying forest for millennia ever since agriculture was discovered (William, 1989). In the

Himalaya too, deforestation is argued to be not a recent phenomenon, it has a long history, being well established in late eighteenth century at least (Mahat et al., 1986). In Himalaya, degradation of forest cover is a primary problem, which gives way to a variety of problems. With deforestation of slopes many environmental degradation processes like soil erosion, slope failures, depletion of soil fertility, scarcity of fuel wood and fodder, increased overland flows, reduced ground water recharge, loss of biological diversity are accelerated.

Study Area

Present study was undertaken to assess soil and forest degradation in the Arnigad watershed located in Uttarakhand, indicating towards the current status of the Arnigad watershed. The Arnigad watershed is situated in Dehra Dun district in the Mussoorie hills (Mussoorie Forest Division) of Uttarakhand state in India. Total area of the watershed is 13.39 km^2 and the elevation ranges between 836 meters and 2175 meters above MSL. This is a typical Himalayan watershed and lies between 30^0 23′25″ to 30^0 27′ 50″ North latitude and 78^0 05′ 05″ to 78^0 07′ 08″ East longitude.

The climate of the area is typically monsoonic with three distinct seasons, viz., summer, monsoon and winter. The watershed lies in sub-tropical zone with an average annual rainfall of 2150 mm. Monsoon normally breaks in the middle of June and lasts till middle of September. About 75% of the total annual rainfall is received from June to September. Winter rains are generally intermittent and mild. May and June are the hottest months with average maximum temperature of 38^0C. Minimum temperature recorded during December and January was 1-3^0C. Frost occurs during these months and sometimes causes damage to tender seedlings and vegetation.Land use pattern of the Arnigad watershed has been influenced by terrain, climate and biotic influence. Four land covers were founding the area, viz., well stock forest, degraded forest and scrub forest. Lower western Himalayan Temperate Banj Oak forest (12/C1a) and Northern Dry Mixed Deciduous Forest (5B/C2) are the forest types occurring in this watershed (Champion and Seth, 1968). In general the Quercus (*Quercus leucotrichophora*) forests were dense and well stocked occurring in upper most portions. The degraded forest land was predominantly occupied by *Lantana camara* and occupied an area of 85 ha. This species covered more than 90% of land in degraded forest and left little scope for other species to survive or establish. However, small number of *Murraya koengii* bushes was seen in this area. About 251 ha of the watershed area constituted scrub vegetation, representing degraded stage of the original forest that had been overexploited for fodder, fuel wood and timber. Scrub forests had a few highly lopped trees.

To see the effects of human, livestock, grazing, fuel wood and fodder collection activities on absolute change in selected land use categories of forest i.e. dense forest, scrub forest and degraded forest during 1985-86 to 2005-06, a study was conducted in Arnigad micro watershed of Mussorie-Dehradun, Uttarakhand and hypotheses were developed; collected primary data was processed and analyzed through the linear and multiple regression models to predict the directional results of research indicating the impacts of demographic activities on the soil and forest ecosystems leading to their degradation.

Methods

The study is based on the primary data collected through the Participatory Rural Appraisal (Mukherjee, 1993) approach by approaching the various representing different age groups and gender. This study is based on the statements and facts collected during 1985-86 and 2005-06 about the soil and forest degradation processes in the selected Arnigad microwatershed.

Bio-economic Analysis Based on Regression Models.

For bio-economic analysis of soil and forest degradation linear and multiple regression models were used.Regression equations were obtained to find out the significance of relationships of:

- Absolute change in forest land use categories with grazing, fuel wood and fodder.
- Absolute change in scrub land use categories with grazing, fuel wood and fodder.
- Absolute change in degraded land use categories with grazing, fuel wood and fodder.
- Land use categories with absolute change during 1985-86 and 2005-06.
- Land use categories with absolute change in livestock population between 1985-86 and 2005-06.
- Income with fodder, crop quantity and animal husbandry (milk selling).
- Absolute change in soil erosion area with grazing.
- Absolute change in soil erosion area with increasing livestock population between 1985-86 and 2005-06.

Hypotheses tested

In relation to the soil and forest degradation processes in the study area the following four main hypotheses were formulated for testing.

Hypothesis 1. Forest degradation is aggravated by grazing, fuel wood and fodder collection activities

Hypothesis 2. Increase in human and livestock population causes change or shift from dense to less dense forest categories of the study area.

Hypothesis 3. Increase in income from different sources of fodder, crop and animal husbandry causes the continuation of the use of resources and ultimately leading to forest degradation.

Hypothesis 4. Soil degradation is aggravated by increased demographic pressure as well as grazing, fuel wood and fodder collection activities.

Results

I.Bio-economic Analysis of Forest Degradation Based on Regression Models

Regression model for a change in degraded forest area in ha by variations of the grazing, fuel wood and fodder use/year in the villages of Arnigad Watershed

Hypothesis 1. Forest degradation is aggravated by grazing, fuel wood and fodder collection activities

Table 1. Coefficients and standard error for the intercept and the independent variables.

Sl. No.	Independent variables and intercept	Coefficients	Standard error
	Intercept	-1.64	0.634
1	Grazing	-4.15x 10-6	4.82 x 10-6
2	Fuel wood	2.79 x 10-5	6.74 x 10-6
3	Fodder	1.79 x 10-5	1.68 x 10-5
R2 = 0.90			

Regression equation for the degraded forest

Y = -1.646 - 4.15 x 10-6 *(grazing) + 2.79 x 10-5 * (fuel wood) + 1.79 x 10-5 * (fodder)

Y = Land use change in degraded forest in ha

90% variations in land use change were due to the grazing, fuel wood and fodder, keeping the other factors of natural origin constant.Observing the analysis of regression of absolute change in degraded land use category from 20 years to recent (2005-06) conditions it was found that by controlling the fuel wood and fodder then change in land use categories by keeping grazing value 1 gives to - 4.15 hectare. If grazing was increased 10 times (in a year or in ten year) then overall change in land use of degraded forest comes to - 41.5 hectare(Table 1). In the same way if grazing and fodder parameters were controlled then the fuel wood extraction from the degraded land caused a change of 2.79 x 10-5 ha if the fuel wood increases by 1 time. If the values of fuel wood go on increasing up to 10 times then the change in degraded land use categories rises to 20.79 x 10-5 ha. Now if fodder scenario was seen through this regression model then by controlling grazing and fuel wood, fodder extraction in1year gives the value of 1.79 x 10-5 ha. If the values of fodder were raised to 10 times then the value of 17.9 x 10-5 ha results to show the change in degraded forest. This shows that if fodder extraction goes on increasing then there will also be a change in the land use of degraded forest by the factor the fodder is extracted in years and in amount. If all the factors. grazing, fuel wood and fodder vary by the value of 10 then the total change in degraded land comes to be -1.645 ha. It is significant to conclude here that the area of the degradation was very less during 1985-86, but as the extraction of fuel wood and fodder and grazing and associated with increase in number of livestock go on increasing then the forest degradation scenario will be much worse.

Regression model for change in Scrub forest in ha by variations of the grazing, fuel wood and fodder use in kg per year

Table 2. Coefficients and standard error for the intercept and independent variables.

Sl. No.	Independent variables and intercept	Coefficients	Standard error
	Intercept	-0.76	1.335
1	Grazing	1.79 x 10-5	1.01 x 10-5
2	Fuel wood	6.11 x 10-6	1.41 x 10-5
3	Fodder	5.47 x 10-6	3.53 x 10-5
R2 = 0.84			

The equation for the regression model of scrub forest by the effect of grazing, fuel wood and fodder use in all the villages of watershed.

Y = -0.766 + 1.79 x 10-5 * (grazing) + 6.11 x 10-6 * (fuel wood) + 5.47 x 10-6 * (fodder)

Y = Land use change in Scrub forest in ha

84% variations in land use change in scrub forest were due to the grazing, fuel wood and fodder, keeping the other factors of natural hazard constant.

Observing the analysis of regression of absolute change in scrub forest between 1985-86 and 2005-06, it was found that by controlling the fuel wood and fodder then, change in land use categories by keeping grazing value 1 gave value of 1.79 x 10-5 hectare. If grazing level is increased 10 times (in a year or in ten year) then overall change in land use of scrub forest comes as 11.79 x 10-5 ha. In the same way if grazing and fodder parameters are controlled then the fuel wood extraction from the scrub forest becomes the cause of a change by the value of 6.11 x 10-6 ha, if the fuel wood extraction from scrub forest increases by a value of 1unit. If the values of fuel wood go on increasing up to 10 times then the change in scrub forest rises to 61.1 x 10-6 ha(Table 2).. Now if fodder scenario is seen through this regression model then by controlling grazing and fuel wood fodder extraction in 1year gives the value of 5.47 x 10-6 ha change (loss of vegetation). If the values of fodder are raised to 10 times then the figures of 54.7 x 10-6 ha makes it appearance to show that if fodder extraction go on increasing then there will also a change in the land use of scrub forest by the factor the fodder is extracted in years or raised amount of fodder from the scrub forest.

Hypothesis was found true in case of scrub and degraded forest. As the activities of grazing, fuel wood and fodder collection got increased then increase in forest degradation of the category degraded forest and scrub forest took place in Arnigad watershed

Regression model of change in dense forest in ha by variations of the grazing, fuel wood and fodder use in kg per year

The reason for the change is not significantly pronounced through 20 years is if in dense forest the trees were neither cut nor used for the fuel wood, fodder and grazing. These factors therefore, did not have significant effect on the change of dense forest category. Further it will be appropriate to predict that the land use change depends on the exploitation of other land use categories frequently to collect the fodder and fuel wood and for grazing purpose. So if scrub area and degraded area has enough green biomass in terms of fuel wood and fodder enough to provide the livestock the required feed then dense forest will not be affected. The degree of scrub and degraded forest are affected keeping constant the other uses than grazing, fuel wood and fodder in dense forest.

Hypothesis 2. Increase in human and livestock population causes change or shift from dense to less dense forest categories of the study area. Regression relationships of human and livestock population with the different land use categories.

Y (Agricultural area) = -0.102 + 0.148 * (Increasing human population)

Regression analysis was found significant for the effect of absolute change during 1985-86 and 2005-06 scenarios in the different land use categories of the Arnigad watershed(Table 3).

Table 3. Coefficient and standard error for the intercept and the independent variable

Sl. No.	**Independent variable and intercept**	**Coefficients**	**Standard error**
	Intercept	-0.102	3.67
1	Increasing population	0.148	0.049
R2 = 0.52			

Table 4. Coefficient and standard error for the intercept and the independent variable.

Sl. No.	**Independent variable and intercept**	**Coefficients**	**Standard error**
	Intercept	-1.54	1.040
1	Increasing population	0.061	0.014
R2 = 0.52			

Regression equation: Y (Degraded area) = -1.54 + 0.061* (Increasing human population)

When the regression analysis was performed it was found that if population increases then there is the change in population over an interval of twenty years increases a change in agricultural area by the degree population increase that is the area under agriculture. This can also be interpreted as the human population increases then the clearing of trees and shrubs etc. may lead to increase in agriculture area or construction activities in the watershed area.

Regression analysis was found significant for the effect of absolute change in population between 1985-86 and 2005-06 in the degraded land use category of the Arnigad watershed. When the regression analysis was conducted it was found that if population increases then there is a change in degraded area by the degree population increase that is the degraded forest show change i.e. it decreases (from still having vegetation to a state of less vegetation) by the change in population over an interval of twenty years(Table 4).In the scrub and dense forest the regression analysis was not found significant. This showed that by the change or increase in demographic pressure the most land use categories affected were the agricultural area and the degraded forest. The reason for why not the scrub and dense forest were affected could be interpreted as both the areas were far away from habitations and both the forest and the scrub area had sloppy topography, which the people of the villages avoided. Therefore conclusively the results showed that the agricultural and degraded forests were most affected by the population pressure due to their nearness and easy access to these areas.

Effect of increased livestock population on the different land use categories

Regression equation: Y (Scrub forest) = 0.560 + 0.0864 * (Increasing livestock population)'

Absolute change in livestock population between 1985-86 and

2005-06 showed highly significant impact on scrub forest. When scrub forest was regressed upon the livestock population it was found that if livestock population increases then scrub forest gets affected by the value 0.64 hectare for each one unit change in livestock population over the twenty years i.e. this value gets eroded in terms of loss of land of covered vegetation and 0.64 ha land will have chances of conversion to degraded land or most likely there will have a conversion from scrub forest to degraded forest(Table 5).. If there is two unit changes in livestock population then the change in scrub forest degradation comes to be 2.28 ha. So if the livestock population go on increasing regardless of time factor then there is a degradation of scrub forest there chances are that scrub forest may become devoid of vegetation and may be converted in degraded land.

Table 5.Coefficient and standard error for the intercept and the independent variable

Sl. No.	Independent variable and intercept	Coefficients	Standard error
	Intercept	0.560	1.204
1	Increasing Livestock population	0.086	0.021
R2 = 0.66			

Hypothesis may not be rejected as the increase in human as well as livestock population causes change in the land use categories and the degradation increases when the human and livestock population go on increasing.

Other land use categories did not show significant relationship with the increase in livestock population on agricultural area. This could be explained by the fact that the agricultural areas were used mostly for crops and livestock had not much role to play in agricultural area. In degraded forest as the time passed the vegetation might have not been suitable for the livestock and they changed their course of grazing from degraded to scrub forest. Though there was not much effect of livestock on the dense forest but as the vegetation of one area goes on decreasing in quantity and quality then livestock may move to dense forest to utilize the green resources of the forest. Although this trend may take long time gap but socioeconomic scenario as shown by this study indicated that if demographic and livestock pressure goes on increasing then there will have increased degradation in the land use categories of the Arnigad watershed.

Hypothesis 3. increase in income from different sources of fodder, crop and animal husbandry causes the continuation of the use of resources and ultimately leading to forest degradation.

Table 6. Coefficients and standard error for the intercept and the independent variables

Sl. No.	**Independent variables and intercept**	**Coefficients**	**Standard error**
	Intercept	15499.03	2932.75
1	fuel wood	0.93	0.018
2	fodder	1.62	0.03
3	crop	7.43	0.20
4	milk	274.17	8.71
R2 = 0.99			

Regression equation for total income from fuel wood, fodder, crop and milk;

Y (Total income) = 15499.03 +0.93 * (Fuel wood) + 1.62 * (fodder) + 7.43 *(crop) +274.17* (Milk)

When income was regressed on fuel wood, fodder, crop and milk as independent variables then the regression equation came as above and was highly significant in favour of total income from fuel wood, fodder, crop and milk sources. So if all the sources' value being 1 then the total income in Rs. results as 15,783.18 on annual basis. If fodder, crop and milk are controlled then the total income from fuel wood will come as Rs. 15,499.96. In the same way if fuel wood, milk and crop are controlled then one unit rise in fodder gives an output of Rs. 15500.65/annum and as fodder quantity/year changes then the output amount also gets changed(Table 6).. Now if fuel wood, fodder and milk are controlled then one unit rise in crop gives Rs.15506.46/annum. Finally if fuel wood, fodder and crop are controlled then total income from crop will give Rs. 15773.2. And fuel wood and fodder quantity in favour of livestock provides income in kind, as fodder is free for them, which is collected from forests of the region concerned.

This hypothesis can also be accepted as the overall results give the impression that as the income increases then there are also the usual activities of using fuel wood and fodder and keeping animals for generating income by regular exploitation or use of the forest resources.

While keeping and using the animals like goat, sheep and mules etc. income is generated through production of milk, meat and their use as means of transportation in the hilly areas of this watershed, collection of fuel wood, fodder and grazing gives them extra income in the form of kind (indirect income). As by collection of fodder, the cattle and other animals are fed. Natural source of green feed for the animals is satisfied by leaving them in the field directly (grazing) and most of the feeding is done in the field and partially by stall feeding (through collected fodder). Collected fuel wood is used for chulha for the routine activities like warming water and preparing food. Although all these activities give villagers the indirect income and if fuel wood and fodder collection is not practiced villagers would have to purchase these from the market or from other sources for which they have to pay.

II. Bio-economic analysis of soil degradation based on linear regression models

Hypothesis 4. Soil degradation is aggravated by increased demographic pressure as well as grazing, fuel wood and fodder collection activities.

Regression equation for absolute change in extent of soil erosion with grazing.

$Y = 3.37 + 4.24 \times 10^{-5}$ *Grazing

Y = extent of soil erosion

Regression coefficient was found significant for the absolute change in soil erosion with grazing between 1985-86 and 2005-06.When regression analysis was applied it was found that with increase in grazing there is change in the area under soil erosion(Table 7).

Table 7. Coefficient and standard error for the intercept and the independent variable.

Sl. No.	Independent variable and intercept	Coefficients	Standard error
	Intercept	3.37	2.41
1.	Grazing	4.24×10^{-5}	9.13×10^{-6}
$R^2 = 0.72$			

Regression equation for soil erosion with absolute change in livestock pollution between 1985-86 and 2005-06:

Y = 4.33 + 0.186 * livestock population

Y = extent of soil erosion

It is inferred that when livestock population increases the extent of area under soil erosion also increases with the degree of increase in livestock population. (Table 8).

Table 8. Coefficient and standard error for the intercept and the independent variable

Sl. No.	Independent variable and intercept	Coefficients	Standard error
	Intercept	4.33	2.64
1.	Increasing livestock population	0.18	0.048
R2 = 0.65			

Although the results of regression analysis were not found significant with increase in human population, fuel wood and fodder but soil erosion was observed in land use categories (degraded, scrub, dense forest, and cultivated site) from where the fuel wood and fodder was collected by the village people of Arnigad watershed.

Discussion

From a case study in Fulzari Village of Pench National Park in Central India (2002)significant regression analysis has been successfully achieved in that study the dependence on forest in Pench National Park was found highly significant with fuel wood and fodder. Fuel wood with estimate 6.839 (p-value 0.050) and fodder estimate 0.000180 (p-value

0.615). From the same study in Pench National Park the livestock was found dependable on forest and for this regression equation also showed significant results with estimate 0.219 (p-value 0.559).

In the current study fuel wood estimate 6.11 x 10-6 (SE-1.41 x 10-5) and fodder estimate 5.47 x 10-6 (SE-3.53 x 10-5) being significant in favour of fuel wood and fodder dependence on forestThe livestock dependence on forest is very high with estimate 0.0864 (SE - 0.021)

In the current study the linear regression model for human population on agriculture and multiple regression model of total income from the fuel wood, fodder, crop and milk (animal husbandry) had shown positive impact on the forests of the study area depicting the dependence on forest areas of the Arnigad microwatershed.

On the basis of the present investigation it can be concluded that the area has high potential in terms of number of species and communities. The occurrence of high number of herbs and shrubs replace the gaps created by felling /removal of trees in the area.

Following alternatives may prove to be significant in judicious management of such kind of watersheds:

- For maintaining the continuous supply of the quantity as well as quality of the fuelwood and fodder produce on sustainable basis, assisted natural regeneration of native species may be encouraged.
- Stall-feeding of livestock be promoted among the villagers.
- Optimum exploitation of natural resources based on scientific methods.
- For reducing the soil and forest degradation processes awareness regarding protection and conservation of natural resources is required.

Conclusions

The data and facts collected from the village population of Arnigad watershed during the years 1985-86 and 2005-06, gave a clear cut picture of the usage and consumption of fuelwood, fodder and livestock grazing and in addition the increase in human and livestock population and consequently increase in agriculture area. Usage of natural resource since a long time led to the increase in extent of area under soil and forest degradation.

Bioeconomic analysis of soil and forest degradation processes based on regression models in the selected watershed led to conclude that if increasing human and livestock population and grazing fuelwood and fodder collection activities continued then as the reqression models predict directionally that the area under soil and forest will degrade and will increase in extent. However, if proper education and scientific methods are applied to the rural communities then such situation can be controlled gradually.

References

Champion, H.G. and Seth, S.K. 1968. General Silviculture of India. Manager of Publications, Delhi

Guppy, N. 1984. Tropical deforestation. a global review. Foreign Affairs. 62407. 928-965.

Gupta, R. D. and Banerjee, S. K. 1991. Problems and management of soil and forest resources of north-west Himalayas. Mahajan Book Center and Publishers, Jammu. 162p.

IPCC, 2001. *Impacts, Adaptation and Vulnerability.* Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. James J McCarthy, Osvaldo F Canziani, Neil A Leary, David J Dokken, Kasey S White;

editors. Cambridge University Press. United Kingdom. 533-590 pp.

Kulkarni Anjali and Vaidya, V. M. (edit) 2002, Economics of protected area – a case study of Pench National park, Nagpur University, Nagpur

Mahat, T.B.S., Griffin, D.M. and Shepherd, K.R. 1986. Human impact on some forest of the middle hills of Nepal. I. Forestry in the context of the traditional resources of the State. Mountain Research and Development. 6. 223-232.

MoEF, 1999. National Forestry Action Programme - India. Volume 1. Status of Forestry in India. Ministry of Environment and Forests, Government of India. New Delhi. 177 pp.

Mukherjee, Neela. 1993.*Participatory rural appraisal. Methodology and applications*. Concepts Publishing Company, New Delhi.

Sayer, J.A. and Whitmore, T.C.1991. Tropical moist forests. destruction and species extinction. Biological Conservation. 55, 119-124.

State of forest report, 2000, Forest Survey of India, Dehradun

Stone, Peter B, 1992. State of the World's Mountains - A Global Report. Mountain Agenda. Peter B Stone, editor. 391 pp.

TERI, 1992. Energy, environment and sustainable development in the Himalayas.Proceedings of the National Workshop on Energy and Environmental issues in Mountain development. Held on 24-25 September 1991 in Shimla, India. Pradeep Monga and P. Venkata Ramana, editors. New Delhi. 202 pp.

William, M. 1989. Deforestation. past and present. In. Progress in Human Geography. pp. 176-208.

Urban Ecotourism for Promoting Stakeholder Participation in Urban Landscape Transformation

Govind Singh, Chirashree Ghosh, Mihir Deb*

Department of Environmental Biology, University of Delhi

Department of Geology, University of Delhi

Abstract

The world today is experiencing an unprecedented rate of urban population growth over the past century. Towns are being converted into cities and cities into mega cities and conurbations. The world population became more urban than rural on May 23rd, 2007 (NCSU, 2007). Consequently, cities are being reshaped and urban landscapes transformed to address economic globalization, handle intercity competition and to meet the requirements of post modernity (Gospodini, 2006). Effective landscape transformation and management requires adequate stakeholder participation. There is evidence that stakeholder participation in environment management can lead to more effective and durable decision making (Reed et al.2009). When this is applied to planning of urban landscapes especially in developing countries, one of the first issues faced is that of pseudo stakeholdership. This paper investigates the ownership crisis faced by the National Capital Territory (NCT) of Delhi and highlights the city's non-inclusive development as its consequence. The role of landscape is investigated from the point of view of Delhi being the capital-of- choice since recorded history. The landscape of Delhi consists of a broad spectrum of environments ranging from the city forests to highly modified artificial landscapes in certain parks (Khera et al, 2009). An attempt is made to correlate landscape management with enhanced ecosystem services in the urban setting of the NCT. To address the stakeholdership crisis which is characteristic in today's cities, and is felt more in Delhi due to its 'capital' nature, the technique of 'urban ecotourism' is explored. We present an experimental 'urban ecotourism' approach of linking natural heritage of Delhi with the citizens, after identifying stakeholders. We show how, with the use of suitable ecotourism tools, the lifelines of Delhi – Delhi Ridge and River Yamuna – have much more to offer and how such an intervention could be a win situation for all.

Keywords: Urban Landscape, Ecosystem Services, Delhi, Urban Ecotourism

Introduction

Urban ecotourism is a now evolving form of ecotourism which advocates the transition from simple enjoyment and satisfaction to stages of greater understanding, attitude change and more environmentally responsible behaviour (Orams, 1995) while living in a city. Although urban ecotourism is an emerging concept, its contents still cannot be clearly laid out. The significance of urban ecotourism in the rapidly urbanizing world order has been highlighted by several authors (Gibson, et al 2003; Higham & Luck, 2002; Kastelein, 2004; Wu & Wang, 2007). The objective of urban ecotourism can be defined very simply as nature travel and conservation in a city environment. Its consequences, on the other hand, can be drastic and very impactful. Sustainable tourism in Singapore city has transformed the garbage-strewn polluted waters of the Singapore River into a zone of recreation and entertainment in a little over three decade period (Savage et al, 2004). Urban environments have long been ignored by ecologists, so much so that ecological knowledge has contributed little to solving urban environmental problems (Grimm et al, 2008). In the rapidly urbanizing nations of Asia and sub-Saharan Africa, cities face another challenge of lacking stakeholders and an ownership crisis of varying intensity. Migration rate is high in these countries which lead to intensification of economic competition thus keeping citizens thoroughly involved in meeting their personal goals. Eventually, decisions of citizens become more and more governed by concerns related to securing household livelihood rather than with a landscape sustainability view. Consequently, landscape users in a city lose sight of important landscape properties such as water flows, soil organic matter movements and landscape diversity. Those who move in to a city from a village or town, do so with hope and aspiration of a more prosperous future. This section of the urban society, which includes all economic strata, may have even lesser appreciation for urban landscape components, especially if these are of no direct benefit to them. However, it is not just 'pure economic gains' mindset but also ignorance about the city and its environment which creates such pseudo stakeholders in the evolving cities of today.

The European Landscape Convention (Déjeant-Pons, 2006) defines landscape as "an area of land, as perceived by people". This lays a greater emphasis on identifying and adequately involving stakeholders for landscape modification and governance. Studies indicate that the views of specialists, as reflected in planning policies and documents presently in force, may not necessarily match up with those of the population at large (Reed, 2008). Consequently, stakeholder participation is increasingly sought and embedded into environmental decision-making processes, from local to international scales (Stringer et al., 2007). For example proponents proposing large projects that may have considerable environmental impact need to carry out a comprehensive Environmental Impact Assessment (EIA) under the Ministry of Environment & Forests, Government of India's guidelines. These guidelines have considerable room for public hearing as is elaborated in the modified EIA Notification (Paliwal, 2006). In India, participating in environmental decision- making is increasingly becoming regarded as a democratic right. The proliferating environmental interest groups are exercising this right in the form of Public Interest Litigations (PIL) and filing Right to Information (RTI) applications. However, participation is a process where individuals, groups and organisations choose to take an active role in making decisions that may or may not affect them. Such individuals, groups and organisations may or may not have a say in the decision making process when it comes to specific landscape transformation. For the purpose of efficiency, this paper understands the stakeholder as those who are affected by and can affect a decision. This definition of the stakeholder, as against engaging with the wider public in meaningful dialogue, is more result oriented (Wandersman, 1981).

The lack of suitable participation by stakeholders is making the urbanization process less inclusive and unsustainable. In India, where the urbanization process is more intense and prominent, unsustainable urban development is closely linked with inequity and deteriorating quality of life. Delhi, the capital of the world's largest democracy and the second most populated country is also grappling with the urbanization challenge. The annual growth rate of the population of Delhi during 1991-2001 was 3.85% (Annonymous, 2007-08), which is double the national average. The increase in the population of Delhi from 4 lakhs in 1911 to 137 lakhs in 2001 exerted understandable pressure on the urban landscape and has transformed it immensely. Landscape components like the Delhi Ridge and River Yamuna, which are also the lifelines of Delhi, are being consumed rapidly. The heritage trees and green spaces are being replaced by high-rises. The transformation is largely facilitated by government policy of zoning and master planning owing to lack of stakeholder identification and challenges discussed above.

This paper discusses an innovative experiment of using urban ecotourism for addressing the ownership crisis in Delhi city. Through guided tours of Delhi's landscape hotspots, citizens' rendezvous with sites of ecological significance is used to create better informed and more responsible citizens. Through four urban eco-bus tours, carefully selected citizens were invited to explore the natural heritage of Delhi and reconnect them to the city's landscape. Two natural landscape features, Delhi Ridge and Yamuna River remained central to these urban ecotours. Landscape transformation with respect to other urban environmental parameters such as waste, transport, energy, and the larger realm of urban planning was also included in the urban ecotour. As citizens witnessed hitherto unknown urban landscape features and transformations, environmental problems became more real to them and solutions began to surface from within the group. Cities are the future of the world and only those nations who can sustain their urban growth, will grow and prosper in a sustainable manner. This requires respecting the natural landscape of the region especially while making decisions that may impact landscape features irreversibly. This in turn requires a civil society comprising better informed and more responsible citizens, creating which is the primary objective of urban ecotourism.

Stakeholder Crisis in Urban Landscape Transformation

Cities are the greatest of human inventions and grow in complex ways due to their sheer size, social structures, economic systems, geopolitical settings and the evolution of technology (Kennedy et al, 2007). The process of urbanization has occurred unevenly across the globe with North America, Europe and Australia already having most of its population living in urban areas. Latin America, North Africa and parts of the Pacific Rim such as Japan are also quite urbanized. These countries have a relatively slow rate of urban population growth today (McDonald et al, 2009). In contrast, Asian and sub-Saharan African countries are currently mostly rural, and are on the steady path of urban growth. Urbanization, which is the longest lasting impact of the industrial revolution, has now become its driving force in the developing economies of Asia and Africa. This has made urban areas hotspots that are driving global environmental change (Grimm et al., 2008). Urban metabolism, defined as the sum total of the technical and socio-economic processes that occur in cities, resulting in growth, production of energy, and elimination of waste, is steadily increasing (Kennedy et al., 2007).

Urban landscapes today are being transformed to accommodate the needs of rapid urbanization and increasing urban metabolism. Urban landscapes affect multiple actors and agencies and are typically complex, which makes their transformation uncertain. This demands transparent decision-making that is flexible to changing circumstances, and embraces a diversity of knowledge systems and values (Reed,2008). Urban landscape management for sustainable urban development is therefore a key contemporary challenge.

Cities and Sustainability

"We cannot confine ourselves to the so-called "natural" entities and ignore the processes and expressions of vegetation now so abundantly provided by man. Such a course is not scientifically sound, because scientific analysis must penetrate beneath the forms of the "natural" entities, and ecology must be applied to conditions brought about by human activity." - A. Tansley (1935)

Cities have been the cradle of human civilization, the birth place of ideas, innovation and the creative class. Urban centers have been the drivers of economic growth especially since the industrial revolution. The economies of scale work with the large population inviting synergy which facilitates the growth process. Since urban sustainability is complex and desired state, understanding urban ecology is crucial to sustaining the growth of our cities. The challenge is to develop a highly interdisciplinary approach which can bring together various skill sets in the mighty task of making our cities work (Mcintyre et al, 2000).

For most of the twentieth century, ecologists shunned urban areas with the result that ecological knowledge has contributed little to solving urban environmental problems (Grimm et al, 2008). Two major reasons for this are lack of interdisciplinary interest and ecologists' pre-occupation with conventional ecological practices. This is no longer the case and a shifting trend is apparent since the last decade. Simultaneously, the world is witnessing a need based interest in carrying interdisciplinary research.

As a result of this shift, ecologists are now exploring unexploited opportunities for research (McDonnell and Picket, 1990), discussing special features of urban ecosystems (Rebele, 1994), asking whether there is a need for a theory of urban ecology (Niemela, 1999), laying down integrated approaches to long term studies of urban ecological systems (Grimm et al, 2000) and even asking if it's time to include marine realm in urban ecology (Bulleri, 2006). However, there is still uncertainty on the difference (or for that matter similarity) between urban and human ecology which stems from the fact that the urban environment is human dominated (Mcintyre et al,2000). The larger fact remains that urban ecological research has begun and answers to some ecological challenges like biodiversity conservation, water quality monitoring, ecosystem management and other biotic and abiotic interactions can now be expected.

Every city and urban region is not standalone and depends for its existence and growth on a globally diffuse productive hinterland several times its size (Rees,1997). At the same time, phenomena such as “sprawl”, “endless city”, “edge effect” are all pushing cities beyond their limit and transforming large metropolis into mega cities, conurbations and mega regions. This global trend towards urbanization and a simultaneous threat of climate change is destabilizing national, regional and local environmental security and posing difficult challenges in sustaining cities and making them work.

Stakeholder participation

Stakeholder participation in urban setting has three fundamental issues that interfere in the decision making process. 1) It is only recently that urban ecological studies have gained momentum. We do not fully understand ‘nature in the city’ and the ecosystem services that urban landscape provide (Grimm et al, 2008), 2) Because of the rapid pace of urban life due to the sheer size, structure and working of modern day cities, citizens become short sighted and oriented towards achieving their personal goals. They have little time for participating in anything other than daily chores as cut-throat competition in every aspect of city life keeps citizens entirely self- consumed, and 3) World over, there is a consistent phenomenon of shifting to urban region in search of better livelihood opportunities and ‘unlimited’ resource availability. The city is, of course, an illusion for many who move in with hope and aspiration for a more prosperous future. Their attitude is that of demanding and few, if any, realize that they also have to give to the city, in some form or the other. Such migrant citizens become pseudo-stakeholders and also reduce the probability of participation of other citizens as immigration intensifies competition.

The concept of landscape is characterized by the importance of individual interaction with place, incorporating both physical and metaphysical aspects, with social, cultural and artistic associations (Phillips, 2000). Cities are a unique platform where people from various culture, communities, economic strata and educational backgrounds come together. Different people may perceive a place in different ways at such a confluence thus making formulation of landscape policy difficult. In spite of this, decision-makers need to formulate strategies, plans and policies that will apply to one and all. The best way to ensure inclusive planning is a participatory policy formulation. A process is needed which rationally seeks to focus on addressing such difficulties by building consensus and addressing conflicts (Conrad et al, 2009). Stakeholder involvement in cities is, however, easier said than done. The process faces difficulty in every step, from identifying stakeholders to involving them in an appropriate manner. The scope of this paper does not make it possible to examine the development and application of stakeholder theory in urban settings. What can be said for now is that measures are required to understand the expansion of cities with respect to biological as well demographic change. And it needs to be ensured that urban change is conducive, productive and in the best interest of all the stakeholders.

Urban Ecotourism as an Ecotourism Sub-set

Ecotourism or ecologically sound tourism is defined as ''small-scale travel to natural areas that conserves the environment and improves the well-being of local people'' (Annonymous, 1990). As is the case with most definitions, multiple debates exist over the most accurate definition of 'ecotourism'. However, the basic principles of conserving nature and benefiting local communities are the central focus of all existing definitions. The term ecotourism (or ‘eco-tourism’) first began to appear in English academic literature only as late as the 1980s (Weaver and Lawton, 2007). The year 2002 was declared as the International Year of Ecotourism (IYE) by the United Nations and a specialised peer-reviewed *Journal of Ecotourism* was established in that year. Ecotourism as a field of academic enquiry has now come of age in the little over three decades of its existence. The field is interdisciplinary and will therefore take time and efforts before it can begin to deliver. Ecotourism is now being viewed as effective for promoting the conservation of endangered species and habitats in developing countries (Bookbinder et al, 2008). Ecological economics tools such as contingent valuation and cost-benefit analysis indicate that ecotourism can contribute to safeguarding biodiversity and ecosystem functions (Gossling, 1999). According to Grenier et al (1993), the simultaneous growth of environmentalism as reflected in the high level of international participation at the 1992 Earth Summit and of the $2.75 trillion world tourism industry in that period focused attention on the ideals of sustainable development and ecotourism and created a niche for landscape architecture and planning.

Urban ecotourism is the extension of ecotourism concepts to urban settings. While the fundamental principles of ecotourism apply to urban ecotourism, there is a key difference between the two. Ecotourism usually brings a set of new individuals to a region of ecological interest, and in the process adds another set of stakeholders. Such individuals become better aware of the issues and challenges of respective ecological spots and help raise awareness in places where they originally reside. Some of these individuals may actively engage with the communities and ecosystems. Urban ecotourism, of the kind being presented in this paper, is more meaningful when it engages the existing stakeholder of a region (the city). The target group for urban ecotourism is the resident of the same urban setting where it is being implemented. While ecotourism could well have negative impacts of various kinds, we need not worry about that in case of urban ecotourism because of its intra-city nature. Likewise, a characteristic difference between ‘urban ecotourism’ and ‘urban tourism’ is that the latter usually invites tourists from places other than the city in which it is implemented.

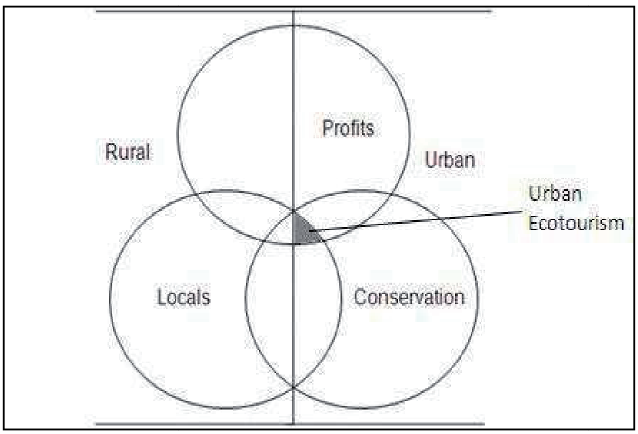


Figure 1. The realm of urban ecotourism as a sub-set of ecotourism

Delhi- The Great Urban Sustainability Challenge

The NCT of Delhi is spread in an area of 1,483 sq. km, lying between latitude 28°24′17′′ to 28°53′00′′ N and longitude 76°50′24′′ to 77°20′37′′ E, of which 558.32 sq. km. is designated as rural and 924.68 sq. km. is designated as urban (Economic Survey of Delhi, 2007-2008). The maximum length of the NCT is 51.9 km and the greatest width is 48.5 km. It shares its border with Haryana and Uttar Pradesh and the Yamuna River and terminal part of the Aravalli hill range are the two main geographical features of the city. The Aravalli hill range is covered with forest and is called the Ridge while the Yamuna is Delhi's main source of drinking water and a sacred river for most of its inhabitants. Also known as the lifelines of Delhi, the Ridge provides natural protection while the river is a perennial source of water right at the gateway to the vast Indo-Gangetic plains. The historical seven cities of Delhi have been cradled by these two features which made Delhi the capital of choice for many a rulers. Present day Delhi has grown beyond and above these features even as these remain the source of meeting the city's basic need of fresh air and water.

According to the Census of India 2001, Delhi was the third most populated city in the country followed by Mumbai and Kolkata. However, due to the spatial advantage not available to Mumbai and Kolkata, Delhi is expanding on all sides with much pace. The city had already overtaken Kolkata and if it continues to grow with the current pace, it will soon enjoy the status of India's most populated city. In order to better manage the National Capital Territory (NCT) of Delhi, a Gazette notification in 1996 divided it administratively into 9 districts and 27 sub-divisions. The NCT of Delhi is most urbanized among all states and union territories in India with 93 percent urban population. The national percentage urban population figure stands at 27.8 (Census of India, 2001).

Cities of today, especially in the developing economies, are acquiring an economic, cultural and literary identity of their own; at times even independent of the identity of the country in which they are located. Delhi, being the National Capital, enjoys a more affluent status in the country which it has also come to exploit. The population of Delhi has grown from 137 lakhs in 2001 to estimated 166 lakhs in 2007 (Annonymous, 2007-08). The now urbanising city has a greater resource demand which is no longer proportional to the increasing population alone. Urbanisation is slowly yet surely accompanied by an increase in per capital demand levels. Delhi'resource demand today is a measure of the affluence of the city. An improvement in living standards and providing of urban-styled basic needs such as all time water supply, access to more units of energy, better transport facilities and greater access to sanitation facilities, etc. all adds greater pressure on the urban landscape. Access to better health facilities has increased life expectancy in Delhi, which, along with the net in-migration to the city has led to a tremendous increase in the city's population. Skewed overall development of the country is another factor which forces migration to Delhi. Sustaining the urban development of Delhi has therefore become a great challenge today, one that needs to be addressed in a role model manner for sustaining our national urban growth.

Since the independence of India in 1947, the now 100 year old capital city of Delhi has formulated three Master Plans aiming at sustainable urban development. The Planning Department of GNCT defines a Master Plan as a long term perspective plan for guiding the sustainable planned development of the city. This document lays down planning guidelines, policies and development code and space requirements for various socio-economic activities during the plan period. It is also the basis for all infrastructure requirements. There is, however, a need for making the process of Master Plan formulation more inclusive to avoid problems encountered in the administration of the Plan (Datta and Jha, 1983). It may be noted here that the Government of NCT of Delhi has now begun to use its affluence and political influence to source resources such as water from as far as the Giri River (MPD 2021,2007). A crucial aspect of sustaining urban growth is to ensure that it is equitable and for all sections of the society. The natural landscape of the city must be respected after appreciating the ecosystem services it provides. At the same time, the use of landscape by all sections of the society must be understood and analyzed for sound urban planning and policy formulation. Stakeholder identification and involvement needs to move beyond just placing an urban modification notice in a national daily. Changes will have to be made both at the policy maker as well as stakeholder level.

Urban Ecotourism in Delhi

Four urban ecotourism trips were organised in Delhi from December, 2008 to March 2009 time period. Each tour covered a respective geographical area that spread over one or two districts. The districts covered included. North/North-west (North city ecotour), East/Central (Central city ecotour), South/South-west (South city ecotour). A fourth city ecotour was organised on World Water Day to explore the relationship between water and urbanization with respect to urban metabolism of River Yamuna.

Methodology

A month long detailed reconnaissance was made of the urban landscape of Delhi to identify sites of ecological significance. Research on the ecosystem services provided by the selected landscape features was carried out. A standard public transport (Delhi Transport Corporation) bus was hired for the urban ecotours, with an objective of promoting the use of public transport with the citizens. The total number of selected sites was analyzed for the time required to spend on each of these sites and the travel distance between them. Based on this analysis, the ecotour was distributed over a period of three days and into three zones. North, Central and South. An additional ecotour was organised on the theme of water and urbanization, based on popular request after the conclusion of the first three ecotours.

Outreach work was carried out to promote the urban ecotours with the target stakeholder group in mind. Various forms of media were used to involve the section of society which has access to them. The Department of Environment, Govt. of NCT of Delhi was approached to provide a half page advertisement of the ecotour in city wide newspaper. Media houses and radio channels were contacted to list and announce the urban ecotours.

Table 1. Description of pioneering urban ecotours.

S.	**Ecotour**	**Urban ecotour sites**
1.	North city ecotour	(1)Vishwavidyalaya Metro Station – (2)Kamala Nehru (North
2.	Central city ecotour	Max Mueller Bhawan - Agrasen ki Baoli - Yamuna River - Ghazipur Landfill - Sanjay
3.	South city ecotour	Max Mueller Bhawan - Agrasen ki Baoli - Bhuli Bhatiyari Park
4.	Water and urbanisatio	Vishwavidyalaya Metro Station – Jheel inside Kamala Nehru

An announcement of the ecotours was made in the active online groups comprising members who discuss city's issues and problems. The registration for the urban ecotours was done online and at certain strategic public places in the city. A total of 960 registrations were made for the ecotours, and 50*3, 150 people were randomly selected from this. An additional 50 individuals were later selected for the fourth urban ecotour in a similar manner.

Delhi Landscape and Ecosystem Services

A comprehensive research was carried out for identifying landscape features in Delhi that provide useful ecosystem services. Table 1 illustrates the different sites selected for the three pioneer urban ecotours. A detailed profile of the North city ecotour is provided to better explain it from the landscape – ecosystem services – ecotourism perspective.

For the North city tour, the Vishwavidyalaya Metro Station (1) was the site for initial gathering and boarding the bus. The significance of Delhi Metro as a mass transport system was highlighted at the gathering point (Siemiatycki, 2006). The Metro versus road transport debate was put forward in the Delhi context. The number of cars taken off the road by the introduction of the Metro was showcased along with the cycle hiring facility at the Metro station. The Kamala Nehru Ridge (2), the Northern extension of the Aravalli hills in Delhi, was chosen as the next destination. The Delhi Ridge was afforested between the time period of 1883 and 1913, receiving stimulus in 1911 with the decision of the transfer of the British capital to Delhi (Mann and Sehrawat, 2008). The more apparent role of the Ridge in regulating air quality was discussed. The role of the Delhi Ridge as a water manager was explained particularly in the light of urbanization impacting ground water quality and quantity in Delhi (Trivedi et al, 2001). Focused work on studying the relationship of urban environments and ground water quality has now begun (Deb, 2009). The North Delhi (Kamala Nehru) Ridge is located adjacent to the University of Delhi and was the site of action for the 1857 revolt against the British rule in India. It therefore has a historical significance characterized with the presence of structures like the Flagstaff Tower and nomenclature such as ‘Khooni Khan Jheel’. The entire stretch of the Delhi Ridge is known in popular writing as ‘green lungs’ of Delhi. The vegetation on the North Ridge helps mitigate the impact of vehicular air and noise pollution giving a serene ambience to the university and neighbouring areas.

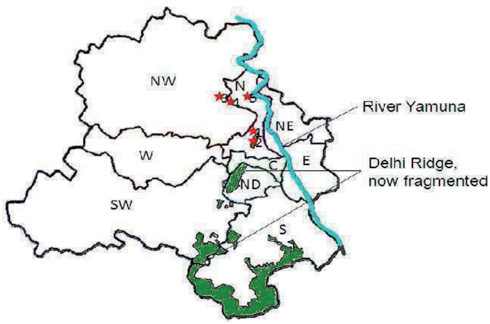


Figure 2. District map of the NCT of Delhi showing River Yamuna and Delhi.

Ridge and Sites of the North City Ecotour

The Ridge supports an array of urban biodiversity including rich avian diversity but a detailed study of the impact of urbanization on urban biodiversity is wanting. Several studies in the country have focused on changes in bird populations and distribution in natural habitats, but very few have attempted to investigate the impacts of urbanization on birds (Urfi, 2006). The Ridge forest is dominated by the invasive *Prosopis juliflora (videshi keekar)* planted by the British which is now leading to an ecological crisis of varying magnitude. While there is much that can be said about the Ridge’s usefulness to Delhi, only an overview was provided during the ecotour keeping the audience in mind.

The next destination for the North city ecotour was the Bhalswa landfill (3), one of the three centralized landfills in the NCT of Delhi. The landfill is now overflowing and the leachates from the waste have also contaminated the regions' ground water (Jhamnani and Singh, 2009). The focus of the urban ecotour here was to let the citizens witness the consequence of the waste generated at the household level. While emptying our dustbins at the local municipal collection center, it is important to realize that out of sight does not mean out of mind in this case. Bhalswa landfill, located at by-pass to the main city, has become a landmark for many who frequent the neighbouring state of Haryana North of Delhi. The stench from the landfill is a sign for many roadways commuters that they are now entering Delhi. Thus, the importance of effective waste management and the success of interventions such as segregation and reduction at source were highlighted at this site. The contribution of Landfill gas, a mix of primarily CO_2 and CH_4, emitted during the decomposition of organic waste, to global climate change was also discussed (Talyan, 2007), along with the difficulty in its inclusion in city based GHG inventory preparation and management (Ghosh,2009). Adjacent to the Bhalswa landfill, along the Supplementary drain, is the centuries old Bhalswa lake and an *Acacia* woodland (4). This became the next site on the North city ecotour. The landscape view of the lake with the hill in the vicinity is interesting but not attractive since the hill comprises waste and the lake sewage fed. Bhalswa lake is a Delhi Tourism water sports site but the quality of water in which kayaking and boating has been allowed is concerning. The close by *Acacia* woodlands is inhabited by a herd of *Boselaphus tragocamelus* (Nilgai), the biggest Asian antelope. Participants were informed about how the name 'Nilgai' (Blue cow) has helped in the conservation of this wild animal as farmers consider it holy and do not harm it.

The final destination for the North city ecotour was selected to be the Yamuna Biodiversity Park (5), a joint venture of the Delhi Development Authority and the University of Delhi. The Yamuna Biodiversity Park (YBP) is spread over an area of approximately 457 acres near Wazirabad village on the flat alluvial plains of River Yamuna. The Park acts as a natural conservation site for specific group of endangered plants and comprises locally extinct native flora and fauna of Delhi. It is an open environmental laboratory and an excellent demonstration of landscape reclamation. The region has high soil salinity which is being addressed using phytoremediation and landscape management measures. YBP has two zones, the visitor zone and the nature reserve zone. The landscape of the Park is so designed that rain water is diverted to any of the two wetlands that host a diversity of migratory birds. A Nature Interpretation Center (NIC) and presence of field biologists at the Park makes it an excellent venue to observe nature in the city (YBP, DDA). YBP gives an interesting insight into the 'web of life' demonstrating different trophic levels and showcasing nature in action. The importance of wetlands, trees, birds, insects, water, air, soil can all be understood through strategically designed walks in the YBP.

Discussion

The Urban Ecotourism project in Delhi received considerable attention and participation from the target section of the society. Participants on the urban ecotour showed good interest in exploring the natural landscape of Delhi and understanding the ecological significance of landscape diversity. Most of the selected sites were visited by the participants for the first time through the medium of the urban ecotour. This category of participants also included those who had been living in the city for more than a decade. During information dissemination and consequent discussions, it became evident that a greater percentage of the participants were familiar with environmental problems and challenges. However, not all of them understood their relationship with the landscape features, especially in the case of waste and water pollution.

An interesting observation was made during the visit to the Bhalswa and Ghazipur landfill sites. While the participants walked towards these sites, and even before they were briefed, it was observed that they discussed the issue of waste among themselves, highlighting all relevant aspects. While returning from the landfill, and after the briefing, the discussion was oriented towards finding and implementing solutions in their respective households and Resident Welfare Associations (RWAs). It was felt that though urbanized, citizens will be able to work better in case of managing common property resources like water, clean air and surroundings if they are brought together. The latter is, however, challenging. Keenness of participants towards understanding solutions and wanting to know more about available options for reducing pollution was developed during the urban ecotour. This showed how, with greater information dissemination, good difference can be made in the city.

To elaborate more on this, many of the participants volunteered active participation in environmental initiatives towards the conclusion of the tour. The experience of exploring the local landscape motivated some to sketch, photograph, plan future excursions and video-document the urban landscape diversity. The creative class in the city, that also had representation among the participants got considerable food for thought during the urban ecotours. This is noteworthy as it is now believed that a creative city is actually a more productive one. Local, national and international media also showed interest in covering the first ever urban ecotour experiment in Delhi (Express News Service; Dastidar, HT; Sinha,

N. (IE); Shoba, V. (IE).

The urban ecotours presented in this paper were organised free-of-cost, with support from the Delhi Greens organisation. However, an on the spot willingness-to- pay (WTP) and willingness-to-accept (WTA) survey, along with tour feedback indicated that organising such tours could be a profitable venture. 85% of the participants agreed to pay reasonable fees for taking similar urban ecotours in Delhi. The remaining 15% participants mostly comprised students. Participants also suggested that such urban ecotours could be organised with schools, colleges, corporate houses and even government agencies at nominal fees. It can therefore be concluded that an urban ecotourism model, as discussed in this paper, can help generate considerable environmental awareness among people living in the city. At the same time, it could also be a profitable venture and has scope for generating green jobs in the process.

Conclusions

Cities are the future of human civilization making it imperative to ensure their health and sustainability. Rapid urbanization is exerting tremendous pressure on urban landscapes of existing and emerging cities, especially in the developing world. Delhi is no exception and is witnessing urban landscape transformation in order to accommodate the needs of an ever growing population with increasing consumption patterns. The struggle to survive and prosper in the fast pace of city life is resulting in cities facing severe ownership crisis. Urban ecotourism could be a useful tool to generate awareness, imbibe ownership in citizens and earn revenue while ensuring the conservation of urban ecosystem components that provide critical ecosystem services.

Ecotourism is a fast maturing field whose capacity to meet its ascribed objectives is increasingly being enhanced. Urban landscape transformation is both an apparent and irreversible trend. It takes place in cities which are known more as regions of social than ecological interactions. While urban ecotourism is a burgeoning subject in the research of ecotourism, more attempts are needed to interpret its contents. However, it is certainly a promising field that provides a useful tool for creating more effective and empowered stakeholders which is absolutely essential in sustainable landscape decision making. Advances in the field of urban ecotourism could well shift the focus from only urban areas to suburbs or surrounding rural areas proportionate to individual city's ecological footprint.

Acknowledgement

The authors acknowledge the support of the Delhi Greens organisation and involvement of the Department of Environment, Government of NCT of Delhi in providing logistics and extending promotional support respectively.

References

Annonymous 1990 The International Ecotourism Society http.//ecotourism.org/ Accessed on 01 Jan. 2011.

Annonymous 2007-08. Department of Planning., Government of NCT of Delhi-8.

Bookbinder, M.P., Dinerstein,E., Rijal,A., Cauley, H.,Rajouria,A. 1998.Ecotourism's Support of Biodiversity Conservation. Conservation Biology 12(6). 1399-1404.

Bulleri, F. 2006. Is it time for urban ecology to include the marine realm? Trends Ecol. Evol. 21, 658–659.

Census of India, 2001. Ministry of Home Affairs, Government of India.

Conrad, E., Christie, M., Fazey, I. 2009. Incorporating people's perception into landscape planning. Ethical challenges in dealing with diversity of opinion within a community. Retrieved on. 28th December, 2010, Retrieved from. http.//www.inter-disciplinary.net/Dastidar, A. “Delhi’s Saturday Greens” Hindustan Times (11 Dec. 2008)

Datta, A., and Jha, G.1983. Delhi. Two decades of plan implementation. Habitat International. 7(1-2). 37-45.

Deb, M. 2009 Report. Spatial distribution of PTE and other pollutant ions in the ground water in varied urban environments of NCT, Delhi. School of Environmental Studies, University of Delhi. Supported by Department of Environment, GNCT of Delhi

Déjeant-Pons, M. "The European Landscape Convention" Landscape Research (31.Apr. 2006. 02 Jan. 2011). Retrieved from. http.//www.informaworld.com/10.1080/01426390601004343

Express News Service. “Hop onto bus, connect with environment” (12 Dec. 2008). Express News Service. How green was my city. eco-tourism on wheels shows impact of pollution” Indian Express. (14 Dec. 2008).

Cuddihy G, C., , J.,Engel-Yan, J. 2007. The changing metabolism of cities. Journal of Industrial Ecology. 11(2). 43-59.

Ghosh, C. 2009 Report. Inventorization of Greenhouse gases – sources & sinks in Delhi. School of Environmental Studies, University of Delhi. Supported by Department of Environment, GNCT of Delhi

Gibson, A., Dodd, R., Joppe, M., & Jamieson, B. 2003. Ecotourism in the city?Toronto’s green tourism association. International Journal of Contemporary Hospitality Management, 15(6), 324–327.

Gospodini, A. 2006 Portraying, classifying and understanding the emerging landscapes in the post-industrial cities. Cities. 5. 311-330.

Gossling, S. 1999. Ecotourism. a means to safeguard biodiversity and ecosystem functions? Ecological Economics. 29(2). 303-320.

Grenier, D., Kaae, B.C., Miller, M.L., Mobley , R.W. 1993. Ecotourism, landscape architecture and urban planning. Landscape and Urban Planning 25(1-2). 1-16.

Grimm, N.B., Grove, J.M., Pickett, S.T.A., Redman, C.L.2000. Integrated approaches to long-term studies of urban ecological systems. BioScience. 50(7). 571-584.

Higham, J., & Lu¨ ck, M. 2002. Urban ecotourism. a contradiction in terms. Journal of Ecotourism. 1(1), 36–51.

Jhamnani, B. and Singh, S.K. 2009. Groundwater Contamination due to Bhalaswa Landfill Site in New Delhi. International Journal of Environmental Science & Engineering. 1(3). 121-125.

Kastelein, B. 2004. Urban ecotourism. impossible conundrum. Business Mexico. 10.36–42.

Khera, N., Mehta, V., Sabata, B.C.2009. Interrelationship of birds and habitat features in urban green spaces in Delhi, India. Urban Forestry & Urban Greening. 8.187–196.

Mann, M. and Sehrawat, S.2008. A City With a View. The Afforestation of the Delhi Ridge, 1883–1913. In. Modem Asian Studies. 1-28. Cambridge University Press

Master Plan of Delhi (MPD) 2021, 2007. Notified by the Ministry of Urban Development, Government of India (Delhi Division). Vide S.O. 141. Mcdonald, R.I., Formanb, R.T.T., Kareivac, P., Neugartena, R., Salzerd, D., Fishera,J.2009. Urban effects, distance, and protected areas in an urbanizing world. Landscape and Urban Planning. 93. 63-75.

McDonnell, M.J. and Picket, S.T.A. 1990. Ecosystem structure and function along urban–rural gradients. an unexploited opportunity for ecology. Ecology 71,1232–1237

Mcintyre, N.E., Knowles-Y Anez, K., Hope, D. 2000. Urban ecology as an interdisciplinary field. differences in the use of "urban" between the social and natural sciences. Urban Ecosystems. 4. 5-24

NCSU, North Carolina State University 2007. World population becomes more urban than rural. ScienceDaily, Retrieved. August, 28, 2010, from http.//sciencedaily.com-/releases/2007/05/070525000642

Neimela, J. 1999. Is there a need for a theory of urban ecology? Urban Ecosystems. 3.57-65.

Orams, M. B. 1995. Toward a more desirable form of ecotourism. Tourism Management 16(1). 3–8.

Paliwal, R.2006. EIA practice in India and its evaluation using SWOT analysis.Environmental Impact Assessment Review. 26(5). 492-510.

Phillips, A. 'International policies and landscape protection' in Landscape and Sustainability. J.F. Benson and M.H. Roe (eds.), Spon Press, London, 2000, pp. 78-96.

Rebele, F. 1994 Urban ecology and special features of urban ecosystems. Global Ecol.Biogeogr. Lett. 4, 173-187.

Reed, M.S. 2008. Stakeholder participation for environmental management. A literature review. Biological Conservation. 2417-2431.

Reed, M.S., Dougill, A.J., Baker, T., 2008. Participatory indicator development. what can ecologists and local communities learn from each other? Ecological Applications 18. 1253-1269.

Rees, W.E.1997. Urban ecosystems. the human dimension. Urban Ecosystems. 1. 63-75.

Savage, V.R., Huang, S., Chang, T.C.2004. The Singapore River thematic zone. sustainable tourism in an urban context. The Geographical Journal. 170(3).212-225.

Shoba, V. “Dilli Darshan with a difference” Indian Express (21 Dec. 2008). Siemiatycki, M.2006. Message in a Metro. Building Urban Rail Infrastructure and Image in Delhi, India. International Journal of Urban and Regional Research.30(2). 277–292.

Sinha, N. “Eco tour takes Delhiites back to city waterbodies” (23 Marc. 2009).

Stringer, L.C., Reed, M.S., Dougill, A.J., Rokitzki, M., Seely, M., 2007. Enhancing participation in the implementation of the United Nations Convention to Combat Desertification. Natural Resources Forum. 31. 198–211.

Talyan, V., Dahiya, R.P., Anand, S., Sreekrishnan, T.R. 2007. Quantification of methane emission from municipal solid waste disposal in Delhi. Resource Conservation & Recycling. 50. 240-259.

Tansley, A.G.1935. The use and abuse of vegetational concepts and terms. Ecology.16. 284–307.

Trivedi, S.M, Yadav, B.R., Gupta, N., Chandrasekhran, H.2001. Effects of urbanization on changes in groundwater quantity and quality in Delhi State, India. IAHS Publ. no. 269, 2001.

Urfi, A.J.2006. Biodiversity conservation in an urban landscape. a case study of some important bird areas on the river Yamuna in Delhi (India). In. Conservation Biology in Asia McNeely, J.A., T. M. McCarthy, A. Smith, L. Olsvig- Whittaker, and E.D. Wikramanayake (editors). Published by the Society for Conservation Biology Asia Section and Resources Himalaya, Kathmandu, Nepal. 303-317.

Wandersman, A., 1981. A framework of participation in community organisations.Journal of Applied Behavioural Science. 17, 27–58.

Weaver, D.B.and Lawton.L.J.2007.Twenty years on.The state of contemporary ecotourism research.Tourism Management.28. 1168-1179.

Wu, Y. Y., & Wang, H. L. 2007. Urban ecotourism, a contradiction? International Ecotourism Monthly. 90, 8–9.

Yamuna Biodiversity Park (YBP), Delhi Development Authority website. Retrieved from. http.//www.dda.org.in/greens/biodiv/yamuna-biodiversity-park.html Accessed on 02 Jan. 2011.

Status of Soil and Spoil Properties in Stone Mine Area, Haryana, India

Vivek Dwivedi and Prafulla Soni*

CEDAR,Vasant Vihar,Dehradun

*Advisor Restoration ecology & Biodiversity

Conservation,Dehradun

Abstract

Present study includes analysis of some salient soil attributes of restored mine spoils, active mining area and undisturbed areas in the vicinity of stone mine in district Faridabad, Haryana. Study was conducted in a total of six sites that is two sites of two age series each, one active mine site and adjacent undisturbed area. Soil samples were collected for the analysis of soil pH, bulk density, soil moisture, electrical conductivity (EC), soil organic carbon (SOC), available nitrogen (N), available phosphorous (P), exchangeable potassium (K). pH ranges from 6.24 to 7.49, electrical conductivity (EC) from 0.009 to 0.098 ds/ m, soil moisture between 1.56 to 7.31, bulk density 0.91 and 1.22, soil organic carbon (SOC) between 37.4 to 9.2 t/ha, available nitrogen in a range of 0.21 to 0.66 t/ha, available phosphorous between 0.0018t/ha and 0.023 t/ha and exchangeable potassium between 0.018 and 0.146 t/ha. Data has been discussed in the in the light of restoration age.

Keywords: Mine spoils, soil organic carbon, restoration age

Introduction

Stone mines of Aravali falls under villages of Ballabgarh Taluk in the district Faridabad of Haryana state namely the Khori Jamalpur and Sirohi stone mines. The area lies in the Survey of India toposheet No. 53H /3 (1.50,000). The two mines lie between latitudes 280 18’ 59” to 280 19’47” N and Longitudes 770 10’ 07” and 770 10’ 47”E. The altitude varies between 232 m to 300 m above the sea level. The topography of the core mining area is hilly while in the buffer area it is flat and undulated. Khori Jamalpur having lease area of 131.05 ha and Sirohi having leased area of 86.6 ha. Haryana Govt. leases the mines to Faridabad Gurgaon Minerals for seven years. The minor minerals being mined from these mines are road metal and masonry stone, used in building, road construction and railways. Therefore, the exact working area available for mining is 68.21 ha in Khori Jamalpur and 47.83 ha in Sirohi mines. Mining is being done in these areas since November 2001 by open cast mining method. The waste product containing soil, sand and small size stone generated during mining operation is dumped in the area and it is also used in back filling of excavated pits. The assessment of rehabilitation works has been carried out in two mines. The climate over most of the year is of a pronounced continental character. It is very hot in summer and markedly cold in winter. The area experiences three distinct seasons i.e. winter (November to mid of March), summer (end of March to end of June) and rainy (end of June to September). The area experiences severe cold during the month of December to February. The temperature varies from 6.1^{0} C to 41^{0} C. Similarly May and June experiences very hot conditions. The monthly maximum temperature may often go up to 46^{0} C.

Mining is an essential activity. Indiscriminate and unplanned mining causes irreversible damage and deterioration of natural resources. Mining activities affect the surrounding i.e. air, water, soil, land, biological diversity etc. and leads to environmental problems like land degradation particularly in opencast mining, land subsidence in underground mining, deforestation, atmospheric pollution, pollution of aquatic bodies, disposal of solid wastes, etc. affecting the ecological balance of the area. Ecosystem approach to restore the productive potential of disturbed mined land is the measure requisite for a sustainable development. Once the target material is excavated, the process of mining consequently leads to the heap of mine spoil. The objective of this study to assess the spoil of mine and soil quality of adjoining natural areas, furthermore to assess that up to what extant one should work on the spoil quality to reach the restoration at a satisfactory level? We can say if we could develop a soil quality index for such degraded mine land than it would help researchers to think beyond that. In the process of restoration it is very essential to make spoil able to support the plantation over it. This paper will discuss the quality of mine spoil and soil quality of the unmined areas.

Material and methods

Study was conducted during 2008 at Forest Research Institute, Dehradun. Soil and spoil samples were collected from 0-30 cm depth from a total of six sites vis-à-vis two sites of two age series, mine site and adjacent undisturbed area, namely; Undisturbed (Site- 1), Four year old plantation at Khori (Site-2), One year old plantation at Khori (Site-3), Mine site (Site-4) Four year old plantation at Sirohi (Site-5) and One year old plantation at Sirohi (Site- 6). Five replicates were taken to conduct the present study. Soil and spoil samples were collected and immediately samples were firstly undergone to measure the moisture content of the samples. Soil moisture content was measured by means of moisture meter No-50. Soil pH was measured by Electrical conductivity was measured with the help of soil conductivity meter. Soil organic carbon (SOC) content was estimated by Walkley and Black (1934) titration method. Core sampler method was used for estimation of Bulk density (Jackson 1967). Available nitrogen (N) was estimated by the alkaline permagnete method using Kjeldahl apparatus. Available phosphorous (P) was estimated by Olsen's method (Olsen *et al.,* 1954) and samples were analyzed through the double beam UV- VIS spectrophotometer (SPECTRASACN UV 2700). Estimation of exchangeable potassium (K) was done by the ammonium acetate solution method using flame photometer model no. 1381. (Richards, 1954). Soil quality was calculated after (Aweto, *et al.,* 1981)

Results and discussion

Delhi quartzites of Alwar series are basic geological formation of this area.Quartzites are predominant rock formation, which are very hard and compact. Sand formation is also predominant in the area.

Table 1. Soil and spoil properties of stone mine area .

Site	Moisture	pH	E.C. (dsm^{-1})	B.D.	SOC (tons ha^{-1})	A.N. (tons ha^{-1})	A.P. (tons ha^{-1})	Ex.K. (tons-^{1})
1.	1.58	7.06	0.012	1.09	37.44	0.66	0.023	0.146
2.	3.25	6.84	0.018	1.16	15.72	0.56	0.013	0.066
3.	4.67	6.9	0.024	1.22	9.84	0.26	0.018	0.080
4.	7.31	7.49	0.009	0.91	9.24	0.21	0.0018	0.018
5.	1.56	6.46	0.024	1.21	31.53	0.60	0.012	0.058
6.	6.10	6.24	0.098	1.19	12.96	0.46	0.021	0.036

SOC- Soil Organic Carbon, E.C- Electrical Conductivity, B.D- Bulk Density, A.N-Available Nitrogen, A.P- Available Phosphorous, Ex. K.- Exchangeable Potassium

The soil of this region is generally silty clay in nature. It is brownish in colour and generally deficient in nitrogen and organic matter content.Present study of stone mine area shows a range of pH between 6.24 and 7.49, site-6 shows the lowest pH value 6.24 while the highest value was observed from the mine site i.e. site site-4.

The pH value between 5.5 to 6.5 means, soil is lime free and satisfactory for of the plantation and pH between 6.5 –7.5 is ideal for the same (Chaudhary, *et al.,* 2008). The pH range of the study area is between 6.24 and 7.49. It is, therefore, can be said that pH ranges between 6.16 and 7.8 are in safe range. High pH value 7.49 was observed in the mine area, hence the lowest available phosphorous value 0.0018 tons ha^{-1} was estimated from the mine spoil samples, and this value shows a relationship between the high pH value and lowest availability of the phosphorous. Chaudhary, *et al.*, 2008, also find out at high Ph > 8.0, availability of phosphorous is very low. Although almost soil and spoil samples were near neutral.

Soil and spoil moisture content was in a range between 1.56 to 7.31% minimum moisture i.e. was measured from site-1, while maximum moisture content was estimated from mine area i.e. site-4, it is because while in the process of mining, machinist use water to lose the soil for excavation of the target material. Second highest value of moisture content was recorded from the site-6 followed by the site-3 and site-2, lowest moisture content was recorded from site-1 and site-5, except these two sites plantation was supported with the proper watering so as to enhance the plantation in these reas. The values of electrical conductivity (EC) reveal a range from 0.009 to 0.098 ds/ m. Mine site shows EC 0.009 ds/ m while highest EC value 0.098 ds/ m was recorded from the site- 6. For agricultural practice electrical conductivity between 0 to 2 ds/ m is safe for all the crops. But the suggested EC value for a degraded mine ecosystem is not fixed so far. If we use the suggested range of EC then we can say that all the EC values for the study site are in a safe range.

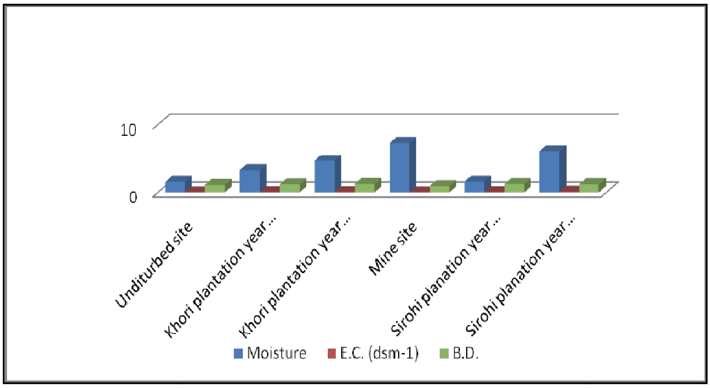


Figure 1. Soil and spoil physical parameters among the sites.

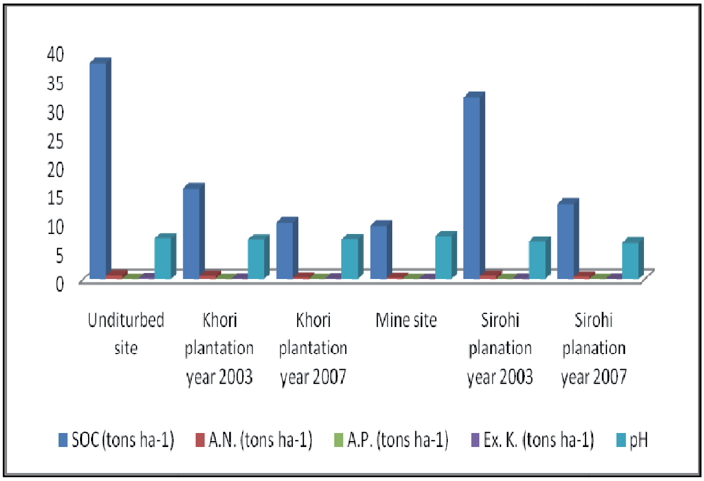


Figure 2. Soil and spoil chemical attributes among the sites.

For agricultural practice electrical conductivity between 0 to 2 ds/ m is safe for all the crops. But the suggested EC value for a degraded mine ecosystem is not fixed so far. If we use the suggested range of EC then we can say that all the EC values for the study site are in a safe range.

Soil organic carbon (SOC) values were between 9.24 tons ha^{-1} and 37.44 tons ha^{-1}. Mine site i.e. site -4 has the lowest 9.24 tons ha^{-1} soil organic carbon value while the highest soil organic carbon i.e. 37.44 tons ha^{-1} was estimated from the natural area (Site- 1) followed by the site-5, which has 31.53 tons ha^{-1} soil organic carbon. It has been suggested that the soil organic carbon (SOC %) was lowest 0.31% in the mine area while the highest value 1.25% soil organic carbon (SOC) was estimated from the site- 1. Site- 4 is totally devoid of soil organic carbon and is not suitable for plantation because the soil organic carbon required for plantation must be in a range between 0.5- 0.75%. site-3, site-4 and site-6 reflecting the very low soil organic carbon values, hence need some additives to strengthen the restoration of mine spoils. Available nitrogen was in a range of 0.21 to 0.66 tons ha^{-1}. the lowest available nitrogen was estimated from the site- 4 while the highest available nitrogen was estimated from the site-1, because the natural or unmined area is dominated with trees of *Prosopis julifora* which is a leguminous species having nitrogen fixing bacteria in its root nodules, which helps in the mineralization of the total nitrogen and made available to the plants. In case of available phosphorous (P) we got a range between 0.0018 tons ha^{-1} and 0.023 tons ha^{-1}. Site-4 has the lowest availability of phosphorous while site-1 has the highest phosphorous followed by the site -6. However there is very low availability of the phosphorous among the sites. So here we can suggest that there must be plantation of those species that can hold a good mycorrhazal association, because in any stress condition plants often cannot uptake the phosphorous directly through the soil. Plants and microorganisms have developed a number of strategies to increase soil P availability.

Table 2. Fertility rejuvenation index (FRI)/ Soil quality index (SQI)

SOC (tons ha^{-1})	41.98718	26.282051	24.67949	84.21474	34.61538
A.N. (tons ha^{-1})	84.84848	39.393939	31.81818	90.90909	69.69697
A.P. (tons ha^{-1})	56.52174	78.26087	7.826087	52.17391	91.30435
Ex.K (tons ha^{-1})	45.20548	54.794521	12.32877	39.72603	23.28767
Average SQI	**57.14072**	**49.682845**	**19.16313**	**66.75594**	**54.72609**

Microorganisms can increase plant P uptake by mobilising more P than they require and by stimulating root growth and mycorrhizal colonisation. (Marschner, *et at.*,2010).

Exchangeable potassium (K) in soil sample of the study sites was between 0.018 tons ha^{-1} and 0.146 tons ha^{-1} in site-4 and site-1 respectively.Site-5 Soil quality index reveals the highest values followed by the site-2, site-6 and site-3. It indicates that an effective plan and its implementation induces the restoration of such degraded mine areas. While site-4 i.e. mine area has the lowest value for soil quality index among the sites.

Data reflected the overall Status of some important soil and spoil properties of Stone mine areas of Aravali. While analyzing the data we would like to say that there is need of some more soil additives that can hold a healthy plantation for restoration soil nutrient or soil quality index for such degraded ecosystems, in this series of restoration studies we must think to improve the soil microbial properties. Second thing we feel strongly that like agricultural soil, scientists and researchers developed some soil quality index in context to the important soil nutrients and soil properties. Here we researchers from the field of ecological restoration, we are trying to develop some soil quality index in reference to the country like India.

Acknowledgments

Authors are thankful to Shri Mr. S.P Sethi, Chairman Sethi Group of Companies and Shri Surinder Sharma Director M/S Faridabad Gurgaon Minerals, New Delhi and Dr. S.S. Negi, Director Forest Research Institute, Dehradun, for providing support for the present study.

References

Aweto,A.O.1981. Secondary succession and soil fertility restoration in south Nigeria. 1. Succession, Journal of Ecology 69. 601- 607.

Better Crops 1998. Functions of Potassium in Plants. Vol. 82 No. 3

Better Crops 1999 Functions of Phosphorus in Plants. Vol. 83 No. 1

Chaudhary, B.L. and Bhatia, S. 2008. Salient soil properties of Sagwara Tehsil of Durgapur District. The Ecoscan 2 (1) . 73- 76.

Marschner, P., Crowley, D., R. Zed, 2010.Interactions between rhizosphere microorganisms and plants governing iron and phosphorus availability. In 19th World Congress of Soil Science, Soil Solutions for a Changing World,1–6,August 2010, Brisbane, Australia. Published on DVD.

Olsen, S.R., Cole, C.V., Wantanabe, F.S. and Dean, L.A. 1954. Estimation of available phosphorous in soils by extraction with sodium bicarbonate. *U.S. Dep. Agric. Circ. No.* 939. USA.

Richards, L.A. 1954. Diagnosis and improvement of saline and alkali soils. USDA *Agric. Handbook. No.* 60. Washington, D.C.

Walkley, A. 1947. A critical examination of rapid method for determining organic carbon in soils. Effect of variations in digestion conditions and of organic soil constituent. *Soil. Sci.,* 63. 251- 263

Walkley,A.and Black,I.A.1934.An examination of the Dejtareff method of determining soil organic matter and a proposed modification of chromic acid titration method. Soil Science 37. 29-37.

Microbial Biomass as Influenced by Restoration measures in Rock Phosphate Mined Area at Maldeota, Doon Valley

Richi Yadav, Mridula Negi, H.B. Vasistha
Forest Ecology and Environment Division,
Forest Research Institute, Dehradun-248006, India

Abstract

Microbial properties have been reported to be useful indicators of soil quality and could possibly serve as assessment criteria of successful rehabilitation of ecologically disturbed areas. Soil microbial biomass is considered as an important early indicator of changes that may occur in the long term with regard to soil fertility and constitutes an important source and sink of nutrients. To assess the impact of restoration on microbial biomass in rock phosphate mined area a study has been conducted at Maldeota, located about 18 km towards NE of Doon Valley; lies in between longitude 77^0 38' to 78^0 20' E and latitude 29^0 35' to 30^0 30' N and is about 750 to 1050 m above mean sea level. Climate of Maldeota has well demarcated summer, rainy and winter seasons. The soil texture of Maldeota varies from sandy loam to loamy sand. The natural vegetation of the site is represented by tropical dry mixed deciduous forest type. Rock phosphate was being mined at Maldeota through open cast as well as underground mining methods. The area was restored way back in 1982. The study sites were 26 year old restored area having plantation of *Acacia catechu* and *Dalbergia sissoo* and Natural forest containing dominant tree species of *Cassia fistula, Nycthanthes arbor-tristis, Bauhinia vareigata, Flacourtia cataphracta* respectively. Results indicated that the microbial biomass in the restored area was found to be greater as

compared to the natural forest area indicating recovery of soil quality after restoration.

Key words: Soil microbial biomass, restored area, soil fertility

Introduction

Little is known about the impact of restoration practices on soil microbial communities. Ecological restoration is defined by the Society for Ecological Restoration (2002) as 'The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed'. Microorganisms play an important role in the functioning of any soil ecosystem as they are actively involved in litter breakdown, cycling of nutrients, formation of stable microaggregates, and structural development. In many restoration projects, the main focus has been on the establishment of native plant species and creation of plant communities that closely resemble those of undisturbed native vegetation (Zedler 2001; Walker and del Moral 2003).

Ecological impacts of restoration procedures on soils can directly affect plant community composition or system-level functions such as nutrient cycling. Monitoring periodical changes not only in vegetation but also in soils portrays the overall success of the restoration process more accurately. Soil microbiological properties such as microbial biomass may be used as early and sensitive indicators of soil quality (Bending *et al*. 2004), for comparisons of soils under different managements (Kieft 1994) and that high levels of microbial activity are fundamental in maintaining soil quality (Garcia *et al*. 2002). Soil microbial biomass is a potential source of plant nutrients, and a higher level of soil microbial biomass is an indicator of soil fertility. The microbial biomass of soil is defined as the part of the organic matter in the soil that constitutes living smaller microorganisms.

Typical microbial biomass carbon ranges from 1 to 5% of soil organic matter. The changes in soil can be easily monitored by following changes in the soil microbial biomass. The soil microbial biomass carbon is an important component of soil organic matter and comprises 1–3% of total organic carbon in soil (Jenkinson and Ladd 1981), but it has a rapid turnover rate and represents a labile reservoir of nutrients (Marumoto 1984). Due to its dynamic character, microbial biomass responds to management practices (cultivation, residue management, amendments, and fertiliser application) and other environmental variables and its effects are often measurable (Batra *et al.* 1997). The soil microflora and the vegetation of an ecosystem are closely interrelated. Plants influence soil biotic processes by delivering organic compounds, whereas soil microbes have a positive impact on plant growth by the decomposition and mineralization of plant material.

Materials and Methods

Study Site

Maldeota, the study area where field observations were undertaken is located in Doon valley. Geographically Doon valley is situated in Northern part of Uttarakhand between longitude 77^0 38' to 78^0 20' E and latitude 29^0 35' to 30^0 30' N stretching in NW-NE direction following the main Himalayan range. It is about 18 km towards NE of Dehradun between 750 to 1050 m above mean sea level. Climate of Maldeota has well demarcated summer, rainy and winter seasons. Because of elevation of this site and its location in Doon Valley, summer is not very hot. Summer is followed by pre-monsoon and local showers. Monsoon breaks towards the end of June and continues up to September. The soil texture of Maldeota varies from sandy loam to loamy sand. Sal forests are the climax type of forests in Dun valley. As per Champion and Seth's classification (1968) natural vegetation of the experimental site is represented by tropical dry mixed deciduous forest type (5B/C2). Predominant species of the natural area are *Mallotus phillipensis, Nycthanthes arbor-tristis, Bombax ceiba, Flacourtia cataphracta, Cassia fistula* and *Acacia catechu* and *Dalbergia sissoo* in riverine ecosystem. Undergrowth mainly consists of *Murraya koenigii, Woodfordia fruticosa, Adhatoda zeylanica, Lantana camara* and *Eupatorium glandulosum*.

Rock phosphate commonly known as Mussoorie Phos was being mined through open cast as well as underground mining methods. The waste product or overburden generated during mining contained major portions of shale, chert and limestone. The area was restored way back in 1982 using native plant species like *Acacia catechu, Wendlandia exserta, Dalbergia sissoo* etc. The adjacent Natural forest was taken as a reference site to the restored area.

Soil Sampling

Soil samples were collected from 26 year old restored site and from adjacent natural forest. A composite soil sample was prepared by mixing soil samples taken from each site. Replicates were taken from the composite sample to avoid the spatial heterogeneity among the soil microbes. Microbial biomass carbon (MBC) was estimated by using modified liquid chloroform fumigation incubation technique (Brookes *et al.* 1987) and Soil organic carbon was determined by Walkley and Black method (Walkley 1947).The statistical analysis of data was done using Statistical Package for Social Sciences (SPSS) 17.0.

Results and Discussion

The data from Table 1 infers that soil microbial biomass ($\mu g\ g^{-1}$)

was found to be maximum (249.61±73.91) for restored site followed by natural forest (205.27±92.17) which is an indicator of good soil quality. The analysis of variance was found to be highly significant between sites and soil organic carbon and between sites and soil organic matter ($p<0.001$). However, it was found significant between sites and microbial biomass ($p<0.01$).

From Table 2, it can be clearly observed that maximum correlation was found between organic carbon and organic matter i.e. +1 at $P<0.01$. Similarly organic carbon had a non-significant but positive relationship with MBC. However, sites and organic carbon had a significant negative correlation. Similarly, organic matter in soil was negatively correlated with sites at $P<0.01$.

Table.1 Soil organic carbon and Microbial biomass carbon of restored rock phosphate mined area and adjacent natural forest of Doon valley

Sites	**Organic Carbon (%)**	**MBC (μg^{-1})**	**Organic Matter (%)**
Restored Area	1.91±0.15	249.61±73.91	3.29±0.26
Natural Forest	0.80±0.09	205.27±92.17	1.37±0.15
Significance	***	**	***
CD	6.45	1006.65	11.11

****Significant at P<0.001*   *Values are mean of five replicates.*

± standard deviation   ***Significant at P<0.01*

The higher microbial biomass carbon recorded in restored site can be attribute due to higher organic matter and moisture content as organic matter can hold moisture five times of its weight(Cohen 2003). Further, insects and microbes digest this organic matter and release nutrients andsubstances that glue together individual mineral soil particles. These aggregated particles enhance soil structure by increasing pore space, which, in turn, increases air and water availability.

Soil organic matter is the most important indicator of soil quality and productivity and consists of a complex and varied mixture of organic substances. A positive correlation was found between soil organic matter and soil organic carbon. Soil organic carbon is important for all three aspects of soil fertility, namely chemical, physical and biological fertility.

Microbial biomass is also increased in the restored site over the period as earlier studies indicates that percent organic carbon content which was 0.76 during early phase of restoration (Soni *et al.* 1992), increased up to 1.91 after 26 years of restoration. The higher organic carbon and resulting component of microbial biomass in restored site than natural forest may be due to high species richness and diversity in former case than later (Soni *et al.* 2008). Furthermore the restoration measures adopted in the area were based on the ecological principles and it was totally depend on adaptability of site conditions.

Table 2. Pearson's Correlation Matrix between Soil attributes of restored rock phosphate mined area and adjacent natural forest of Doon valley

	Sites	**%Organic Carbon**	**MBC (µg g^{-1})**	**% Organic Matter**
Sites	**1**			
%Organic Carbon	**-.913****	**1**		
MBC (µg g^{-1})	**-.132**	**.155**	**1**	
% Organic Matter	**-.913****	**1.000****	**.155**	**1**

*** Correlation is significant at the 0.01 level (2-tailed)*

It was observed during the restoration chronosequence, soil organic carbon and microbial biomass increased in the restored site. Results indicated that restored site is having higher microbial biomass and soil organic carbon value than Natural forest area which is an indicator of good soil quality and recovery. Thus, we can conclude that over the years of restoration, the soil was trying to come back to its original state as observed indicating the fertility status of the soil.

Acknowledgements

We thank Dr. (Mrs.) Prafulla Soni, Head of Division, Forest Ecology and Environment Division, Forest Research Institute, for providing the facilities and Dr. Ashish Rawat for his help in statistical analysis.

References

Batra, L, Kumari, A, Manna, M.C, Chhabra, R. 1997. Microbiological and chemical amelioration of alkaline soil by growing Karnal grass and gypsum application.*Experimental Agriculture,* 33: 389–397.

Bending, G.D., Turner, M.K., Rayns, F., Marx, M.C. and Wood, M. 2004. Microbial and biochemical soil quality indicators and their potential for differentiating areas under contrasting agricultural management regimes. *Soil Biology and Biochemistry,* 36: 1785- 1792.

Brookes, P., Vance, E. and Jekinson, D.J. 1987. An extraction method for measuring soil microbial biomass C. *Soil Biology and Biochemistry*, 19:703-707.

Champion, H.G. and Seth, S.K. 1968. *Revised Survey of Forest Types in India*. Govt. of India Publication, New Delhi.

COHEN, J. 2003. The Impacts of fire on ecosystems. Available online at http://www.micro.utexas.edu/courses/mcmurry/spring98/10/jerry.html.

Garcia, C., Hernandez, T., Roldan, A. and Martin, A. 2002. Effect of plant cover decline on chemical and microbiological parameters under Mediterranean climate. *Soil Biology and Biochemistry,* 34: 635-642.

Jenkinson, D.S. and Ladd, J.N. 1981. Microbial biomass in soil, measurement and turnover. In: Paul, W.A. and Ladd, J.N. (eds.), Marcel Dekker, New York, *Soil Biochemistry*, 5: 415–471.

Kieft, T.L. 1994. Grazing and plant canopy effects on semi-arid soil microbial biomass and respiration. *Biology and Fertility of Soils,* 18: 155-182

Marumoto, K. 1984. Mineralization of C and N from microbial biomass in paddy soils. *Plant and Soil*, 76: 165-173.

Society for Ecological Restoration 2002. The SER Primer on Ecological Restoration.http://www.ser.org/.

Soni, P., Vasistha, H.B. and Om Kumar, 1992. Surface Mined Lands-Problems and Prospects: A report on Eco Restoration of Rock Phosphate Mined area.*ICFRE-18*, ICFRE, Dehradun.

Soni, P., Negi, M. and Uniyal, S. 2008. To Study Ecological Succession in Restored Mined Areas. Project Report, Division of Ecology and Environment, Forest Research Institute, Dehradun.

Walkley, A. 1947. An examination of methods for determining organic carbon and nitrogen in soils. *J. Agri.Sci.,* 25:598-609.

Walker, L. R., and del Moral, R. 2003. *Primary Succession and Ecosystem Rehabilitation.*Cambridge University Press, Cambridge,United Kingdom.

Zedler, J. B. 2001. *Handbook for Restoring Tidal Wetlands*. CRC Press, LLC., Boca Raton, Florida.

Agroforestry as a landscape for the management of cotton pests

T. S. Dange, Y. Sridhar* and R. Sundraraj**

Forest Research Centre, (ICFRE), Hyderabad, India-50014

*National Research Centre for Soybean – Indore, India

** Institute of Wood Science and Technology, (ICFRE), Bangalore, India

Abstract

The key challenge of the 21st century pest managers is to translate ecological principles into practical alternative system to suit the specific needs of farming communities in different agroecological regions of the world. A major strategy to design a more sustainable agriculture is to restore agricultural diversity by following key agroecological guidelines by increasing biodiversity in time and space through multiple cropping and agroforestry designs and enhancing landscape diversity with biological corridors. The present study is aimed to know the insect pests management of cotton under different agroforestry systems in Andhra Pradesh to see the effects of various tree combinations on insect pest and natural enemy fauna of cotton. For this purpose agroforestry systems were developed wherein Cotton *was* grown as an intercrop with Neem, Bamboo, Custard apple, Eucalypts, Aonla, and Moringa. Seasonal incidence and population dynamics of major pests and natural enemies were observed. Treatment combinations of custard apple + cotton, bamboo + cotton and bamboo + cotton were found highly effective to support less density of sucking pests and more of natural enemies. Correspondingly increase in yield of cotton was observed in these combinations. The study clearly indicated that the insect pest problems associated with monoculture of cotton can be minimized with habitat fragmentation and landscape restoration which demonstrated the potential of developing multifunctional pest stable

agroforestry models for cotton production in small holdings with low inputs for ecological reasons (sustainability, stability, equity and productivity) in the long run.

Keywords: Agroforestry, landscape, pest management, natural enemies

Introduction

The spread of modern agriculture has resulted in tremendous changes in landscape diversity. There has been a consistent trend towards simplification of field due to monoculture and intensive cultivation practices leading to decrease in inter-and intra-specific diversity within the planted field. Although these trends appear to exist worldwide, they are more apparent, and certainly best documented, in industrialized countries. Increasingly, evidence suggests that these changes in landscape diversity have led to more insect outbreaks due to the expansion of monocultures at the expense of natural vegetation, through decreasing habitat diversity. One of the main characteristics of the modern agricultural landscape is the large size and homogeneity of crop monocultures, which fragment the natural landscape. Massive expansion and increases in production of crops such as rice, wheat, maize, cotton and soybean, in various regions of the developing world led to major environmental degradation and loss of biodiversity, especially in bird populations (Donald, 2004). Such agricultural intensification can also directly affect the abundance and diversity of natural enemies, as the larger the area under monoculture the lower the viability of a given population of beneficial fauna. At hand is also the issue of colonization of crop "islands" by insects. In the case of annual crops, insects must colonize from the borders each season, and the larger the field, the greater is the distance that must be covered. The increased monoculture leads to more frequent insect outbreaks. Many ecologists have conducted experiments testing the theory that decreased plant diversity in agro-eco- systems allows greater chance for invasive species to colonize, subsequently leading to enhanced herbivorous insect abundance, many of these experiments have shown that mixing certain plant species with the primary host of a specialized herbivore gives a fairly consistent result. specialized species usually exhibit higher abundance in monocultures than in diversified crop systems (Andow, 1983). Several reviews have been published documenting the effects of within habitat diversity on insects (Altieri and Letourneau, 1984; Risch *et al.,* 1983). Two main ecological hypotheses (the natural enemy hypothesis and the resource concentration hypothesis), have been offered to explain why insect populations tend to explode in monocultures and how in agroecosystems insect populations can be stabilized by constructing vegetational architectures that support natural enemies and/or that directly exert inhibitory effects on pest attacks (Root, 1973).

Agroforestry systems create landscape structure that is important for the biological pest control. In structurally complex landscapes, parasitism is higher and crop damage lower than in simple landscapes with a high percentage of agricultural use. When carefully designed, woody and herbaceous corridors such as hedgerows, windbreaks, shelterbelts, wooded alleys and forest edges, can be needed to protect soil, conserve moisture and improve dry land crops. Corridors provide habitat that benefit wildlife within agricultural landscapes and provide diversity that supports natural enemies of crop pests. Benefits to wildlife include protection from wind and adverse weather, escape or refuge cover, food and foraging sites, reproductive habitat and travel areas. Birds living in a wooded corridor forage in the crop field and consume insect pests blown or attracted to the edge. Diversity in habitat and fauna through the application of agroforestry principles appears to bring stability to agricultural landscapes.

Material and Methods

The Experiment was carried out during 2005-08 at Forest Research Centre, Hyderabad (17^{o} 20′ N latitude and 78^{o} 30′ E longitude with an altitude of 536m. MSL). Cotton (*Gossypium hirsutum*) *was* grown as an intercrop with different trees viz; Neem (*Azadirachta indica),* Custard apple (*Annona squamosa),* Eucalyptus (*Eucalyptus tereticornis),* Aonla (*Emblica officinalis)* and Moringa (*Moringa oleifera)*and Bamboo (*Dendrocalamus strictus*). The experiment was conducted in completely randomized block design with three replications. Each plot was measuring 28 m X 20 m. along northern and southern edges and in median of each plot three rows of trees at 2 m X 2 m spacing were planted. Cotton was cultivated in eight meters wide area available between the two strips of three tree rows each with an espacement 90x60cms. An isolation distance of four meters was maintained between two treatment plots. Spacing between tree crops was narrowed (2 m X 2 m) as compared to conventional practices in tune with the study objectives to get the desired impact. Insect pests and the natural enemies like parasites, predators, and spiders of cotton, trees and bamboos, *were* recorded during the early hours of the day at fortnightly interval during the experimental period. Yield of cotton and trees were recorded accordingly. Data were subjected to ANOVA. Means were separated by Duncan's Multiple Range Test (Duncan, 1955). Correlations between the abiotic factors and incidence of major insect pests were correlated. Data was analyzed using SPSS software.

Results and Discussion

Extent of damage was expressed in terms of percentage change in seed cotton yield over control (Table 1). In 2005-06, as compared to control, in treatment combinations of neem + cotton, bamboo + cotton, custard apple + cotton, eucalyptus+ cotton and aonla + cotton an increase in seed cotton yield by 6.49, 1.66, 10.68, 7.15, and 12.44 per cent respectively was recorded. Whereas in moringa + cotton, a decrease in yield by 8.48per cent was recorded. In 2006-07, neem + cotton, custard apple + cotton, eucalyptus + cotton, and aonla + cotton recorded an increase in yield by 5.18, 9.10, 0.76, and 10. 42 per cent respectively, as compared to control.

Table 1.Percentage change in cotton yield under different agroforestry systems as compared to control

Treatment combination	2005-06	2006-07	2007-08	Mean
Control	453	450.54	445.56	449.70
Neem+cotton	482.42 (6.49)	476.70 (5.18)	407.50 (-8.54)	455.54 (1.30)
Bamboo+cotton	460.54 (1.66)	447.03 (-0.78)	380.56 (-14.59)	429.38 (-4.52)
Custard apple+cotton	501.39 (10.68)	491.54 (9.10)	464.65 (4.28)	485.86 (8.04)
Eucalyptus + cotton	485.41 (7.15)	453.96 (0.76)	390.26 (-12.41)	443.21 (-1.44)
Aonla + cotton	509.37 (12.44)	497.47 (10.42)	448.37 (0.63)	485.07 (7.87)
Moringa + cotton	414.59 (-8.48)	395.60 (-12.19)	402.42 (-9.68)	404.20 (-10.12)

Whereas in bamboo + cotton and moringa + cotton, a decrease in yield by 0.78 and 12.79per cent was recorded as compared to control. In 2007-08, custard apple + cotton, and aonla + cotton an increase by 4.28

and 0.63 per cent respectively as compared to control was recorded. In neem + cotton, bamboo + cotton, eucalyptus + cotton and moringa + cotton a decrease of yield by 8.54, 14.59, 12.41 and 9.68 per cent respectively was recorded as compared to control. Whereas the pooled mean values of three years indicated an increase in seed cotton yield in neem + cotton, custard apple+ cotton, and aonla + cotton by 1.30, 8.04 and 7.87 per cent respectively as compared to control. Whereas in bamboo + cotton, eucalyptus + cotton and moringa + cotton, a reduction in yield by 4.52, 1.44 and 10.12 per cent respectively over control was recorded.

With regard to insect pest control, population dynamics of three regular and major sucking pests namely, aphids, thrips, and jassids were observed during the period of experiment (Table 2). For, aphids, thrips and jassids, treatment combination of custard apple + cotton (20.71% reduction), bamboo + cotton (41.90% reduction) and bamboo + cotton (64.71% reduction) respectively were found highly effective.

Table 2. Percentage changes in population density of major insect pests their natural enemies in cotton under different agroforestry combinations.

Treatment	Aphids	Thrips	Jassids	Coccinellids	Spiders
Neem+cotton	-14.20	-32.38	-47.06	36.84	150.94
Bamboo+cotton	7.10	-41.90	-64.71	-5.26	77.36
Custard apple+cotton	-20.71	-38.10	-43.14	42.11	156.60
Eucalyptus+cotton	-8.88	-18.10	-31.37	5.26	121.70
Aonla+cotton	-15.98	-22.86	-37.25	78.95	106.60
Moringa+cotton	-14.79	-18.10	-31.37	5.26	60.38

In a nutshell, data engendered during the study revealed clearly that cotton, combined with trees supported significantly lower aphid, thrips, and jassid populations and higher coccinellid and spider populations as compared to cotton sole crop, suggesting suppression of aphids, thrips and jassids populations due to increased abundance of generalist predators namely coccinellids and spiders in agroforestry systems.

This is a clear demonstration of diluting monoculture effects by crop diversification. These results are in harmony with van Emden and Williams, 1974; Goodman, 1975; Cromartie, 1981; Altieri *et al.,* 1990.

References

Altieri, M.A. and Letourneau, D.K. 1984. Vegetation diversity and insect pest outbreaks. *CRC Critical Reviews in Plant Sciences,* 2. 131-169.

Altieri, M. A., Glaser, D.L. and Schmidt, L.L. 1990. Diversification of agro- ecosystems for insect pest regulation. Experiments with collards. *In.* Gliessman, S.R *ed*. Agro ecology. Researching the ecological basis for sustainable agriculture. Berlin. Springer Verlag.

Andow, D.1983. Plant diversity and insect populations in experimental agroecosystems. interactions among beans, insects and weeds. Ph.D. dissertation. Cornell University.

Cromartie, W.J. 1981. The environmental control of insects using crop diversity. *In.*Pimentel D. *Ed*. *CRC handbook of pest management in agriculture.* Florida. CRC Press.

Donald, P.F. 2004.Biodiversity impacts of some agricultural commodity production systems. Conservation Biology, 18, 17-37.

Duncan, D. B. 1955. A significant test for differences between ranked treatments in analysis of variance. *Virginia Journal of Science*, 2. 171-181.

Goodman, D. 1975. The theory of diversity-stability relationships in ecology.*Quarterly Review of Biology,* 50. 237-266.

Price, P.W.1976. Colonization of crops by arthropods. non-equibrium communitiesin Soyabean field. *Environmental entomology*,5,605-12.

Risch, S.J., Andow, D. and Altieri, M.A. 1983. Agroecosystem diversity and pest control. data, tentative conclusions and new research directions. *Environmental Entomology,* 12 (3). 625-629.

Root, R.B. 1973. Organization of a plant-arthropod association in simple and diverse habitats. the fauna of collards *(Brassica oleracea). Ecology Monographs,* 43.95-124.

Van Emden, H.F. and Williams, G.F. 1974. Insect stability and diversity in agro ecosystems. *Annual Review of Entomology,* 19. 455-475.

Carbon Sequestration through Soil Organic Carbon Store Estimation under Different Land uses in Lower Altitudinal Region of Uttarakhand

M.K. Gupta

Forest Soil & Land Reclamation Division

Forest Research Institute, Dehra Dun

Abstract

Soil carbon has much longer residence mean times than the carbon in the vegetation that the soils support. Storage of organic carbon in the long residence time, pool is referred to as Carbon sequestration. Intergovernmental Panel on Climate Change has recognized soil organic carbon pool as one of the five major carbon pools for the Land Use, Land Use Change in Forestry sector. Land use and soil management practices can significantly influence soil organic carbon dynamics and carbon flux from the soil. No systematic study has been undertaken to estimate the soil organic carbon pool in forests, as well as in other land uses in this area. A study was conducted in three land uses *viz.* Forests, Horticulture and plantations occurring below 1000 m altitude in Uttarakhand to estimate SOC pool. Soil samples were collected from Dehra Dun, Haridwar, Pauri, Nainital, Tehri, Champawat, Pithoragarh, Chamoli, Bageshwer, Udham Singh Nagar, Uttarkashi and Rudrapryag districts. Under forests land use, Soil Organic Carbon pool was estimated in Sal (*Shorea robusta*), Chir (*Pinus roxburghii*) and Miscellaneous forests. Under horticulture land use SOC was estimated in Mango, Litchi and Guava orchards while under plantation land use SOC pool was estimated under Teak, Chir, Eucalyptus, Shisham and Poplar. Maximum SOC pool was estimated in the soils under forest (64.40 t ha^{-1}) followed by

horticulture (49.12 t ha^{-1}), and the least was under plantations (37.21 t ha^{-1}). Differences in the SOC pool under these land uses were statistically significant. Forests have 30.33 % higher SOC pool as compared to Horticulture and 72.05 % higher as compared to plantations. Horticulture has 32.01 % higher SOC pool as compared to plantation land use. Share occupied by individual land use, out of total SOC pool has been worked out and observed that forests has occupied the maximum share (42.58 %) followed by Horticulture (32.76 %). Plantations occupied the least share (24.81 %) in this low altitudinal region of Uttarakhand state.

Keywords : Soil carbon, land use change, carbon pool, plantation.

Introduction

Soil Carbon has much longer residence mean times than the Carbon in the vegetation that the soils support. Storage of organic Carbon in this long residence time, pool is referred to as Carbon sequestration. The concern about increasing atmospheric CO_2 and its role in future global climate change has lead Soil scientists to quantify soil organic carbon content (also referred as stocks or storage) (Lacelle *et al.,*2001). Accurate quantification of soil carbon is necessary for detection and prediction of changes in response to changing global climate.

Concentration of atmospheric CO_2 can be lowered either by reducing emissions or by taking CO_2 out from the atmosphere and stored in the terrestrial, oceanic or aquatic ecosystems. Tree growth serves as an important means to capture and store atmospheric carbon dioxide in vegetation, soils and biomass products (Makundi and Sathaye, 2004). Most of the carbon enters the ecosystem through the process of photosynthesis in the leaves. After the litter fall, the detritus is decomposed and forms soil organic carbon by microbial process. Eventually, after the death of animals, the detritus decomposed in to the soil organic carbon by microbial activities.

Soils and vegetation, therefore, represent potential sinks for this additional carbon and several authors have suggested afforestation as a possible means of mitigating global climate change (Shivanna *et al.*, 2006 and Ramachandran *et al.*, 2007). Intergovernmental Panel on Climate Change has recognized soil organic carbon pool as one of the five major carbon pools for the Land Use, Land Use Change in Forestry sector. It is mandatory for all nations to provide soil organic carbon pool and changes from LULUCF sector of the forests under National Communications to the UNFCCC.

Land use and soil management practices can significantly influence soil organic carbon dynamics and carbon flux from the soil (Batjes, 1996;Tian *et al.,*2002). Some reports indicate, up to 87 % decrease in soil organic carbon due to deforestation. There is intense anthropogenic pressure on the forests. From 1951 to 1980, about 4.3 m ha forest was diverted to non - forest use mainly for agriculture (62 %) and river valley project (hydro - electric and irrigation) (12 %) industrial purpose (4%) and other purpose (22%) (Ravindranath, 2002).

No systematic study has been undertaken to estimate the soil organic carbon pool in forests, as well as in other land uses in this area. Therefore, a study was conducted in Uttarakhand State, to estimate SOC pool under different land uses by ground truthing. The results of this study have provided the authentic and comprehensive estimates of the SOC pool under different vegetation covers.

Materials and Methods

Because the input of organic matter is largely from aboveground litter, forest soil organic matter tends to concentrate in the upper soil horizons, with roughly half of the soil organic carbon of the top 100 cm of mineral soil being held in the upper 30 cm layer. The carbon held in the upper profile is often the most chemically decomposable, and the most directly exposed to natural and anthropogenic disturbances (IPCC, 2003). Therefore, soil organic carbon pool was estimated up to the depth of 30 cm in this study.

Study was conducted in three land uses *viz.* forests, horticulture and plantations occurring below 1000 m altitude in Uttarakhand. Under forests land use, Soil Organic Carbon pool was estimated in all available forest covers below 1000 m altitude *i.e.* Sal (*Shorea robusta*), Chir (*Pinus roxburghii*) and Miscellaneous forests. Under horticulture land use SOC was estimated in Mango, Guava and Litchi orchards, which was available at this altitudinal region. Poplar, Eucalyptus, Shisham, Teak and Chir plantations were available in this region, therefore SOC pool under these plantations were also estimated. 360 soil samples from all these land uses were collected. Soil samples were collected for organic carbon estimation, bulk density and coarse fragment estimation from different forest covers and horticulture.

In Uttarakhand, below the altitude of 1000 m, sampling sites were selected in all the districts in which these forest covers, plantations and orchards were available. Sampling points have been selected randomly and at each sampling point, an area of about ½ km were covered and collect five soil samples from this area for soil organic carbon estimation and two separate samples were collected for bulk density and coarse fragment estimation. It was ensured that sampling points typically represent the study area. Variation in the number of samples was due to difference in area available under particular forest stand. Details of the sites from where soil samples were collected in different ranges and numbers of sample collected are presented in Table 1.

Table 1. Details of the sites under all land uses in Almora district.

Sl. No.	Vegetation Cover	Area Covered (Districts)	No. of samples Collected
Forest Land Use			**120**
1	Sal	Dehra Dun, Haridwar, Nainital,Tehri, Champawat, Pauri and Pithoragarh	45
2	Chir	Dehra Dun, Pauri, Chamoli, Champawat,Bageshwer	30
3	Miscellaneous	Dehra Dun, Haridwar, Nanital, Tehri, Uttarkashi, Rudrapryag, Pauri, Chamoli and Pithoragarh	45
Horticulture Land Use			**120**
1.	Mango	Dehra Dun, Haridwar, Nainital, Udam Singh Nagar, Champawat, Pauri, Bageshwer and Pithoragarh	50
2	Guava	Dehra Dun, Haridwar, Nainital, Udam Singh Nagar and Pauri	35
3	Litchi	Dehra Dun, Haridwar, Tehri, Champawat and Pauri	35
Plantation land Use			**120**
1	Poplar	Haridwar and Udam Singh Nagar	20
2	Eucalyptus	Dehra Dun, Haridwar, Udam Singh Nagar and Pauri	35
3	Shisham	Dehra Dun, Haridwar and Champawat	20
4	Teak	Dehra Dun, Haridwar, Nainital. Tehri, Champawat and Pauri	35
5	Chir	Dehra Dun	10
Total samples Collected			**360**

Latitude, Longitude and altitude of each sampling site were recorded by GPS and depicted the sampling sites in Figure 1. Forest floor litter of an area of 0.5m x 0.5 m, at each sampling point was removed and a pit of 30 cm wide, 30 cm deep and 50 cm in length was dug out. Soil from 0 to 30 cm depth, from three sides of the pit, scraped with the help of Kurpee. This soil mixed thoroughly and removed gravels. Keep in a polythene bag and tightly closed with thread with proper labeling. In the laboratory, samples were air dried and after drying the samples, grind it and sieve it through 100 mesh sieve (2 mm sieve). This sieved sample used for soil organic carbon estimation. Soil organic carbon was estimated by standard Walkley & Black (1934) method. Amount of coarse fragments were estimated in each sample collected from different forests and deducted from the soil weight to get an accurate soil weight per ha basis and soil organic carbon estimation. Bulk density of every site was estimated by standard core method (Wilde *et al*., 1964). All the methods used in this study are in accordance to Ravindranath, and Ostwald, (2008).

The data for SOC pool was calculated by using the following equation as suggested by IPCC Good Practice Guidance for LULUCF (IPCC, 2003).

Equation for SOC.

$$SOC = \sum_{Horizon=1}^{Horizon=n} SOC_{horizon} = \sum_{Horizon=1}^{Horizon=n} ([SOC] * \text{Bulk density} * \text{depth} * (1 - C\ frag) * 10)_{horizon}$$

Where,

SOC = Representative soil organic carbon content for the forest type and soil of interest, tones C ha.$^{-1}$

SOC $_{horizon}$ = Soil organic carbon content for a constituent soil horizon, tones C ha $^{-1}$ [SOC] = Concentration of SOC in a given soil mass obtained from analysis, g C (kg soil)$^{-1}$

Bulk density = Soil mass per sample volume, tones soil m^{-3} (equivalent to Mg m^{-3}) Depth = Horizon depth or thickness of soil layer, m

C Fragment = % volume of coarse fragments / 100, dimensionless

Results and Discussion

Soils under different forests covers occurring below 1000 m above mean sea level, were collected from Sal, Chir and Miscellneous forests from Dehra Dun, Haridwar, Pauri, Nainital, Tehri, Champawat, Pithoragarh, Chamoli, Bageshwer, Uttarkashi and Rudrapryag districts. Forests occurring below 1000 m altitude having on an average 64.40 t ha^{-1} SOC pool. Among these forest covers Miscellaneous forests have maximum SOC pool (71.50 t ha^{-1}) followed by Sal (62.76 t ha^{-1}) and the least SOC pool was in the soils under Chir (56.21 t ha^{-1}). Subset for α = 0.05 indicate that Miscellaneous and Sal stands separately (a) while Sal is also with Chir (b) (Table 2). Soils under Miscellaneous forests have 13.92 % higher SOC pool as compared to Sal while 27.20 % higher in comparison to Chir. SOC pool under Sal was 11.65 % higher as compared to Chir forests.

Mitigation potential for different forests covers was worked out against Chir forests which has the least SOC pool and observed that Miscellaneous have maximum mitigation potential (1.27) followed by Sal (1.11). Standard Error of SOC pool, in all the forest covers is varied from

2.59 to 3.89 which reflect low variation in the data.

Table 2. Soil organic carbon pool under different Land uses in Almora district (up to 30 cm)

Sl. No.	Vegetation Cover	SOC Pool (t/ha)	SD	Mitigation Potential	Mitigation Potential (Combined for all land uses)	St. Er.
Forest Land Use						
1	Miscellaneous	71.50[a]	± 26.1076	1.27	2.32	3.89
2	Sal	62.76[ab]	± 20.7870	1.11	1.88	3.09
3	Chir	56.21[b]	± 14.2105	1.00	1.68	2.59
	Over all Forests	64.40[a]	± 22.3162	--	--	2.03
Horticulture Land use						
1	Mango	55.29[a]	± 31.3408	1.40	1.65	4.43
2	Litchi	48.69[ab]	± 33.1412	1.23	1.46	5.24
3	Guava	39.41[b]	± 18.3817	1.00	1.18	3.35
	Overall Horticulture	49.12[b]	± 29.7756	--	--	2.71
Plantation Land use						
1	Teak	39.70[a]	± 20.9159	1.19	1.19	3.53
2	Chir	39.12[a]	±	1.17	1.17	2.96

			9.3637			
3	Eucalyptus	37.10[a]	± 17.6540	1.11	1.11	2.98
4	Poplar	35.85[a]	± 25.6393	1.07	1.07	5.73
5	Shisham	33.45[a]	± 16.6703	1.00	1.00	3.72
	Over all Plantation	37.21[c]	± 19.3602	--	--	1.76

Same alphabets represent statistically at par group

Soils under different orchards occurring below 1000 m above mean sea level, were collected from Mango, Guava and Litchi forests from Dehra Dun, Haridwar, Pauri, Nainital, Tehri, Udam Singh Nagar, Champawat, Pithoragarh and Bageshwar districts.

Orchards occurring below 1000 m altitude having on an average 49.12 t ha^{-1}SOC pool. Among these orchards Mango have maximum SOC pool (55.29 t ha^{-1}) followed by Litchi (48.69.76 t ha^{-1}) and the least SOC pool was in the soils under Guava (39.41 t ha^{-1}). Subset for $\alpha = 0.05$ indicate that Mango and Litchi stands separately (a) while Litchi is also with Guava (b) (Table 2). Soils under Mango orchards have 13.55 % higher SOC pool as compared to Litchi while 40.29 % higher in comparison to Guava. SOC pool under Litchi was 23.55 % higher as compared to Guava.

Poplar, Eucalyptus, Shisham, Teak and Chir plantations were available in the region of < 1000 m altitude of Dehra Dun, Haridwar, Udam Singh Nagar, Pauri, Tehri, and Champawat districts of

Uttarakhand. On an average these plantations have

37.21 t ha^{-1} Soc pool in this region. Out of these plantations, Teak has the maximum SOC pool (39.70 t ha^{-1}), followed by Chir (39.11 t ha^{-1}), Eucalyptus (37.10 t ha^{-1}), poplar (35.85 t ha^{-1}) and the least pool was under Shisham (33.45 t ha^{-1}). SOC pool under Teak and Chir has marginal differences while under teak it was 7.03 % higher as compared to Eucalyptus, 10.73 % as compared to poplar and 18.68 as compared to Shisham. SOC pool under Eucalyptus was 3.45 % higher as compared to Poplar and

10.88 % as compared to Shisham. Subset for $\alpha = 0.05$ indicate that SOC pool under all the plantations were not statistically significant and can be placed all together (a) (Table 2). Standard error varied from 2.96 to 5.73 which are considerably low and indicate not much variation in the sites.

When all the forest covers, plantations and orchards were integrated in their land uses and over all SOC pool under these three land uses viz. forests, horticulture and plantation were compared, it was observed that maximum SOC pool was in the soils under forests (64.40 t ha^{-1}) followed by horticulture (49.12 t ha^{-1}) and the least was under plantation (37.21 t ha^{-1}).). Subset for $\alpha = 0.05$ indicate that forests stands separately (a) while Horticulture is also stand seperately (b) and plantation (c) (Table 2). Forests have 30.33 % higher SOC pool as compared to Horticulture and 72.05 % higher as compared to plantations. Horticulture has 32.01 % higher SOC pool as compared to plantation land use.

The effect of land use change on soil carbon stock is of concern in the context of international policy agendas on GHG emission mitigation. Gua and Gifford (2002) reported that soil C stocks decline after land use change from native forest to plantation (- 13 %), native forest to crop land (- 42 %) and pasture to crop land (- 59%). Soil C stocks increase after land use change from crop to pasture (+ 19 %), crop to plantation (+ 18 %) and crop to secondary forests (+ 53 %). The conversion of natural vegetation to various land uses results in decline in soil organic matter (Post and Kwon, 2000).

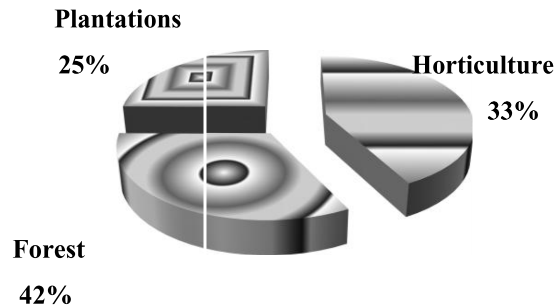


Figure. 1 Share of total SOC pool occupied by different land uses.

Share occupied by individual land use, out of total SOC pool has been worked out and depicted in Figure 1. Forests has occupied the maximum share (42.58 %) followed by Horticulture (32.76 %). Plantations occupied the least share (24.81 %).

Results of one - way ANOVA indicates that SOC pool between the forest covers were significantly different at 0.05 level (Variance ratio, F = 4.696; p = < 0.05). SOC pool under Miscellaneous was significantly different from the SOC pool under Chir. SOC pool between different land uses were also significant differences at 0.05 level (Variance ratio, F = 38.023; p = < 0.05) (Table 3). SOC pool in the soils under forests was statistically significantly different with the pool under horticulture and plantations.

Table 3. Statistically significant mean differences on the basis of CD (LSD).

Sl. No.	Vegetation	Mean Difference	P value
1	Miscellaneous Vs Chir	15.2937*	0.058
2	Forests Vs Horticulture	15.2807*	0.000
3	Forests Vs Plantations	27.1945*	0.000
4	Horticulture Vs Plantation	11.9137*	0.000

References

Batjes, N.H. 1996. Total carbon and nitrogen in he soils of the world. *Euro. J. SoilSci.,* 47. 151-163.

Guo, L.B. and Gifford, R.M. 2002. Soil Carbon stocks and land use change. a meta analysis. *Global Change Biology* 8 (4). 345 - 360

IPCC 2003. Good Practice Guidance for Land Use, Land Use Change and Forestry.Published by the Institute for Global Environmental Strategies (IGES) for the IPCC. Publishers Institute for Global Environmental Strategies, Japan

Lacelle, B.; Waltman, S.; Bliss, N. and Orozco, C.F.2001. Methods used to create the North American soil organic carbon digital data base.485– 494 pp

Makundi, Willy R. and Sathaye, Jayant, A.2004. GHG mitigation potential and cost in tropical forestry – relative role for agroforestry. *Environment, Development and Sustainability* 6. 235-260

Post, W.M.and Kwon,K.C.2000.Soil carbon sequestration and land use change.Process and potential. *Global Change Biology* 6 . 317–327.

Ramachandran, A., S. Jayakumar, R.M. Haroon, A. Bhaskaran and D.I. Arockiasamy.2007. Carbon sequestration. estimation of carbon stock in natural forests using geospatial technology in the Eastern Ghats of Tamil Nadu, India. *Current Science,* 92 (3). 323-331.

Ravindranath, N.H. 2002. Climate change forests and India CO_2 emission, impact, mitigation and global negotiations in climate change and India. Issues, concerns and opportunities (eds.) P.R.Shukla, S.K.Sharma and P. Venkata Ramana. Tata Mc Graw – Hill Publishing Co. Ltd. New Delhi.

Ravindranath, N.H. and Ostwald, M.2008. Carbon Inventory Methods. Handbook for Greenhouse Gas Inventory, Carbon Mitigation and Round wood Production Projects. Springer

Shivanna, H., P. Janagiri, H.C. balachandra and S. Kyatappanvar 2006. Potential of *Pongamia pinnata* in carbon sequestration – An important bio-diesel plant. *My Forest*, 42 (1). 5-11.

Tian, H., J.M. Melillo and D.W. Kicklighter. 2002. Regional carbon dynamics in monsoon Asia and implications for the global carbon cycle. *Global and Planetary Change,* 37. 201-217.

Walkley, A. and I. A. Black. 1934. An Examination of Degtjareff Method for Determining Soil Organic Matter and a Proposed Modification of the Chromic Acid Titration Method. *Soil Sci.* 37.29-37.

Wilde, S.A., Voigt, G.K. and Iyer, J.G.1964. *Soil and Plant Analysis for Tree Culture.*Oxford Publishing House, Calcutta, India.

Soil Mineralogical Investigations for Sustainable Restoration of Different Land Uses in Uttarakhand

Joystu Dutta

Forest Soil and Land Reclamation Division,

Forest Research Institute, Dehradun

Abstract

Soil mineralogical studies helps in evaluating the petrographic origin of soils, the stage of weathering, their nutrient reserve and many other physical and chemical properties, thereby, rendering it an adequate or an inadequate medium for plant growth. Forest have a much longer period of growth, therefore, fertile soil should able to supply adequate amount of nutrients over the entire growth period so that increased production on a sustained basis can be ensured. The plant nutrients are chiefly derived from the weathering of minerals, the reserve and availability of nutrients depends largely on the mineralogical composition of soil and their parent material. The importance of soil-mineralogical research is mainly due to intimate relationship between the mineral content and soil fertility. The loss of nutrients through felling, subterranean drainage, run off etc. should easily be replenished by the constant release of nutrients resulting from weathering under favourable conditions in the soils developed from parent material rich in nutrient bearing minerals. The paramount importance of mineralogical studies in forestry is thus quite obvious and merits greater attention in the soil investigation.

In view of the relatively long period of tree growth, the nature and amount of minerals present in the soil and parent material are of vital significance in forestry. Mineralogical studies have not only been of fundamental value in correlating the regional relationship of different soils and in understanding other pedological aspects but also of great utilitarian

significance in evaluating the soil fertility status and in managing the soil for higher productivity. Mineralogical studies have also been helpful in understanding the successional status of forest and in investigating the various problems like reduction of growth, quality, vigour, and incidence of mortality, diseases and pests etc.

To establish the contribution of soil mineralogy for sustainable restoration of different land uses, studies were carried out in the natural forests of *Cedrus deodara* at Barkot (Upper Yamuna Forest Division, Uttarkashi), barren lands of Raipur Range (Mussoorie Forest Division) and sodic land of eastern Uttar Pradesh respectively. Geologically , the rocks in Barkot and Raipur range are of pre-cambrian to early paleozoic age with recent and subrecent deposits. Sodic lands forms a part of Indo-Gangetic alluvial plain which owes its origin to a depression probably formed contemporaneously with the uplift of Himalayas (Krishnan, 1982). The plains are built up of layers of sands, clays and occasional organic debris of geologically very recent date (Pleistocene and Recent) filling up a deep depression between two other units. Soils belong to *Typic Paleudoll*, *Typic Argiudoll*, *Typic Paleudult* and *Humic Hapludult* in Upper Yamuna Forest division and *Typic Argiudolls*, *Typic Argiustolls*, *Typic Dystrochrept* and *Ruptic-Alfic Eutrochrepts* in Mussoorie Forest Division. From the field, micromorphological and mineralogical observations were carried out. In sodic lands it has been observed that sedimentation and pedogenesis have been closely interrelated in the study area. The study further revealed that relief and age acting on geology govern the existing soil whereas effect of altitude and climate on geology gives rise to natural vegetation. Climate and aspect on a particular site has given rise to existing floristic composition. Suitable strategies based on soil mineralogy for restoration of different land uses have been tested and reported in the paper.

Keywords: Petrography, Pedology, Land uses, Soil mineralogy, Sustainable restoration, Strategies

Introduction

Uttarakhand forests of Garhwal are a most fascinating segment of the Himalayas in many ways. These are quite unique in their geological setting. Mussoorie Forest Division of Garhwal Himalayas has been attracting the attention of soil scientists, geologists, environmentalists, ecologists etc. from all over the world for conservation and sustainable use of forest products because it is a store of all the rock formations resulting in different soil and vegetation types (Raina & Jha,2005).The Garhwal Himalayas are a mass of intricate folding & faulting and composed of igneous, sedimentary and metamorphic rocks (Valdiya, 1980).

Soil is one of the most important factors for tree growth which is mainly governed by weathering and climatic conditions.

Fields of study

Soil occupies the pedosphere, one of Earth's spheres that the geosciences use to organize the Earth conceptually. This is the conceptual perspective of pedology and edaphology, the two main branches of soil science. Pedology is the study of soil in its natural setting. Edaphology is the study of soil in relation to soil- dependent uses. Both branches apply a combination of soil physics, soil-chemistry, and soil-biology. Due to the numerous interactions between the biosphere, atmosphere and hydrosphere that are hosted within the pedosphere, more integrated, less soil-centric concepts are also valuable. Many concepts essential to understanding of soil come from individuals not recognised strictly as soil scientists. This highlights the interdisciplinary nature of soil concepts.

Research

Dependence on and curiosity about soil, exploring the diversity and dynamic of this resource continues to yield fresh discoveries and insights. New avenues of soil research are compelled by a need to understand soil in the context of climate change, greenhouse gases, and carbon sequestration. Interest in maintaining the planet's biodiversity and in exploring past cultures has also stimulated renewed interest in achieving a more refined understanding of soil.

The rate of growth and type of species depend upon the mineral composition of soil and parent rock. Plant nutrients are chiefly derived from the weathering of minerals. The reserve and availability of nutrients depends largely on the mineralogical composition of soils and their parent material.

Geologically the rocks of the study area are of Pre-Cambrian to early Paleozoic in age with recent and sub recent deposits.

The forest types of the areas are Himalayan moist temperate forests as per Champion & Seth (1968) with *Quercus leucotrichophora*, *Pinus roxburghii*, *Dalbergia sisoo*, *Acacia catechu*, *Cassia fistula*, *Shorea robusta*, *Cedrus deodora*, *Lannea coromandelica*, *Terminalia belerica*, Miscellaneous (*Bauhinia variegata*) etc. as the dominant species.

Kempty Range of Mussoorie Forest Division covers an area of about 2,500 ha, but information on forest soil in relation to vegetation and parent rock is meager (Raina *et al.* 2001; Raina and Jha, 2005). A few studies on morphology, mineralogy, genesis and classification of Himalayan soils and their correlation with vegetation have been carried out (Yadav, 1963; Singh *et al.*, 1989, Singhal *et al.,* 1989 Minhas *et al*., 1997; Raina and Negi, 2007; Raina and Gupta 2009; Manhas and Tripathi, 2011). However, the information on these aspects especially in relation to parent material appears to be scanty. Keeping in view the importance of the area, the study was, therefore, undertaken to understand the prevailing status of soil formation in relation to vegetation and parent material in the natural forests of Kempty range, Mussoorie Forest Division (Uttarakhand). Analysing the importance of such aspects, this study was carried out in natural forests of Mussoorie Forest Division to correlate the relationship between soil, parent material and vegetation for sustainable management of such sites.

Methodology

The study area Maldeota and Dhanaulti is located in Dehradun and Tehri Garhwal districts, which is bounded by the Lesser Himalayas in North and Siwalik hills in the South respectively. The area situated between longitude $78^0$7' 40"to 78^0 5' 20" east and 30^0 20' 30" to 30^0 27' 20" North latitude and at an altitude between 900m and 2200 m above msl covering an area more than 2000 km².

Table 1.Site Characteristics

Site	Principal Species	Parent Material	Altitude	Land
Dhanaulti	1.*Cedrus deodara* 2.*Pinus roxburghii* 3.*Quercus leucotrichphora*	Limestone Dolomite Quartzite	2290	Forest
Maldeota	Miscellaneous vegetation	Quartzite, Phosphorite & Black shale	943	Open Forest

Two pedons having different vegetation and parent material in Maldeota and Dhanaulti area representing forest and open forest landforms were exposed in the study area at typical sites having different parent material for sand and clay mineralogical investigation.

Physiography

The Mussoorie forest division is a longitudinal depression in the Great north western complex of the Himalayan ranges, and thus constitutes an important relief feature & geological significance. The study area, physiographically is confined to the lesser Himalayas and presents topography typical of a mountain terrain. To the north lies Jaunpur forest range which is characterized by high mountain peaks and latter extends upto Surkanda peak with an average height of about 3000m above mean sea level. Towards the north-eastern part of the study area, Sankri Dhar and Kanastal Dhar attain an avg. height of about 2500m above msl. As one move from north to south, lowest elevation goes upto 1500m, with the central place of Buraskhanda which is about 1800 m above msl. The general alignment of the of the division is from north to south. In the entire area a high number of high mountain ranges as well as ridges are seen. The area is rough and rugged intersected by criss-cross streams.

Climate

The climate of Mussorie Forest Division is moist temperature characterized by dry and warm spring, hot summer, extended rainy season and cold to severe winters. The lowest average temperature in Jaunpur range is 1-2^0 C as against 25^0 C in July. Severe winters extend from mid-December to last week of February. Frequent showers are observed in spring. Higher reaches of Dhanaulti sometimes experience an early snowfall in the month of November. In winter months, mist and fog is common leading to poor visibility.

There is a great variation in rainfall over the tract. Mean annual average rainfall experienced is 2000mm with 59% rainfall received during monsoon months (June to August) followed by 16% during post-monsoon months (September to November). 10% during winter months (December to February) and 15% during pre- monsoon months (March to May).Rainfall during November and December is scanty.

Drainage

A drainage pattern refers to special relationship amongst streams which may be influenced in their erosion by the inequalities of slope, rock resistance, structure and geological history of the region. A number of drainage channels originate in the Jaunpur range of Mussoorie Forest Division which ultimately drain in the area into major Song and Bandal rivers with numerous other tributaries like Devli, Aglar, Guchu etc.

Both large and small streams are flooded for a short time during the monsoons. Most of them remain dry in other periods of the year. The major streams drain the area in a series of dividing & reuniting channel pattern. The drainage pattern of the study area is of dendritic type. Most of the streams are of consequent type as seen on the hill sides flowing straight down the slopes. Besides consequent streams, there are some whose course is dissected by rock structures such as faults, joints, tectonic adjustments etc. resulting in development of other numerous subsequent streams.

Field Sampling

The field survey work was carried out in Maldeota and Dhanaulti blocks of Mussoorie Forest Division (Uttarakhand) for collection of rock and soil samples. Vegetation analysis was also carried out separately.

Geology

The field work consisted collection of representative specimens and their mineralogical and petrological studies. Field study consisted basically of identification of rock types and their joining pattern and systematic sampling. The stratigraphy of the surrounding rocks was carried out. Fresh rock samples were collected for further laboratory studies.

Soil

Dhanaulti block of Jaunpur range & Maldeota of Mussoorie Forest Division were selected for soil studies. Soil profile was excavated and samples were collected from different genetic horizons for studying their physico-chemical characteristic features.

Vegetation

Vegetation analysis was also carried out through quadrat analysis methods.

Sample Processing

Sample processing was done in the laboratory by standard sampling techniques to

analyse soil mineralogical parameters as well as to identify vegetation types

Results and Discussion

The relationship between parent material, soil & vegetation has been important for natural woodland ecosystem. Vegetation once established naturally or man-made, modifies the soil development processes due to the parent material, topography, climatic conditions, inter-alia etc., by minimizing soil erosion and changing hydrology of the watersheds. Hence, the parent material, soil and vegetation relationship is dynamic as well as temporal. The vegetation is a climatic climax and belongs to Himalayan moist temperate forests in the Dhanaulti block of Jaunpur Range of Mussoorie Forest Division.

Inter-relationship between geology, soil and vegetation

Table 1. Physical & chemical properties of soil at Dhanaulti Block

Main	Depth (cm)	Sand %	Silt %	Clay %	pH	O.M.	Ex.Ca++	Ex.Na+Ex	.k+[cmol(	p+)kg	CEC_1	Ca:Mg	WHC (%)
Cedrus deodora	0-10	38.8	31	30.2	5.7	6.5	32.1	4.2	3.2	0.2	0.4	1.3	75.7
	10-30	36.8	40	23.2	5.5	1.5	27.7	3.5	3.4	0.3	0.3	1.0	64.7
	30-50	41.8	30	38.2	5.0	0.7	30.3	2.5	3.0	0.2	0.3	0.6	59.7
	50-85	39.8	40	20.2	5.0	0.4	23.0	3.7	2.1	0.1	0.4	1.7	58.3
	85-110	45.8	35	19.2	4.9	0.3	29.0	3.8	1.9	0.2	0.4	2.0	55.7

Table 2. Physical & chemical properties of soil at Maldeota Block

Main vegetation	Depth (cm)	Sand %	Silt %	Clay %	pH	O.C	E.C.	Total (%)			
								Ca	Mg	K	P
Miscellaneous Types	0-9	71.09	17.13	11.56	6.55	1.75	0.36	5.43	1.89	0.93	4.5
	9-30	72.02	17.20	10.78	6.55	2.00	0.35	4.68	1.57	1.23	4.56
	30-55	71.88	16.56	11.56	6.70	1.70	0.34	5.55	1.70	0.88	5.80
	55-90	69.80	17.55	13.28	7.01	2.55	0.37	4.83	1.48	0.98	5.85
Miscellaneous Types	0-9	71.09	17.13	11.56	6.55	1.75	0.36	5.43	1.89	0.93	4.5
	9-30	72.02	17.20	10.78	6.55	2.00	0.35	4.68	1.57	1.23	4.56
	30-55	71.88	16.56	11.56	6.70	1.70	0.34	5.55	1.70	0.88	5.80
	55-90	69.80	17.55	13.28	7.01	2.55	0.37	4.83	1.48	0.98	5.85

Various studies with regards to soil and their correlation with plant growth have been carried out in the deciduous forests of the country

(Ghosh *et.al.* 1980; Singhal and Sharma 1985; Raina and Negi, 2005**)**. However, the information in these aspects especially in the Garhwal Himalayas in relation to parent material is scanty. Studies were carried out in correlation with micronutrient status of soils in outer Himalayan region. Singhal (1974).

Effect of Vegetation

Soils developed under *Cedrus deodara* had yellowish brown to brown colour in A & B horizonsof the soil under *Pinus roxburghii* had yellowish brown colour in A & B horizons. Soil under vegetative cover of *Quercus leucotrichophora* had A and B horizons of dark yellowish brown colour. The lower values and chromas of the soil formed under *Pinus roxburghii & Quercus leucotrichophora* is attributed to the addition of leaf litter annually and slowy decomposition of organic matter.

The study area revealed impact of geology on vegetation is evident in some sites. Observations clearly indicate that *Cedrus deodara* grows well in limestone, dolomite, quartzite and shale whereas *Pinus roxburghii* and *Quercus leucotrichophora* flourishes with geo regeneration on phyllite, slate, sandstone, slaty shales etc.(Raina *et al.* 2001).It was observed that besides climate and geology, presence of species was more dependent on altitude and aspect.

Singhal.*et.al* (1987) reported that *Quercus leucotrichophora*, *Cedrus deodara and Pinus wallichiana* occurred below 2000m above msl whereas between 2000-2500m above msl. *Quercus floribanda, Abies pindrow & Picea smithiana* were found and *above 2500* m above msl *Quercus semicarpifolia and Abies pindrow* were recorded. During the study *Cedrus deodara, Pinus roxburghii and Quercus leucotrichophora* were noticed between 2000-2300 m above msl.

Characteristic of Soil

Soils are generally acidic. Variation in soil pH under different forest vegetation ranges from 5.0 to 6.0. In general, the pH was higher in upper horizons than in lower ones. The soils observed under *Quercus leucotrichophora* & *Pinus roxburghii* were more acidic than soils under *Cedrus deodara*.

The soil organic matter was generally higher in different forest vegetation at higher altitude as than in lower areas with maximum accumulation in the surface horizon. It decreased with depth but without a different trend. It was much higher in the surface horizon of the soils developed under *Pinus roxburghii* & *Cedrus deodara* at an altitude of 2000 and 2300 mts above msl respectively.

Conclusions

- The physical and chemical properties of the soil were successfully studied in the study area and readings have been put forwarded in the paper.
- The mineralogical properties of soil & rocks were studied extensively.
- A general relationship between geology, soil and vegetation of the study area has been seen in the area of study

Acknowledgements

I express my deep gratitude and personal regards to my guide Dr. A.K.Raina,Scientist-F & Head, FSLR Division, Forest Research Institute, Dehradun, for his cordial guidance, constant supervision, tireless inspiration, constructive criticism and affectionate attitude during the entire course of preparation of the paper.

I express my sincere thanks to Dr.S.S.Negi, IFS Director, Forest Research Institute, Dehradun, Dr. A.K Aima, IFS Dean, Forest Research Institute University, Dehradun and Dr. A.K.Tripathi, Scientist E &

Registrar, Forest Research Institute University, Dehradun for introducing the concept of paper and for providing all the necessary facilities to complete the paper successfully.

References

Ghosh, R.C., Singhal R.M. & Sharma, S.D. 1980. Electrophoretic fractionation and characterization of humic acids of the soils of Doon Valley under sal (*Shorea robusta*). *Indian Forester* 106 (3) : 205-210.

Minhas, R.S., Minhas, Harminder and verma, S.D. 1997. Soil characterization in relation to forest vegetation in the wet tempearate forests of Himachal Pradesh. *J. Indian Soc., Soil Sci.,* 45(1): 146-151.

Manhas, R.K., Tripathi, A.K., Gupta, M.K., Raina, A.K. and Kamboj, S.K. 2011.Sand and Clay Mineralogy of Sal forest soils of the Doon Siwalik Himalayas. *J. Earth System Sci.,*Vol 120 No.1. Pp: 123-144.

Raina A.K., M.N.Jha and S.C.Pharasi 2001. Forest soil:vegetation relationship in Mussoorie forest division (Uttaranchal) *Indian Forester.*127(8):883-890

Raina, A. K. and Jha, M.N. 2005. Interrelationship between geology, soil and vegetation in Raipur range of Mussoorie forest division, Uttaranchal. *Indian Forester* 131(9): 1201-1209

Raina, A.K. and Negi, S.S.2005. *Significance of soil minerals for sustainable management of Uttaranchal forests*. Paper presented in the National Seminar held at Wadia Institite of Himalayan Geology, Dehradun on“Sedimentary basins of the Himalaya-Challenges for the future and XXII Convention of Indian Association of Sedimentalogists(IAS-2005)w.e.f.21 23 December, 2005.

Raina, A. K. and Negi S.S.2007. Soil mineral relationship with different forest types in Mussoorie forest division of Uttaranchal, India *Himalayn Geology* 28(1):79-86

Raina, A.K and Gupta, M.K.2009. Soil and vegetation studies in relation to parent material of Garhwal Himalaya, Uttarakhand, India". *Ann. For.* 17 (1) : 71 – 82

Raina, A.K. and Gupta, M.K. 2009. Soil characteristics in relation to vegetation and parent material under different forest covers in Kempty forest range, Uttarakhand forests. *Indian Forester* 135 (3): 331 -341

Singh, R.P., Gupta, M.K. and Singhal, R. M. 1989. Seasonal moisture variation under high altitude coniferous forests of Himachal Pradesh. *J. Nat. Con.*1 (2): 143-153.

Singhal, R.M. (1974). Micro-nutrient status of some forest soils of outer Himalayas. *Forestry Conference*, Dehra Dun.

Singhal, R.M. and Sharma, S.D.1987. Biochemical and elemental composition of sal (*Shorea robusta*) litter of Dehra Dun forests (Uttar Pradesh). *Indian J. Forestery* 10 (2) : 111-113.

Singhal, R.M., Kumar, P. and Sharma, S.D.1987. Study of the humus forms in some ecosystems of Chakrata Forest, (Dehradun) U.P., *Indian Forester* 113 (2): 117-126.

Singhal, R.M. and Sharma, S.D. 1985. Study of the soils of Doon Valley forests.*J. Indian Soc. Soil Sci*. 33 : 627-634.

Singhal, R.M. and Sharma, S.D. 1985. Nature and properties of soil humus substances of Doon Valley forests. *J. Indian Soc. Soil Sci*. 33 : 896-898.

Singhal, R.M., Soni, S. and Sharma, S.D. 1989. Study of the soils of

Mussoorie area (Gharwal Himalyas). *Indian Forester* 15 (12) : 924-933.

Yadav, J.S.P. 1963. Studies on soil profiles in Chakrata Forest Division of U.P.*Indian Forester*. 89 (1): 18 – 38.

Valdiya, K.S. 1980. Geology of Kumaon lesser Himalaya. Wadia Institute of Himalayan Geology. Dehradun.

Tree Inventory-A Management Tool in Landscape Restoration and Management

Ramesh Madav and Gouri Keskar
Terracon Ecotech Pvt. Ltd., 6th Floor, 'Swagat'
Shraddhanand Road,
Vile Parle (East), Mumbai- 400 057, India,

Abstract

Landscape alteration for essential development is major environmental problem across the globe.Forests, which have provided the human race with wide range of products and services, have often been used extravagantly and thereby either becoming fragmented or diverted to non forestry uses. Landscape changes due to growing need of infrastructure and development in developing regions lead to damage in the natural vegetation cover. This necessitates restoration and management of landscapes. Although restoration should be a key element, this does not mean simply getting as much forest cover back as possible. A more comprehensive approach to restoration should emphasize the importance of both the quality and quantity of tree cover. Qualitative and quantitative assessment of tree cover is a step towards landscape restoration, which can be made easy with the help of 'Tree Inventory'. Tree inventory is used to create and use baseline information on trees which facilitates better provision of trees in proposed development areas. It regulates adequate number of new trees in those areas; growing need and importance of preserving biodiversity that we already have. For e.g., the tree inventory of proposed Bangalore Chennai expressway predicts the impact of development of highway and the need of qualitative and quantitative plantation post completion of the project. With the available

baseline data one can analyze the need of plantation and can better select the tree species according to the native trees present pre project. Tree inventory has capacity to enhance and regenerate the urban landscapes with natural benefits and services provided by ecosystems in their natural state.

Keywords: Tree inventory, landscape restoration, habitat fragmentation

Introduction

Human activities can leave landscape features that are present for a long time.These can impact the natural environment in many ways. Features such as roads, power transmission lines, seismic lines and pipelines create new corridors that influence human and animal movement patterns. Land use activities impact the natural environment in many ways. Some activities remove vegetation and add to the fragmentation of the natural landscape for many generations. Vegetation plays a significant role in the ecosystem and is considered as a major factor which is affected due to infrastructure activities.

The fact is that tree cover no longer dominates many forest landscapes. In some areas, the current land-use configuration has led to a dramatic and detrimental decline in the availability of forest goods and services. In such degraded landscapes, agricultural production tends to suffer, local shortages of timber and fuel wood prevail, household income falls, and biological diversity declines. Often, the effects of landscape degradation are felt further ownstream – siltation loads increase and water quality declines. Forest landscape restoration can help reverse some of the more severe impacts of forest loss and degradation.

The foremost step towards restoration of fragmentation caused by building new infrastructure and reconstruction is assessing the total vegetation cover before any development activity takes place. Restoration in this generation not only means restoring the habitats which have already been destroyed but also taking care that the development activities will not impact the forest patches. Tree inventory is not only essential for assessing the present forest cover for bringing back the forest cover after completion of the project but also for better planning of the project. This highlights maintaining the eco-sensitive patches of the forest, maintaining the significant habitats at the site and taking care that the wildlife is least affected. This paper focuses on tree inventory which assesses the forest cover or urban vegetation cover to restore the vegetation in accordance with current infrastructural developments. Moreover tree inventory facilitates to study the landscape ecology of the site. It is the study of the interaction between abiotic and biotic landscape components in space and time and the related flora and fauna (Vink,1980; Naveh and Lieberman, 1984; Forman and Godron, 1986). As flora forms the fundamental factor of the ecosystem, it is essential to assess and restore it in a form which will be beneficial for mutual relationship of human and nature.

Overview of Current Situation

Infrastructure in India is described as vast land of construction opportunity.The physical presence of roads and railways in the landscape creates new habitat edges, alters hydrological dynamics, and disrupts natural processes and habitats. Maintenance and operational activities contaminate the surrounding environment with a variety of chemical pollutants and noise. In addition, infrastructure and traffic impose movement barriers to most terrestrial animals and cause the death of millions of individual animals per year. The various biotic and abiotic impacts operate in a synergetic way locally as well as at a broader scale. Transportation infrastructure causes not only the loss and isolation of wildlife habitat, but leads to a fragmentation of the landscape in a literal sense.

Vegetation provides habitat to wildlife and ecosystem services such as food and fuel and many other products to humans. Vegetation defines landscapes in people's minds, and is an essential component of any biome or environment. The movement of organisms is a fundamental property of life. Plants 'move' passively via natural (*e.g.* wind, water, and animals) or human (*e.g.* vehicles) vectors that transport their pollen or seeds (Verkaar 1988; Wace 1977). Few studies have been carried out to investigate the effect of infrastructure on plant movements, but there is evidence that weeds and many exotic plant species spread along infrastructure verges into adjacent habitats. Animals are more directly affected by infrastructure barriers.

With over 33 lakh kilometers of roadways, India has the second largest road network in the world. It includes all types of roads - paved roads, unpaved roads , national highways, state highways, major district roads, minor district roads, village roads, link roads etc. The national highways with a length of over 70, 548 kilometers, account for 2% of the total road network but carry 40% of the movement of goods and passengers. State Highways have a total length of 1, 31,899 km, major district roads-4,67,763 km; rural and other roads 26,50,000 km. The Indian Government, via the National Highway Development Program (NHDP), is planning more than 200 projects in NHDP Phase III and V to be bid out, representing around 13,000 km of roads. In order to foster the economic and social growth of the developing nation, central government of India has initiated various road construction projects to increase the road connectivity network across the nation. National Highways Authority of India (NHAI) has decided to take up about 1000 km of expressways under Phase-VI of the National Highways Development

Project (NHDP).The paper covers one of the case studies of the infrastructure project under NHDP and highlights the need of tree inventory and its importance in landscape restoration strategy.

Tree Inventory in Development Projects

Restoring urban landscapes requires development of green belt along the verges of the developing road structures. It serves as habitat as well as a corridor for many species, restoring and reserving the native potential of the habitat. Tree inventory facilitates establishment of such structures with vegetation along the verges.

Numerous inventories indicate the great potential of verges to support a diverse range of plant and animal species (*e.g.* Hansen and Jensen 1972; Hansen 1982; Mader *et al.* 1983; Van der Sluijs and Van Bohemen 1991; Sjölund *et al.* 1999). In areas, where much of the native vegetation has been destroyed due to agriculture, forestry or urban development, verges can serve as a last resort for wildlife (Loney and Hobbs 1991). Shrubs and trees can provide valuable nesting sites for birds and small mammals (Adams and Geis 1973; Laursen 1981; Havlin 1987; Meunier *et al.* 1999) and also offer food and shelter for larger species (Klein 1971; Rost and Bailey 1979). Other elements of the infrastructure itself can also provide attractive, yet sometimes hazardous, habitat for wildlife. Careful design, management and maintenance of these structures are required in order to minimize the potentially negative impacts on the wildlife. It is not surprising that species, which regularly visit road corridors to forage or nest, feature frequently in traffic mortality statistics. In this respect,infrastructure corridors may act as an ecological trap, outwardly offering favourable habitat conditions but with the hidden high risk of mortality. When designing and managing verges, it is therefore advisable to consider the risk of creating an ecological trap that may kill more species than it sustains.

It is clear that infrastructure verges can facilitate animal movement and enable the spread of plants and other sessile species. It may therefore seem feasible to integrate infrastructure corridors into the existing (natural) ecological network. Considering the unavoidable need of development of infrastructure for human progress, the solution of establishing green cover in the modern landscapes is of current interest. The vegetation along the verges of the modern infrastructure has its own pros and cons but tree inventory of the patches under development can help infrastructure planners to layout a vegetation plan which will least affect the native habitat of the project site and offer least disturbing habitat to biotic components.

To minimize the conflicts between the developmental activities in forest patches and wildlife, a more comprehensive approach to restoration should emphasize the importance of both the quality and quantity of tree cover. Such integrated assessment is possible through tree inventory.

Tree Inventory / Tree Census.

In dealing with habitat fragmentation, a distinction has to be made by between fragmentation caused by the existing infrastructure network and the fragmentation caused by building new infrastructure and reconstruction. Tree inventory is a tool to assess vegetation of both the types of infrastructure networks as well as of any development project.

The collection of a database that characterizes trees and their locations which is then used to achieve management objectives is called Tree Inventory. On the same lines of Human Census, the concept of tree inventory is introduced to measure the area under green cover and number of trees in the jurisdiction / project area. Various ratios can be derived from this data such as tree to human population, concentration of species as also percentage of area covered under green cover etc.

Importance of Tree Inventory

Tree inventory helps to manage & analyze information related to trees and take decisions effectively and efficiently for further plantation or removal of trees in particular areas. Due to rapid industrialization and urbanization, corporations and organizations are required to take steps for tree plantation, protection of existing trees and preparation of proposal of compensatory afforestation.Tree inventory is largely carried out by municipal corporations, large institutions, development agencies and industries for plans for development of tree cover.

While it is mandatory for corporations and industries to develop and maintain green belts, tree inventory is the first step to collect base line data that can be utilized for other green initiatives.Calculations of Carbon credits and carbon sequestration mechanism will also need proper and authentic tree inventory data for validations and assessment. Similarly development of infrastructure needs quantitative and qualitative assessments of the tree cover which helps in better planning and management for restoring the vegetation cover of the site. Tree inventory is useful in effective landscape tree management; it creates a baseline data for setting management objectives; used as resource for creating plan to meet management objectives; it provides information to educate and persuade customers and constituents and also provides data to justify maintenance recommendations and contract estimates.

Process of Tree Inventory

Tree Inventory means counting of trees which have woody stem or trunk with a minimum girth of 10 cm and height of more than 4 ft from the ground level. Tree inventory help us identify species composition, tree size distribution, tree condition, prevalent defects and disorders, maintenance needs. It also helps inventory-facilitated management activities like - tree risk management, tree health management, species diversity management, maintenance need assessment and prioritization,tree planting and removal planning and prioritization. It allows us to measure inventory-based management outcomes like improved communication, improved efficiency and effectiveness in management activities, healthier, less-hazardous trees, improved service and satisfaction to citizensof the locality.

Terracon Ecotech Pvt. Ltd. (Terracon) has pioneered the activity of Tree Inventory in India. With a team of qualified experts in the field of GIS, GPS, Botany, Taxonomy, Environment science etc,Terracon has developed a systematic & organized process for tree inventory.Terracon has qualified botanists and competent field officers supported with industry's most modern technology & gadgets for tree inventory. Field officers are equipped with GPS devices which map exact tree location with latitude and longitude values. Field assistant then enters information of other observations of tree. All this information is then transferred to server and then to VrukshSharad software. VrukshSharad is Terracon's proprietary software that allows users to monitor & analyze tree inventory information with various analytical tools and tree knowledge bank.

Terracon uses various equipments and accessories like PDA or GPS device, Desktop PC / Laptops,Server City, Server Master, Tree inventory Software viz. VrukshSharad, maps, measuring tapes etc.Before going to field, Inventory Planning is carried out in order to determine the purpose of the tree inventory, the data needed to meet that purpose & the resources needed to collect the data.Accordingly, procedure is developed for how to collect baseline data from the field.

Terracon has a knowledge bank of more than 600 plant species. Each and every plant species is identified, counted & recorded with Latitude / Longitude value of that plant. If field officer finds new species, he brings back taxonomically identifiable parts of that plant (viz. leaves, flowers, fruits, etc) to office and confirms it with senior taxonomists and / or books and journals. The knowledge is also updated in our knowledge bank. Counting of trees is done area wise. Tree Location & ownership of land is classified as i.e. government, private, industry, road side, or any other premises; health status of tree is classified as. healthy, infested, dangerous and dead.

For every tree inventory activity, Senior Plant Taxonomist is monitoring over all process technically,and Coordinator, team leader, experienced Field officers (B. Sc. or M. Sc. with Specialization in Plant Taxonomy), Field assistants, admin support as programmers, data entry operators, data analysts. Tree Inventory report is then prepared with count of trees. Tabular representation of each and every tree is drafted with following 15 observations –

1. Latitude and Longitude reading
2. Tree Number
3. Common name
4. Girth
5. Approximate height
6. Approximate age
7. Approximate canopy cover
8. Tree ownership classified as Government, Private, Industry, Road side or
Other
9. Information on Importance of fruit, aesthetic, cultural, economic

and ecological aspects of tree species

10. Condition of the tree
11. Botanical name
12. Family name
13. Colour photograph of a few peculiar / rare species
14. Total trees and types found in the location
15. Remarks or Recommendations for plantation

Such assessment of the project area makes restoration activities easy and is a ready handed tool which can be used for any development project in accordance with the need of the native habitat.

Case Study

Project: Inventory of Trees on the Proposed Bangalore Chennai National Expressway under NHDP

NHAI awarded work of development of an expressway corridor between Bangalore and Chennai to facilitate high speed travel in this corridor. The existing National Highway which is running parallel to the proposed expressway carries one of the highest traffic carrying corridors in India.

As a part of ecological study of the area, Terracon carried out tree inventory for a stretch of 259 km belt going through 3 states viz; Karnataka, Andhra Pradesh and Tamil Nadu. Elaborative study on the tree species observed was carried out during the survey. The report contains list of the trees with respect to chainages, species wise count of the trees with their common & scientific names, list of trees along with their multilingual names, list of rare and endangered species, list of medicinal tree species and list of dominant species in surveyed area. The report is also supported with photographs of some of the key species observed in the field.

Location- Bangalore-Chennai Expressway Project in the States of Karnataka, Andhra Pradesh and Tamil Nadu.

Distance- Bangalore (Haskote) – Chennai (Shriperumbudur) 260 km

Spur- Bhangarpeth – Betmangla to Bangalore-Chennai Expressway (52 km chinage) 2 km

Forest patch- 13 -14 km length, 120 m width

Width- 120 m

Inventory period- 18th October 2010 to 29th October 2010

The detailed study of the trees of project site enables to summarize ecological health of the ecosystem as trees form the major link between the biotic factors of the environment. The study site included agricultural lands, residential areas, villages and 2 reserve forests viz., 8 km in to Palamner Reserve Forest (RF) and 1 km in to Bodabanda RF in the state of Andhra Pradesh. The survey yielded 2, 04,442 tree individuals of 124 species. The road chainage will severely impact the status of these 2 lakh trees counted during the survey. The amount of damage will still be restricted to commercial and cultivable trees as top 5 species comprise of common trees like Nilgiri, Mango,Coconut, Toddy and Neem. The table below gives the number of each tree species which will be suffered.

Composition of trees in the area subjected to suffer due to project activity.

Eucalyptus globulus Labill.	1,52,886
Mangifera indica L.	20,541
Cocos nucifera Linn.	6,867
Borassus flabellifer L.	3,999
Azadirachta indica A. Juss	2,503

.

The study suggests that the flora of this 260 km long stretch is monotonous as it is dominated by Eucalyptus which amounts to be 75 % of the total trees counted during the survey. Thus as the area is monotonous, the impact can be reduced by restoration.

In the survey, the 8 km of chainage that passes through Palamner reserve should be treated as critical as it holds up about 5,567 individuals of 31 species of trees. This area shows unique diversity and has a presence of 338 individuals of *Chloroxylon swietenia* DC which is classified as vulnerable by International Union for Conservation of Nature (IUCN) standards. Necessary steps should be taken to mitigate and reduce the impacts. Restoration of the same number may be an ideal option. The tree inventory report also notes it with concern that, the tree specific survey is still not covering the status of the reserve forest when considered with shrubs, climbers and other vegetation that may not be fitted in definition of trees. Such vegetation that doesn't amount to be the trees can still play critical role in ecosystems. In concern with the palamner RF this comment shall be considered critically.

During the overall survey, 2 species were found to be vulnerable (*Chloroxylon swietenia* DC and *Santalum album* Linn.) and 1 species which is critically endangered (*Nothopegia castanaefolia* Roth.) was found.

To summarize, the impact as analyzed by the survey can be mitigated by restoration and plantation of critically endangered individuals. The tree inventory survey also suggests the mitigation measures for the Highways and Expressways as per the Environmental Impact Assessment Guidance Manual,MoEF.

• Tree plantation plan to compensate the trees cut can be prepared as per the government Norms

• Possibility of tree transplantation should be examined

• Identification of sensitive natural environments in the early planning stage so that alternative routes, changes in width of the road can be examined

• Compensate the loss of forest coverage by appropriate plantation programme.

• Survival rate of plants must be included in the contract specifications so as to ensure that the compensatory plantation achieves its objective

• Development of green belt on either side of the highway consisting of a variety of trees would help to enrich ecology of the area and add to aesthetics.

• Regeneration of rare plants of economic importance including medicinal plants

• Conservation plan for conservation and protection of flora, rare species and medicinal plants

• The location for roadside green belt can be finalized keeping in view of future expansion of the highway

Thus the intensive tree inventory survey not only assesses the present forest cover but also gives the mitigation measures according to the need of the project and helps conserve the natural status of the environment.

Conclusions

Transportation infrastructure, notably roads and railways, strongly contribute to the fragmentation of habitats. However, the long-term consequences to nature are difficult to quantify and evaluate. Trees form the major factor of the ecosystem and are directly and indirectly responsible for maintaining the health of the ecosystem. The knowledge of trees is essential to integrate ecological assessment and infrastructure or development project planning processes. This need is fulfilled with the help of tree inventory which is a ready hand tool for assessing the health of the ecosystem and determining the impact of the development project on the environment. Tree inventory helps to regain ecological integrity and enhance human well-being in degraded landscapes. Thus it helps in restoration activities with consideration of developments in developing countries.

References

COST 341national state of art report Sweden *Terracon Ecotech Pvt. Ltd*, October 2010, Inventory of trees on the proposed Bangalore Chennai National Expressway under NHDP.

Elizabeth Montgomery, 2008, PricewaterhouseCoopers, Infrastructure in India – A vast land of construction opportunityRuth Wenger, Rosmarie Sommer, Susanne Wymann von Dach, Info Resources Focus, Forest Landscape Restoration (FLR).

Seiler, Andreas and Folkeson, Lennart (eds.), 2006, Habitat Fragmentation due to Transport Infrastructure,World wide fund for Nature's *(WWF)/* International Union for Conservation of Nature's (IUCN), Forest Landscape Restoration

Web Sites referred:

http.//www.enr.gov.nt.ca/_live/pages/wpPages/soe_human_activities.aspx

http.//www.tnhighways.org/nh.htm.

Ecological Impact of Forest Fire on Undergrowth Diversity Under Ten Years Old Teak Plantation of Tarai Forest in Haridwar Forest Division, Uttarakhand

Nirmal Ram, Pramod Kumar and Lal Singh

Forest Ecology & Environment Division, Forest Research Institute, Dehradun

Abstract

Nearly all countries, in every stage of economic development and in every ecological zone are suffering with environmental, social and economic consequences of forest fires. The frequency and intensity of forest fires around the globe in recent years have become alarming. The forest fire result in loss of vegetation, forest floor, destruction of soil, soil and water erosion, wild animals, birds which tender the entire ecosystem in-effective, resulting ecological imbalance. Forest undergrowth are first victim of forest fire. Forest undergrowths play major ecological role for providing shelter to fauna, protecting soil and water erosion, improving soil fertility. In Uttarakhand forest fires are common phenomenon during summer in every forest types. To assess the ecological impact of forest fire on undergrowth diversity, under 10 years old teak plantation, a study has been carried out in Chiriyapur forest range of Haridwar Forest Division. Total density (ha^{-1}) and basal area ($m^2 ha^{-1}$) of the teak trees were 600 and 18.28, respectively. Shrubs richness, density (ha^{-1}), diversity and evenness were 13, 1217, 1.84 and 0.50, respectively. Herbaceous ecological status under unburnt and burnt forest floors during rainy season did not show any changes in species richness but recorded changes in species density, diversity and evenness than winter season.

Further herbaceous species richness, density, diversity and evenness during winter and rainy season was recorded more under unburnt forest floor than burnt forest floor. Similarity in herbaceous vegetation between unburnt and burnt forest floor during winter season was 80% whereas it was 30% during rainy season. *Ageratum conyzoides* and *Parthenium hysterophorus* an alien species was found be invaded in the burnt forest floor. Besides in burnt forest floor during rainy season the biomass production of grass was 487.5 kg ha^{-1} and biomass production of *Parthenium* was 300 kg ha^{-1} whereas in unburnt forest floor grass biomass production was merely

14.7 kg ha^{-1}. Results indicate that fire invites invasion of weeds and boosting the productivity of herbaceous and grass vegetation.
Keywords: Forest fire, diversity, similarity, biomass, invasion.

Introduction

Nearly all countries, in every stage of economic development and in every ecological zone are suffering with environmental, social and economic consequences of forest fires. The frequency and intensity of forest fires around the globe in recent years have become alarming. The forest fire result in loss of vegetation, forest floor, destruction of soil, soil and water erosion, wild animals, birds which tender the entire ecosystem in-effective, resulting ecological imbalance. Forest undergrowth is first victim of forest fire. Forest undergrowths play major ecological role for providing shelter to fauna, protecting soil and water erosion, improving soil fertility. Ground flora diversity and biomass production from plantations of different trees species of different agro-climatic zones varies to a great extent (Sharma, *et al,* 1978; Mathur, *et al,* 1980; Mathur and Soni, 1983; Singh *et al,* 1986; Prasad and Jalil, 1987; Chaudhery *et al.* (1988); Prasad, 1992; Chakravarty and Mathur, 1992; Ram and Jana, 1997; Shadangi and Nath, 2005; Ram,2006;; Upadhyay *et al.,* 2006; Zonner *et al.,*2006; Kern *et al.,* 2006; Mcdonald and Treena, 2007; Gachet *et al.,* 2007; Amin-Al *et al.,* 2007) and have influences on earthworms (Campan, *et al,* 2002). Fire impact on undergrowth diversity and soil attributes have been studied by Srivastava (2006) and Ram (2006). In Uttarakhand forest fires are common phenomenon during summer in every forest types. To assess the ecological impact of forest fire on undergrowth diversity, under 10 years old teak plantation, a study has been carried out in Chiriyapur forest range of Haridwar Forest Division.

Study Sites

Study sites in Chiriyapur Forests were located within 29047'472'' to29048'905'' N. to 78013' 875'' to 78015'616'' E and elevation range 266.7 to 286m msl. Maximum and minimum temperatures are being experiences by area during May to June and December to January. Average rainfall was 1171 mm. Maximum rainfall occurs during July and August. Although monsoonal rainfall starts with effect from June and lasted up to September, October – December experiences dry season.

Materials and Methods

For determination of phytosociological attributes of trees, shrubs and herbs several quadrats of 10X10 m 5X5 m and 1X1 m size respectively were laid out (Misra, 1968) under 10 years teak plantation. Several 1X1 m sizes quadrats were laid out during winter and rainy season to assess its phytosociological structure change season wise. Following formula was used to determined structure of the species. Diversity Index was calculated (Shanon and Wiener (1963):

$H' = \sum (n_1 x\ N) \log (n_1 x\ N)$ Where H= Diversity Index of Species

n_1= Total number of individual of a species

N= Total number of individuals of all species in the stand

Richness of the species was counted as per encountered in study plots. Similarly Index of the species between two stands was calculated (Sorenson, 1948) as per following:

Similarity index = 2 C ------ X100 (A+B)

Where,C= Number of common species in both the stand. A= Total number of species in one stand.;B= Total number of species in another stand.

Equitability/ Evenness was calculated as per Pielou (1975):

Evenness (E) = H'/Hmax= H logs

Where H'= Diversity Index Value of all species. Hmax= Number of species in the stand. (S).For determination of undergrowth biomass five harvest method (Ram & Jana, 1997) was used.

Results and Discussion

Total density and basal area of teak plantation 1997 was 600ha^{-1} and 18.28 m^{2} ha^{-1} respectively(Table 1). It can be seen from table 1 that ecological status of shrubs under unburnt teak forest floor. *Adhatoda zeylanica* shows maximum frequency (100%),density (514 ha^{-1}), and dominance (IVI 76.83). Total density of the shrubs was 1217 ha^{-1}. Diversity index of shrubs was 1.84.

Ecological status of herbs under unburnt forest floor during winter and rainy season are given in table 2 and 3. It was found that during winter season *Aerva lanata* shows 100% frequency followed by *Sida acuta* (80%) whereas during rainy season *Imperata cylindrica* shows 100% distribution.

Table 1 .Ecological status of shrubs under unburnt teak plantation (1997).

Species	F (%)	Density ha^{-1}	R.F.	R.D.	R.Dom.	IVI
Adhatoda zeylanica	100	514	20	42.20	14.62	76.83
Clerodendron viscosum	33	156	6.67	12.84	2.64	22.15
Cordia myxa	33	22	6.67	1.83	1.08	9.58
Flemaugia	17	11	3.33	0.92	0.54	4.80
Helicteris isora	33	45	6.67	3.67	7.91	18.24
Holarrena antidysenterica	17	11	3.33	0.92	1.39	5.65
Holoptelea integrifolia	17	156	13.33	12.84	10.55	36.73
Lantana camara	50	78	10	6.42	19.24	35.66
Mallotus philippinensis	17	11	3.33	0.92	34.87	39.12
Murraya koenigii	67	156	13.33	12.84	5.98	32.16
Syzygium cumini	17	11	3.33	0.92	0.28	4.53
Vallaris heynei	17	11	3.33	0.92	0.10	4.36
Zizyphus jujuba	33	34	6.67	2.75	0.78	10.20
Total		**1217**				

H' (Diversity index) = 1.84

Table 2. Ecological status of herbs under unburnt teak plantation (1997) during winter season.

Species	F (%)	D ha^{-1}	R.F.	R.D.	R. Dom.	IVI
Achyranthus aspera	20	200	4.17	0.87	3.41	8.45
Adhatoda zeylanica (s)	30	700	6.25	3.04	13.66	22.95
Aerva lanata	100	4700	20.83	20.43	3.41	44.68
Cynodon dactylon	20	2100	4.17	9.13	3.41	16.71
Cyperus monocephalus	10	100	2.08	0.43	3.41	5.93
Desmodium triflorum	10	100	2.08	0.43	3.41	5.93
Evolvulus numularis	10	300	2.08	1.30	3.41	6.80
Ichnocarpus frutescence	50	1100	10.42	4.78	24.89	40.09
Imperata cylindrica	60	7700	12.50	33.48	3.41	49.39
Limonia acidissima (s)	10	100	2.08	0.43	3.41	5.93
Murraya koenigii (s)	10	100	2.08	0.43	13.66	16.17
Oplismenus burminnii	30	700	6.25	3.04	3.41	12.71
Rungia himalayensis	40	1100	8.33	4.78	3.41	16.53
Sida acuta	80	4000	16.67	17.39	13.66	47.71
Total		**23000**				

Table 3. Ecological status of herbs under unburnt teak plantation (1997)during rainy season in Chiriyapur Forest, Haridwar Forest Division.

Species	F (%)	D ha^{-1}	R.F.	R.D.	R. Dom.	IVI
Acacia catechu	16.67	556	2.56	0.85	0.84	4.26

Achyranthus aspera	83.33	18337	12.82	28.21	3.70	44.72
Adhatoda zeylanica	33.33	834	5.13	1.28	9.13	15.54
Aerva lanata	33.33	2778	5.13	4.27	10.26	19.67
Cassia tora	16.67	5835	2.56	8.97	18.51	30.05
Cissampelos pareira	16.67	278	2.56	0.43	5.66	8.66
Commelina benghalense	16.67	278	2.56	0.43	10.26	13.26
Ichnocarpus frutescence	66.67	3890	10.26	5.98	4.06	20.29
Imperata cylindrica	100	5001	15.38	7.69	10.86	33.94
Oplismenus burmanii	50	3612	7.69	5.56	1.89	15.13
Phyllanthus niruri	66.67	3334	10.26	5.13	4.06	19.44
Setaria glauca	33.33	8613	5.13	13.25	6.57	24.95
Sida acuta	83.33	10558	12.82	16.24	3.35	32.41
Urena lobata	33.33	1111	5.13	1.71	10.86	17.70
Total		**65013**				

H' (Diversity index) = 2.16

Total density of herbs during winter season was 23,000 ha^{-1} whereas during rainy season it was 65,013 ha^{-1}. *Imperata cylindrical* was dominant (IVI 49.39) during winter whereas during rainy season *Achyranthus aspera* was dominant (IVI 44.72).During winter season regeneration of three shrubs were observed whereas during rainy season one tree and one shrub regeneration was observed. Table 4 and 5 describe phytosociological attributes of species under teak plantation

1997 duly burnt in the month of February. Richness of species in winter and rainy season was 11 and12 respectively with total density 15,400 and 23,600 ha^{-1} respectively. During winter *Sida acuta* was dominant (62.41IVI) followed by *Imperata cylindrica* (55.72 IVI). Seedlings of *Zyzyphus jujuba, Limonia acidissima* and *Murraya koenigii* were observed.

Table 4. Ecological status of herbs under burnt teak plantation (1997) during winter season in Chiriyapur, Haridwar Forest Division.

Species	F (%)	D ha^{-1}	R.F.	R.D.	R.Dom.	IVI
Aerva lanata	50	1800	17.24	11.69	3.13	32.05
Cynodon dactylon	30	3000	10.34	19.48	12.50	42.33
Cyperus monocephalus	10	100	3.45	0.65	3.13	7.22
Ichnocarpus frutescens	20	200	6.90	1.30	3.13	11.32
Imperata cylindrica	50	4000	17.24	25.97	12.50	55.72
Limonia acidissima (s)	10	100	3.45	0.65	12.50	16.60
Murrya koenigii (s)	10	400	3.45	2.60	12.50	18.55
Oplismenus burminnii	20	300	6.90	1.95	12.50	21.34
Rungia himalayensis	20	800	6.90	5.19	3.13	15.22
Sida acuta	60	4500	20.69	29.22	12.50	62.41
Zyzyphus jujuba (s)	10	200	3.45	1.30	12.50	17.25
Total		**15400**				

H' (Diversity index) = 1.78

Fire boosted regeneration of trees (Ram, 2006) during rainy season *Parthenium hysterophorus* was dominant (55.98 IVI) followed by *Paspalum sanguinalle* (41.41 IVI).

Table 5. Ecological status of herbs under burnt teak plantation (1997) during rainy season.

Species	**F (%)**	**D. ha^{-1}**	**R.F.**	**R.D.**	**R. Dom.**	**IVI**
Adhatoda zeylanica (s)	10	100	2.33	0.42	0.93	3.68
Agaretum cohyzoides	10	100	2.33	0.42	7.93	10.68
Artemisia vulgaris	20	300	4.65	1.27	25.37	31.30
Cynodon dactylon	20	2100	4.65	8.90	0.42	13.96
Ichnocarpus frutescence	40	900	9.30	3.81	2.45	15.56
Imperata cylindrica	40	2700	9.30	11.44	6.91	27.65
Lantana camera (s)	10	100	2.33	0.42	7.24	9.99
Oxalis corniculata	50	3500	11.63	14.83	2.11	28.57
Parthenium hysterophorus	60	2300	13.95	9.75	32.28	55.98
Paspalum sanguinalle	60	4500	13.95	19.07	8.39	41.41
Rungia himalayansis	50	1600	11.63	6.78	3.25	21.66
Sida acuta	60	5400	13.95	22.88	2.73	39.56
Total		**23600**				

H' (Diversity index) = 2.06

Fire invites invasion of alien species (Srivastava, 2006) seedlings of *Lantana camara* and *Adhotoda zeylanica* was observed during rainy season. There was no trees seedling in winter season. *Paspalum sanguinalle* and *Cynodon dactylon* presence indicate its biotic impact. Diversity index of herbs during winter and rainy season was 1.70 and 2.06 respectively. Affect of forest fire under teak plantation in foot hills of Darjeeling was studied by Ram and Jana (1998) and observed increase in herbaceous species and germination of seedling, reduction in saplings, shrubs and undergrowth biomass production. Krishnamurthy (1983) reported that forest fires have deleterious effect on forests, forest produce including timber, young regeneration, soil and vegetation cover, rates of evaporation and transpiration resulting into degradation of the forest and the ecosystem as a whole.

Table 6. Ecological relationship of undergrowth during winter and rainy seasons under unburnt and burnt teak plantation.

Site Condition	Season	Undergrowth	Richness	Density ha^{-1}	Diversity	Evenness
Unburnt	Winter	Shrub	13	1217	1.84	0.50
		Herb	14	23000	1.91	0.50
	Rainy	Herb	14	65013	2.16	0.57
Burnt	Winter	Herbs	11	15400	1.78	0.50
	Rainy	Herbs	12	23600	2.06	0.57

Table 7.Similarity of herbs between unburnt and burnt teak forest floors during rainy season.

Forest Condition	Unburnt	Burnt
Unburnt	Unburnt	Burnt
	100	80
Burnt	-	100
	100	80
Burnt	-	100

During rainy season less (31%) similarity of herbs was observed between unburnt and burnt forest floors whereas maximum similarity (80%) was observed during winter season.

Table 8.Season wise undergrowth biomass production (kg ha-^{1}) under unburnt and burnt teak forest floors

Components	Site Condition			
	Unburnt		Burnt	
	Winter	Rainy	Winter	Rainy
Total biomass excluding grass	1101.6	4728.0	51.0	1206.0
Grass	10.4	14.7	144.0	487.5
Partherium	-	-	-	300.00

The undergrowth biomass (kg ha^{-1}) production during winter and rainy season from unburnt and burnt forest floor was given in table9. Grass production from burnt forest floor was observed many folds increase during rainy season than winter season. *Parthenium hysterophorus*, an alien species, productivity during rainy season from burnt forest floor was 300 kg ha^{-1} whereas its productivity from unburnt forest floor during winter and rainy season and burnt forest floor during winter season were nil. The undergrowth biomass production from brunt floor was less (Ram, 2006).The result indicates that fire favour luxuriant herbs appearance during rainy season as reported by Srivastava (2006).

It can be concluded from the study that fire to the forests invites invasion of weeds and boosting of the productivity of herbaceous and grass vegetation.

References

Campana, C; Gavom, S and J.F Pange 2002.Influence of ground cover on earthwork communities in a unmanged beach forest linear gradient studies.*European Journal of soil*, 38(2): 213-224

Chakravarty, D and H.N, Mathur 1992. Camparative iundergrowthj studies and bioomass estimation in ecucalyptus plantation in Tripura *Effects of Growing Eucalyuts(Edt. Singhal, R.M. & Rawat, J.K,F.R.I., Dehradun.)*

Chaudhery, O.P., Mishra, G.P. and Ram Prasad 1988. Phytosociological studies of teak plantation and mixed natural forests in Madhya Pradesh. II Disturbed; species diversity; productivity and some quantitative parameters of ground flora.*Journal of Tropical Forestry,*4(11):177-187.

Gachet, S., Leduc, A., Bergeron, Y., Nguyen-Xuan, T. and Francine Tremblay 2007. Under story vegetation of boreal tree plantation: Differences in relation to previous land use and natural forests. *Forest Ecology and Management,* 242: 49-57.

Kern,C.C.,Brain,J.P.and Terry F.Strong 2006. Ground layer plant community responses to even –age and uneven age. Silviculture treatments in Wisconsin northern hardwood forests. *Forest Ecology and Management,* 230: 162-170.

Krishnamurthy, A.V.R.G. 1983. *Forest and Wildlife in India.*Committee on Science Technology in Developing Countries, IIT. Madras.Mathur H.N; Naveem ,Jain and S.S. Sajwan 1980. Ground cover and undergrowth in eucalyptus, brush wood and sal forest. An ecological asssement .*Van Vigyan* 18 (3&4) : 56-61,

Mathur,H.N. and P. Son 1983. Comparative account of undergrowth under ecualyptus and sal in three different localities of doon valley. *Indian forester* 109 (9):882-890

Mcdonald, S.E. and E.F. Treena 2007. Under story plant community of Boreal mixed wood forests and response to variable retention harvesting. *Forest Ecology and Management,* 242: 34-48.

Mishra, R. 1968. Ecological Work Book. Oxford and IBH Publishing CO. New Delhi.

Pielou, E.C. 1975. Ecological Diversity. John Willey and Sons, New York.

Prasad, Ram 1992. Ground floor diversity and grass production under plant- aiton of eucalpyputs and other species *Effects of growing eucalyputs* (edt. Singhal,R.M. and Rawat, J.K, FRI Dehradun).

Prasad, Ram and P. Jalil 1987. Grass production from man-made forests. A paper presented in the seminar on *Plantation Strategy* held at SFRI Jabalpur (June 27-28, 1987

Ram, Nirmal and M.M. Jana 1997. Ecological impact of compaction under Teak plantation in the foot hill of Darjeeling Himalyan , *Indian Forester* 123 (7): 623-630.

Ram, Nirmal and M.M. Jana 1998. Ecological impact of forest fire under teak plantation in the foot hill of Darjeeling Himalaya. *The National Seminar on Environment And Sustainable Development* November 19-21, 1998, Dept. of Geography, North Bengal University Daljeeling West Bengal, India.

Ram, Nirmal 2006. Ecological impact of forest fire under *Cryptomeria japonica* plantation in wet temperate zone of Balason catchment of Darjeeling hills. Proceedings of the XIIth Silvicultural Conference (1-3rd Feb, 2006). Pp. 159- 166. Ed. Negi, S.S. *et al.* FRI, Dehradun.

Shadangi, D.K. and V. Nath 2005. Impact of seasons on ground flora, under plantation and natural forest in Amarkantak. *Indian Forester,* 131 (2). 240-250.

Shanon, C.E. and W.E. Wiener 1963. The Mathemetical Theory pf Communication University of Illinois Press. Urbana, USA. Pp 117.

Sharma S.K, Verma C.M. and L.D.,Ahuja 1978. Production of Ground Story (grass components) in afforested area in arid regions of India. Sympo on *Arid Zone Research And Development* (AZRI) Jodhpur, Feb, 14-15, 1978

Singh, Bakshish, Mathur H.N. and P. Joshi 1986. Effect of shade on grassland production in the moist -subtropical region of Northern India. *Indian Journals of Forestry* 13 (4)345-348.

Singh, Sanjay, 1998. Vegetational studies under noth and south aspects on the temperate zone of Tirthan Valley of Western Himalaya, *Indian Journal of Forestry*, 21 (3): 217-223

Sorenson, T. 1948. A method of establishment group of equal amplitude in plant society based on similarity of species. *K. Danske Videnst Selsk*, 5:1-34.

Srivastava, R.K. 2006. Impact of forest fire on Indian Biodiversity. Proceedings of the XIIth Silvicuture Conference (1-3rd. Feb, 2006). Pp 143-145, Ed. Negi, S.S. *et al.* FRI, Dehradun.

Upadhyay, K., Pandey, H.N. and R.S. Tripathi 2006. Understory plant diversity in sub- tropical humid forest of Mrghalaya. *International Journal of Ecology and Environmental Science,* 32: 207-219.

Zonner, K., Eric , Kebrick, J.M., Jensen, R.G., Peck, J.E. and J.K. Grabner, 2006. Responses of ground flora to a gradient of harvest intensity in the Missouri Ozarks. *Ecology and Management,* 222: 326-334.

Forest Conservation through Biodiversity Informatics

Neelesh Yadav

Forest Informatics Division

Forest Research Institute, Dehradun-248006

Abstract

The fundamental basis of all efforts to effectively conserve biodiversity and natural ecosystems lies in efficient access to knowledgebase on biodiversity and ecosystems resources and processes. While, enormous amount of biodiversity knowledge is available and generated daily, data / information is scattered and not digitized. This hampers the sustainable development, especially in developing and under-developed part of the globe. Authors elaborate the role of digital libraries in collating information from various sources and develop interoperability mechanism for better exchange / sharing of information. Digital Library Initiatives (DLI) in biodiversity would lead to creating virtual research space for evaluating hypothesis. The Forest Research Institute, Dehradun has established a Bioinformatics centre to achieve the objectives of digital library conservation for its historical biological collections. Land managers researchers and the public currently often are unable to obtain useful biodiversity information of forests because the subject represents such a large component of biology, ecology, forestry and systems to compile and organize this information do not exist. Information on vascular plant taxonomy, trees information, ecosystem database etc. are the key factors of forest biodiversity. The biodiversity informatics will lead to conserve the forests because it will provide the all kind of information via digital and electronic medium to the common people and create an understanding of climate change and global warming, so its importance is must for adoption at all research level. The forest ecosystem covers biggest amount of biodiversity, so the development of biodiversity informatics is the need of time. Biodiversity Informatics is the application of informatics to recorded and yet-to-be discovered information specifically about biodiversity, and the linking of this information with genomic, geospatial and other biological and non-biological datasets. Biodiversity Informatics is the application of information technology (IT) tools and approaches to biodiversity information, principally at the organismic level. It thus deals with information capture, storage provision, retrieval, and analysis, focused on individual organisms, populations, and species, and their interactions. The use of Information and communication technology will provide one platform for the forest biodiversity conservation. The Forest Research Institute, Dehradun (India) is working for biodiversity informatics for forest conservation. All museums specimens and forestry information is going to become digital through biodiversity informatics.

Keywords: Biodiversity informatics, digital library, forest biodiversity

Introduction

Biodiversity informatics is an interdisciplinary research and infrastructure development activity. It thrives on collaborations among environmental biologists, computer scientists, and network and software engineers. The field brings together leading information processing technologies such as semantic frameworks, information models, data integration engines, network communications protocols, standards, software applications and web services, to enable wholly new kinds of analytical and synthetic research in environmental biology.

Biodiversity research is inherently a global enterprise. Systematists and ecologists in the western hemisphere for over a century have collaborated across political borders to document the distribution of species and of biological diversity. And in recent decades much work has been focused on understanding the dynamics of ecological processes responsible for the creation and maintenance of diverse systems.

Biodiversity informatics attempts to accurately acquire, represent, communicate, integrate, analyze and apply information extracted from natural systems. The field can be modeled as a process or 'value chain' of activities beginning with the methods and activities associated data collection, and ending in the application of derived knowledge for science and society. *(Source Global Biodiveristy Information facility, www.gbif.org)*.

Biological Diversity

Earth is the only planet in solar system known to inhibit the life. E. O. Wilson,who first coined the word "Biodiversity" project that there are about 10 million species, of which 1.5 to 1.7 million are known to us (Wilson, 2000). Biodiversity, refers to the variety and variability among living organisms within ecological systems in which they occur; as well as the way they interact with each other in their environment. Hence, it encompasses all levels of natural variations from molecular and genetic levels to the species level. A responsible use of the earth's natural resources requires in-depth knowledge of the size and quality of stocks and its locations, a conscious exploitation plan and monitoring of consequences of the use of these resources. Since our fate and economic prosperity are so completely linked to the natural world, information about biodiversity and ecosystems – as well as the infrastructure that surrounds it – is vital to wide range of scientific, educational, commercial and governmental uses (Schnase et.al., 1997). Hence, information about biodiversity forms the basis of our most important knowledge domains

(Schnase,2000).

Biodiversity Information- Availability, Content and Quality

The major characteristics of the biodiversity information is its diverse,distributed sources as well as diverse discipline, types and formats in which it is available. From traditional paper based libraries to scattered databases of varying size and physical specimens preserved in natural history collections throughout the world, record on biodiversity is uncoordinated and poorly integrated, and large parts of it are isolated from general use. No guide exists to what data are available, access is often on an ad hoc basis, and scales and content of data sets are not consistent (Schalk,1997, 1998). Hence, though abundant biodiversity data and information are incomplete and dispersed among organizations, government agencies and individuals. Complicating this picture further, the quality of data and information available if often unknown. Thus, a common language and system for information exchange and management is needed urgently. It is like having data without information system. Information and Communication Technology (ICT) may provide an answer to this challenging problem.

Biodiversity Informatics

Currently, the biological informatics activity is synonymous with the molecular and genetic informatics, popularly known as bioinformatics. However, the complete value of molecular or genetic information cannot be realized until it is possible to correlate genetic information with data on (for example) the native habitat, neurobiology, physiology, or genealogical relationships of the species from which the genes are derived.

At the end of the last millennium we witnessed the birth of a new field of science. biodiversity informatics. This is a broad field of applying ICT to all kinds of biological sciences. Worldwide there are several measures being initiated to develop tools, techniques and standards for collection, collation, storage, analysis, modeling, simulation and dissemination of the diverse and distributed information about the vast biotic resources and their environs (Schalk, 1992; Schalk and Los, 1995; Sugden and Pennisi, 2000). This has given birth to many information systems and networks dedicated to cater information needs of specific bio-geographic areas and ecosystems. This first wave of biodiversity informatics resulted into massive information sources (Bisby, 2000), however, second wave aims at pulling together these sources, bringing coherence and organization in information collated. There are several international treaties calling for comprehensive, high quality information on the status of biodiversity.

Digital Library Initiatives (DLI)

Digital Library Initiative (DLI), is coordinated set of heterogeneous actors /organizations interact through an electronic and communication network to develop, add-value, disseminate, and achieve electronic information and related specialist services. Digital libraries are not just limited to information warehousing. Current breed of digital library activities include data mining, indexing and classification, linking, filtering and ranking as well as interoperability across multiple platforms to access and retrieve many digital representations for text and multimedia object. Some even offer intelligent agents, while others reach towards the goal of video searching. Site neutrality, open access, variety and granularity of information, information sharing, up-to-date and round the clock availability are distinguishing characteristics of DLI. This helps transcend language barriers reaching across continents and languages. DLI offers collaborations amongst laboratories where information and data is raw material, forming digital collaboratory laboratory.

DLI in Biodiversity Informatics

Major objectives of the DLI in biodiversity are to increase the amount of useful information available to decision-makers, scientists, and the public. This can be achieved by providing open, worldwide access to existing biodiversity information, achieving compatibility through standardization and interoperability and track information needs, priorities and best practices, and also by prioritizing and promoting expansion in content.

The digital library, which serves as a clearinghouse for scientific data, maps, metadata, documents and GIS data, can characterize the ecology of the given region. DLI efforts in biodiversity should first aim at becoming clearinghouse of knowledge by developing meta-databases. This calls for co-operation within and amongst agencies. Development of metadatabases, electronic catalogues, electronic data archival leading to clearinghouse mechanism would be the assured way to ensure the wider dissemination of wealth of information that is available in our libraries. The first step in this direction would be to make our catalogue available on the Net, followed by the step wise electronic archival of legacy literature and development of data retrieval interfaces to make them available on the web.

Ram.,et.al. (2000), state that DLI initiatives in the area of biodiversity should support dynamic resources that can be updated by users or an information provider at any time. This would result in, -reduced cost of obtaining updated information, -direct communication with the end users, -creation of cooperative atmosphere to encourage information exchange, -improved cost effectiveness of research efforts by expediting and increasing information flow, and –mechanism for direct public participation in the information gathering process.

Biodiversity DLI in Third World – Status

By collecting data, recording the information and disseminating this knowledge, using the latest technologies available, Third World countries will be better able to manage their biodiversity and help maintain nature's fragile balance. However, given the fact that – information infrastructure is just beginning to span its way, it is not surprising that biodiversity information within many developing and under-developed nations are dispersed, distributed, not in exchangeable form. However, the negative attitude towards information management initiative is what worries us the most. Many a times authorities as well as data generators escape with the argument that the data is classified and hence can't be shared, even restrictively within the nation. Further, those interested in information management activities are discouraged, as it is not treated as scientific activities. This prevent domain expert from taking active part in scientific information management. This is further worsened by the widening gap between the data managers and data producers, mostly due to lack of trust. Since the ecological, economical and social value of data are not realized, millions of dollars worth of information never sees the light of the day.

This is particularly true for the discipline like biodiversity where several socio-political forces wish not to have efficient, accurate, authenticate and quality information disseminated. Hence, DLI in Biodiversity in Third World is imperative for sustainable utilization of their natural resources. This would not only aid better research, but would also reduce the cost of doing research – which often is issue when funding ideas and concepts. It would also prevent duplication of doing same things by different groups, involving waste of intellectual ability, time, money and infrastructure. Thus, knowledge management mechanism and its implementation are essential for the developing countries, especially in today's competitive world of intellectual property rights.

Major Application Areas and Challenges

We see great potential for DLI in biodiversity within the developing and under-developed nations. Major application areas can be categorized as:

- Information Collection, Collation
- Processing / Organization of information
- Information Analysis and Discovery
- Access / Interaction leading to collaboration
- Policy and Procedure
- Human Resource Development

This is very much within the reach as current breed of digital libraries include data mining, indexing and classification, linking, filtering and ranking; as well as interoperability across multiple access and retrieve many digital representations for text and multimedia objects. Thus, the chief structural characteristic of a digital library is a high degree of data integration across formal boundaries. Some offer intelligent agents, while other digital library systems reach toward the goal of video searching.

In addition to knowing what's where and who's who in the field of biodiversity; and access to formal ways of publications; digital libraries should be able to develop the mechanism to tap the informal intellectual discussions and exchange / sharing activities such as email or even informal notices. We should be able to analyze and forecast based on this tapped information.

Some of the technologies and standards, which have been evolved during past few years as part of the global research in the field of digital library, are bound to play significant role in biodiversity knowledge management. Notable amongst them are metadata creation, information harvesting, and interoperability between datasets. In subsequent part of this paper we shall discuss them in detail.

Information Harvesting and Archiving

One of the major characteristics of biodiversity information is its content diversity and distributed sources. Since, information is available in patches and owned by individuals / institutions, it becomes difficult to arrive at efficient decisions based on accurate, precise, authenticate, up-to-date information. Single biggest challenge for information managers and biodiversity domain experts is to collate this dispersed information in single repository or achieve cross-linking between these multivariate and multi-standard datasets. Since, it is impossible to develop a single repository, an approach of easily accessible, distributed data network to collate and disseminate information on biodiversity would be viable and working solution. With the help of information extractors or robots or harvesters, data /information can be pulled together and made available to end-user as one single query result. These "Agents" or "Robots" uses pull technology to retrieve data from distributed sources and conglomerate information into common accessible format. Hence, information residing in various electronic databases linked on the net can be virtually pulled together.

However, in developing and under-developed nations not all the biodiversity information procedures are online, hence offline information acquisition can be practiced. Since many of these organizations are in beginning stages of data/information digitization, efforts could be made to develop common-formats for similar type of data such as taxonomy, biology. Biogeography, ecology, environmental stress and pollution etc This would pave way for easy-to-handle information integration. This calls for collaborative and joint action on behalf of digital libraries and domain experts.

Much of the information in the Third World is still on non-electronic media and non-exchangeable format. Much of the information is available in print media, card-files, biological specimens and field notes of individual workers. Archiving this information in digitized form and making it available online would be significant contribution in building "digital biodiversity knowledge library" ollation of these individual repositories would form full proof and integrated *"national natural history management information facility"*.

We are of the opinion that, DLI in our environments should reach beyond the development of factual databases - data sets, which collate actual scientific data that is generated through our R&D and environmental surveillance programs. Mechanism to acquire data as and when generated is imperative. However, there is a need to evolve ways to provide security to data until objectives are accomplished. This would bring significant change for developing and under-developed regions of this planet earth, where much of the information / data on biodiversity remains scattered and unplanned to the date.

Interoperability amongst databases

Modern electronic biodiversity databases are highly diverse and heterogeneous, ranging from genomic databases, to specimen databases, to ecological and ecosystem databases. To understand and manage biodiversity, the different varieties of data must be combined and analyzed together. It is because of this biological and information complexity (Schnase at. al., 1997), in biodiversity research people act as sophisticated filters and query processors. Though this process of extracting higher-order understanding from dispersed datasets is intellectual in nature; yet it breaks down quickly as the volume and dimensionality of the data increase.

Means to manage this complexity are must. DLI can promote interoperability dispersed biodiversity knowledge.

The interoperability issues of the biodiversity information community are both technical and organizational in nature. Organizations have evolved their own systems, legacy databases, and applications to serve internal needs. This has resulted in data models and applications uniquely tailored to meet specific internal requirements. However, as the importance of sharing information across organizational computing environments is recognized, data interoperability becomes paramount.

The interoperability of biodiversity information across systems and platforms is also an organizational issue. There is an urgent need to access distributed information from many organizations to address boundary-spanning problems such as; disaster relief, environmental monitoring, interagency coordination, joint force deployment, and provision of integrated geospatial mapping services over the Internet. The need to access information resources across bureaucratic and hierarchical boundaries calls for new organizational processes that permit open network exchanges.

Digital libraries can play an instrumental role in overcoming current impediments to interoperability by harmonizing the transfer of open biodiversity data. Open data models can reduce transaction costs, stimulate component generation, and provide a standard platform for new components and applications. Using ANSI/NISO Z39.50, a standard for information interchange and retrieval that has proven successful in the bibliographic and geospatial domains, it is now possible to search and retrieve biodiversity information from multiple databases connected by the Internet (Soberon, 1999). Common Object Request Broker Architecture (CORBA) can be used to provide access to biological databases bringing their content together. Further, Extensible Markup Language (XML) is being used increasingly to describe cross-discipline data (e.g. taxonomy, natural history, botany, weather, geospatial as well as cellular and molecular biology information). Authors group has recently developed BCML(Biological Collections Markup Language) (http.//www.ncbi.org.in/bcml/) to help describing biological specimen repositories. Use of these protocols and standards by developing and under-developed nations in setting up distributed national CHM would achieve interoperability amongst data sources maintained by different data custodians.

Conclusions

The foregoing discussion reveals that there is great potential at the same time challenges that lies before the DLI in Biodiversity for the Third World. If the standards, tools and techniques and experiences of similar efforts in the other part of the globe is used wisely, digital library would play vital role in archiving and digitizing biodiversity information storehouse unexplored in Third World. This would result in development of “Open and Distributed” virtual biodiversity knowledge facility and would greatly aid the sustainable usage and conservation of our biotic diversity. The forests hve largest amount of biodiversity information so the application of biodiversity informatics in forestry data may be a right and correct beginning. Biodiversity informatics is very significant tool for forest conservation.

References

Schalk, P. H.1898. Management of marine natural resources through biodiversity informatics. Marine Policy, 22(3).269-280.

Helly, John, T Case, F. Davis, S. Levin and W Michener (l995). The state of Computational ecology. Available at http.//www.sdsc.edu/compeco_workshop/report/report.html

Schnase, J. L. 2000. Research directions in Biodiversity Informatics. Proc. 26th Int.Conf. Very Large Databases, Cairo, Egypt, 2000.

Bowker, G. C. 2000. Work and information in the sciences of biodiversity. Proc. 26thInt. Conf. Very Large Databases, Cairo, Egypt, 2000.

Cotter, G. A. and B. T. Bauldock 2000. Biodiversity Informatics Infrastructure. An information commons for the biodiversity community. Proc. 26th Int. Conf. Vary Large Databases, Cairo, Egypt, 2000.

Lane, M.A., J. L. Edwards and E. S. Nielson. 2000. Biodiversity Informatics. The challenges of rapid development, large databases and complex data. Proc. 26th Int. Conf. Very Large Databases, Cairo, Egypt, 2000.

Sugden, A. and E. Pennisi. 2000. Diversity Digitized. Science, 289 (5488). 2305.

Wilson, E. 0. 2000. A global biodiversity map. Science, 289 (5488). 2279.

Bisby, F. A. 2000. The quiet revolution. biodiverrity informatics and the Internet.Science, 289 (5488). 2309-2312.

Edwards, J. L., M. A. Lane and E. S. Nielson. 2000. Interoperability of biodiversity databases. biodiversity information on every desktop. Science, 289 (5488).2312-2314.

GBIF Business Plan, Draft 5 2000. Global Biodiversity Information Facility Business Plan, Draft 5,September, 2000., pp. 38.

Ram. Sudha., M. R. Kunzmann, J. Kim and J. Abbruzzi. (2000). A Digital "Living" Library – Prototype for Harvesting Ecological Data over the Internet.

Schnase, J. L., M. A. Lane, G. C. Bowker, S. L. Star and A. Silberscgatz 1997.Building the next generation biological information infrastructure. Proc. Natl. Acad. Sci., Forum on Nature and Human Society. The Ouest for a sustainable World, October 27-30, 1997. Washington DC, USA.

Plant Species for Fragmented Landscapes

Diversity of Medicinal Plant Species in the Thar Desert (Rajasthan), India

S. R Baloch, G. Singh* and Pramod Kumar

Forest.Research.Institut. Dehradun

Arid Forest Research Institute, Jodhpur*

Abstract

With the advent of human civilization, many systems of therapy have been developed primarily based on plants i.e. Ayurveda, Homeopathy, Sidda, Unani, etc. The plant-based traditional medical systems continue to provide the primary health care to more than three-quarters of the world's populace. Thus, it is necessary that we should have full knowledge regarding the occurrence, frequency and distribution of these plants for their proper utilization. Thar Desert of Rajasthan has great potentiality both from the economic and botanical points of view. Therefore, a study was undertaken in Forest land, Community land and Agriculture land of Barmer, Jaisalmer, Bikaner and Pali districts of Thar Desert of Rajasthan. The study aimed to look into the diversity of plant resources that are used by local people for curing various ailments. The study revealed that the 57 plant species belonging to 37 families were recorded in the study area. Out of this, 14 tree species, 18 shrub species, 25 herb species, have been recorded. Mimoceae and Caesalpiniaceae were found to be the most dominant family in tree species; Amaranthaceae and Asclepiadaceae in shrub species and Poaceae and Febaceae, Asteraceae, Malvaceae, Euphorbiaceous, Solanaceae herb species, respectively.

Keywords: Thar Desert. plant species, diversity.

Introduction

Traditional utilization of plants for medicinal purposes in India has been documented long back in ancient literature (Tulsidas, 1631; Charak , Drdhbala, 1996) Indian Systems of Medicine (ISM), which is one of the most ancient medicine practices known to the world, and derives maximum formulations from plants and plant extracts that exist in the forests has always played a key role in the health systems. However, organized studies in this direction were initiated in 1956 (Rao,1996) and off late such studies are gaining recognition and popularity due to fading of traditional knowledge and reducing plant population. Right from its beginning, the documentation of traditional knowledge especially on the medicinal uses of plants, has provided many important drugs of the modern day (Anon., 1994; Cox and Ballick,1994; Fabricant and Farnsworth, 2001). Even today this area holds much more hidden treasure, as almost 80% of the human population in developing countries is dependent on plant resources for healthcare (Farnsworth et al., 1985). In India the native people are exploiting a variety of herbals for effective curing of various ailments. But, in the rural areas of Thar Desert districts, plants are the major source of local medicine for their well being. Information on folk medicinal uses of the plants has recently become of renewed interest in search for new therapeutic agent. A vast knowledge on medicinal plants exists as oral among the folklore and primitive societies of India, where a large number of potent medicinal herbs are found growing wild. The plant parts used, preparation, and administration of drugs vary from one place to other. However, the knowledge of herbal medicines is gradually perishing, although some of the traditional herbal men are still practicing the art of herbal healing effectively. These plants are frequently used by the local inhabitants of the area for treatment of various diseases. Some modern drugs have been deducted from folklore and traditional medicines. Living close to nature, traditional societies have acquired unique knowledge about the use of wild flora and fauna, most of which are unknown to the people who live away from such natural ecosystem as forests. Such knowledge and practices/experience were subjected to further modification or enriched with new knowledge of practice by succeeding generations and become a part of the tradition, culture, art, belief, folklore and knowledge base of these traditional communities. The traditional knowledge, skill and practices thus developed are freely exchanged cared for and nourished as a common property of the communities (Pushpangadan and Kumar, 2005).The value and importance of traditional knowledge are now being increasingly all over the world (Posey and Dutfield, 1996). The Indian Thar desert supports a number of plant species of which a few are used as medicinal purposes despite of adverse climatic conditions and high biotic pressure (Singh, 1985; Bhandari and Shringi, 1987; Mertia, 1990). The plants of the arid region have been well documented for their medicinal values (Atal *et al*., 1975; Bhandari, 1997; Joshi *et*. *al,*1998; Katewa and Guria, 1997; Mertia and Nagarajan, 1997). However, information on the uses of plants as traditional medicines has not been documented and there is still need for proper documentation of these plants because such type of study basically lies in finding out the usage of plants or its parts for betterment of the forest dwellers to achieve their socio-economic development. Keeping this in view, the present study was initiated, with an aim to document the knowledge of rural people and folklore on the utilization of medicinal plants in remote areas of Barmer, Jaisalmer, Bikaner, and Pali districts of Thar Desert, Rajasthan

Survey Data Collection

The survey was conducted in these districts during the evaluation of Combat Desertification Project & Study on biological diversity in Mangala, Sarswati and Rageshwari areas of Rajasthan Hydro carbon project. The population of the study area is predominantly rural. The main occupation of these communities is farming and livestock rearing. During survey interactions were made with villagers and local communities of the respective areas for collecting information's on various plant drugs used by them to treat different ailments and their mode of administration. With the help of the information provided by them regarding plant species was then compared and confirmed with authentic literature.

Results and Discussion

In the modern age, people are very alert about their health and health hazards caused by allopathic drugs due to their side effects. After recognition of the World Health Organization Assembly (1977), day by day herbal medicines are become popular all over the world. Now a day's, it is estimated that about 80 percent of the world population relies on herbal medicines for primary health care. The present study reveals that there is a great wealth of knowledge and practice regarding use of plant for therapeutic purpose in different parts of state because the efficacious of these plants have been tried and tested by various communities since a long time.

Plants medicines deserve detailed studies. The traditional knowledge of rural is valuable not merely as an indicator of plant to be screened but also equally important to evolve new methodological approach and strategies towards treatment and research. The information presented can prove to be invaluable as a starting point to provide for screening plants for therapeutic use and furthering the research on traditional medicinal plants for improving their quality and efficacy. No survey of naturally growing medicinal plants of the present study area has been reported till date.

Table 1. Diversity of Medicinal herbaceous species in Thar Desert of Rajasthan

Species	**Local Name**	**Habitat**	**Family**	**Medicinal Uses**
Achyranthrus aspera	Lathjira/ Apamarg	Herb	Acyranthaceae	Root Cough A pinch of root powder in combination with pepper and honey is given in cough. Hemorrhoids Powdered roots mixed with honey are given internally.
Abutilon indicum	kanghi	Herb	Malvaceae	Leaves are used bleeding piles.
Argemone mexicana	Pili kateli / Satayanasi	Herb	Papaveraceae	Root is used for chronic skin diseases. Leaves for Gonorrhoea dropsy and jaundice, scabies and other skin disease. The yellow juice is used in eye affection and leaves are given to camels. The juice rubbed on the body relieves

				rheumatic pain .The oil form the seeds is used externally for the skin.
Boerhavia diffusa	Sinawari	Herb	Nyctaginaceae	It used for nervous system, leprosy, skin, eyes disease snake bite, rat-bite infection aemia, heart disease, cough and intestinal colic. The Tibbi physicians used in asthma, jaundice.
Cassia angustifolia	Sena	Herb	Caesalpiniaceae	Traditional use for purification the blood bowel and other organs in many
Cleome viscosa	Hulhul	Herb	Cleomaceae	Leaf juice Headache Applied on forehead with
Citrullus colocynthis	Tumba	Herb	Cucurbitaceae	Fruits are used for Tumors.
Convolvulus desertii	Santari	Herb	Convolvulaceae	The plant is one of the sources of important indigenous drugs. The drug is used as a laxative and as a brain tonic

Convolvulus microphyllus	shankhpushpi	Herb	Convolvulaceae	Leaf used for indigenous drug Sankhpushpi is a brain tonic.
Cyperus rotundus	Motha	Herb	Cyperaceae	Rhizome Tonsillitis Paste of one rhizome rubbed inwards on tongue and also used Snake bite.
Cynodon dactylon	Dhob	Herb	Poaceae	It is used for stopping bleeding from piles. fresh cuts and also used in snake bite, scorpion-sting.
Datura innoxia	Dhatura	Herb	Solanaceae	Dried leaves and twigs of the plants are smoked as in antispasmodic in asthma, whooping cough.
Euphorbia hirta	Dudheli	Herb	Euphorbiaceae	Leaf extracts were assessed in rats using acetazolamide and furosemide as standard diuretic drugs.
Fagonia cretica	Dhamasa	Herb	Zygophyllaceae	It is used for tonic, prophylactic against small

				pox.
Fagonia bruguieri	Dhaman	Herb	Zygophyllaceae	It is used for tonic, prophylactic against small pox and also useful in Cholera and prolonged fever.
Glinus lotoides	Bakada	Herb	Molluginaceae	Plant pounded and boiled in water it is used as a remedy against urinary trouble and also used in indigestion and purgative.
Mollugo cerviana	Chirio – ro- khet	Herb	Aizoaceae	Root is tonic, stomachic, febrifuge. Used for fattening of horses
Solanum surattense	Bhuri ringani	Herb	Solanaceae	The roots, seeds, and flowers are all used in medicines.
Panicum antidotale	Gramano, Ghirano	Herb	Poaceae	It is used medicinally in wounds and as disinfectant in small-pox.
Pulicaria crispa	Dhola-Lizru	Herb	Asteraceae	The bruised leaves are applied to relied headache
Sida cordata	Adio -	Herb	Malvaceae	Leaves are dried

	Bel			pounded and used in local medicines for cuts and bruises.
Tephrosia purpurea	Sarphan ko	Herb	Fabaceae	It usually causes gas trouble.
Trianthema partulacastru m	Safed Santo	Herb	Aizoaceae	The plant is some time eaten as a pot herb. It's excessive used said to produce paralytic effect.
Tribulus terrestris	Gokhru	Herb	Zygophyllacea e	Plant extract for Urinary stone given orally. Seeds for Tonic.

The present information indicates that these plants are traditionally utilized for various diseases such as ache, fever, rheumatic pain, brain tonic, rejuvenator etc. Many of these plants are also described by Bhandari (1990), Jain (1991), Mertia and Nagarajan, (1997) and Dam *et al*. (1998).

However, the present study further broadens the base of this information. Though, attempt has been made to collect the in-depth information, yet it may not be complete and many more information may sti ll unknown. Further work in this direction may help about the uses of plants in traditional medicine.

Table 2.Diversity of Medicinal shrub species in Thar Desert of Rajasthan

Species	Local Name	Habitat	Family	Medicinal Uses
Acacia jacquemontii	Bhubavali	Shrub	Mimosaceae	The bark of root is used in the disttilization of sprits.
Aerva tomentosa	Choti bui	Shrub	Amaranthaceae	Use for Skin infection, abdominial warms remove swelling. Woolly seeds stuffed in pillows relieve headache and protective against rheumatism.
Asparagus racemosus	Satawar	Shrub	Boraginaceae	The roots are bitter, emollient, cooling, nervine tonic, diuretic, aphrodisiac, rejuvenating, ophthalmic, appetizer and useful in diarrhea and rheumatic complaints
Aloe barbadenesis	Guwarpatha	Shrub	Asphodelaceae	The plant is used as an anthelmintic, ulcergenic, antiprotic,, purgative and alexiteric. It is also useful in ophthalmia,

				jaundice and asthma and inflammation and wound healing, piles and rectal fissures.
Balanites aegiptiaca	Higota	Shrub	Simaroubaceae	The juice of bark and leaves is used in skin eruptions. The pulp is used in cough mixtures and to clean silk.
Calotropis procera	Aak	Shrub	Ascelpiadaceae	It is considered valuable for the treatment of pain and painful inflammation, such as in filariasis, rheumatism (leaves), ulcers, and dermal wounds (root bark), skin diseases, malaria etc. The flowers are tonic, digestive and useful in dysentery and diarrhea and root has antiplacentation property.
Capparis decidua	Ker	Shrub	Capparaceae	The plant is used as an anti-helminthic, anti-diabetic property, commonly used

				as laxative and for asthama/ cough/ intensine related problems.
Clerodendrum phlomidis	Irana	Shrub	Verbenaceae	The leaves are applied locally against guinea-worm. They are also given to cattle against diarrhea
Crotalaria burhia	Siniya	Shrub	Paplionaceae	The leaves and branches are used in the preparation of indigenous medicines that have a cooling effect.
Cordia gharaff	Gondi	Shrub	Ehretiaceae	The decoction of the bark is used for gargles.
Commiphora wightii	Guggal	Shrub	Burseraceae	Traditionally guggul lipid has been used to treat arthritis, rheumatism, urinary disorder, skin diseases and high cholesterol. Guggul (aka guggulu) is a gum resin, historically used for its antiseptic and deep penetrating actions in the treatment of elevated blood cholesterol and

				arthritis.
Euphorbia caducifolia	Danda Thor	Shrub	Euphorbiaceae	The milky juice is used as a cure for coughs and is applied to the skin on blister. The leaves are eaten and rarely sold in the market for vegetable and also used in fencing.
Leptadenia pyrotechnica	Khimp	Shrub	Ascelpiadacea e	Whole plant Wound healing The bruised stem and leaves are used to promote healing of wounds.
Lycium barbarum	Morali	Shrub	Solanaceae	The leaves pounded and mixed with Ghee are applied to abscesses. The bark is pruned and the powder blown in to the nostrils of horses against bronchitis.
Lawsonia inermis	Mehandi	Shrub	Lythraceae	Used in ulcer, edema, hair fall, graying of hair, burning sensation, headache, hepatitis, skin diseases, and

				anemia.
Maytenus emarginata	Kankero	Shrub	Celastraceae	The leaves burnt and mixed with the ghee from an oint used to heal sores. The fruit are used in medicines to purify blood.
Ocimum sanctum	Ban tulsi	Shrub	Lamiaceae	Tulsi is aromatic, antipyretic. It has antistress, antihypertensive, Central Nervous System depressant, antitumour, antibacterial and anti venom (snake and scorpion sting) also and herbal tea**.**
Salvadora persica	Pilu		Salvadoraceae	leaves heated and tied up in thin cotton cloth are applied in rheumatism

Table 2.Diversity of Medicinal tree species in Thar Desert of Rajasthan.

Species	**Local Name**	**Habitat**	**Family**	**Uses**
Acacia nilotica	Desi	Tree	Mimosaceae	Gum of the tree is highly nutritive and

	Babool			is useful for pregnant mothers. Raw fruits have medicinal values in women diseases, and also used in tooth paste.
Acacia tortilis	Kekar	Tree	Mimosaceae	Leaves, bark, seeds, and a red gum are used in many local medicines. Fronds are used for curing scorpion bites. Juice of the frond is expectorant, emetic and diuretic.
Acacia senegal	Kumbh at	Tree		Gum is used internally in Inflammation of intestinal mucosa and externally to cover inflamed surfaces as burns, sore nipples and nodular leprosy.
Albizia lebbeck	i Sares	Tree	Mimosaceae	The bark leaves and fruit are boiled together, and the infusion is given in cases of anaemia.
Azadiracht a indica	Neem	Tree	Meliaceae	The stem bark is bitter tonic, used to cure chronic fever. Bark is also used for wound. The effects of neem on pests of plants.
Ailanthus excelsa	Shajan	Tree	Simaroubaceae	Plant pacifies vitiated kapha, pitta,

				diarrhea, dysentery, worm infestations, skin diseases, gynecological diseases, fever, and found to be effective in Leukemia.
Balanites aegyptiaca	Higota	Tree	Balanitaceae	All parts of the tree have a medicinal uses including fruits, seeds, barks and roots. The most important is a steroidal, saponins, which yield diosgenin, a source of steroidal drugs, such as corticosteriods, contraceptives and sex hormones. (Farid *et al.,* 2002; Pettit *et al*., 1991; FAO, 1985).
Cassia fistula	Amaltas	Tree	Febaceae	The plant has a high therapeutic value and it exerts an antipyretic and analgesic effect it is useful against skin diseases, liver troubles, tuberculous glands and its use in the treatment of haematemesis, pruritus, leucoderm and diabetes.
Dalbergia sisso	Shisam	Tree	Fabaceae	Decoction of leaves is useful in

				gonorrhoea. Root is astringent. Wood is alterative, useful in leprosy, boils, and eruptions and to allay vomiti eruptions and to allay vomiting.
Eucalyptus camaldulensis	Safeda	Tree	Myrtaceae	Reported to be anesthetic, antiseptic, astringent, eucalyptus is a folk remedy for colds, colic, coughs, diarrhea, dysentery, laryngitis, sore throat, spasm, trachalgia, and wounds (Duke and Wain, 1981).
Ficus religiosa	Pipal	Tree	Moraceae	Tender leaves uses for ulcers, constipation, and ear drop. The bark is useful in inflammations and glandular swelling of the neck. Its root bark is useful for stomatitis, clean ulcers, and promotes granulations & gout. Its fruit is promotes digestion heart diseases, asthma urinary troubles and checks vomiting.
Prosopis cineraria	Khejari	Tree	Caesalpinaceae	Flowers are pounded, mixed with sugar and eaten by

				women during pregnancy as a safe guard against miscarriage.
Tamarix aphylla	Faras	Tree	Tamaricaceae	Traditional phytotherapy for jaundice. Leaves are boiled in water. The water is strained and the hot leaves are tied on the affected area daily. The treatment is continued for a week. This phytotherapy is used for the treatment of Rheumatism, wound and abscesses.
Zizyphus mortiana	Ber	Tree	Rhamnaceae	The juice of the root bark is applied externally.

References

Bhandari, M.M. 1990. Flora of the Indian Desert. Printed by MPS Repros. Jodhpur.

Baloch, S.R., Kumar, Pramod 2009 Study of Phyto-diversity of the Thar desert, Rajasthan. IV National Forestry Conference 9th to 11th November 2009. Proceedings, 347-350

Charak, Drdhbala, 1996. In. Sastri, R., Uppadhayaya, Y., Pandeya, G.S., Gupta, B., Mishra, B. (Eds.), The Charak Samhita explained by K. Sastri and G.N. Chaturvedi, 22nd revised ed. Chaukhamba Bharti Academy, Varanasi.

Fabricant, D.S., Farnsworth, N.R., 2001. The value of plants used in Traditional medicine for Drug Discovery. Environment Health Perspectives 109, 69–75.

Jain, A., Katewa, S.S., Galav, P.K., Sharma, P., 2005. Medicinal plant diversity of Sitamata wildlife sanctuary, Rajasthan, India. Journal of Ethnopharmacology. 102, 143–157.

Khan, T.I. and Frost, S.2001. Floral biodiversity. a question of survival in the Indian Thar Desert. *The Environmentalist,* 21(3). 231-236.

Katewa, S.S., Choudhari, B.L., Jain, A., 2004. Folk herbal medicines from tribal areas of Rajasthan, India. Journal of Ethnopharmacology 92, 41–46.

Mishra, A., Kumar, A., 2000. Medicinally important trees of Rajasthan. International Journal of Mendel 1–8, 37-38.

Mertia RS, Nagarajan M., 2003. Towards conservation of medicinal plant lore of Indian arid zone. *(The) Indian Forester*, 129(2), 268-274 [11 Ref].

Parveen B. Upadhyay**,** Shikha Roy and Ashwani Kumar Traditional uses of medicinal plants among the rural communities of Churu district in the Thar Desert, India Journal of EthnopharmacologyVolume 113, Issue 3, 25 September 2007, Pages 387-399

Singh, G. 2005. Ecological and environmental assessment in the on-shore area of RJ-ON-90/2 block'. Technical Report AFRI, Jodhpur. Submitted to M/S Cairn Energy Pvt. Ltd, Chennai.

Shetty, B.V. and Singh, V.1993. Flora of Rajasthan. Vol I – III. Boatanical Survey of India, Calcutta.

Singh, V., Pandey, R.P., 1983. Economic and medicinal plants of Indian Desert. Tulsidas. Ramcharitmanas (1631 samvat)**.**

Establishment of an Arboretum for Conservation of Temperate Himalayan Flora

Vaneet Jishtu and Mohinder Pal*

Rain Forest Research Institute, Jorhat (Assam)

*Himalayan Forest Research Institute, Shimla (HP)

Abstract

Conservation of biodiversity is fundamental to achieving sustainable development. It provides flexibility and options for the current and future use of our fast depleting natural resources. Biodiversity conservation is basically carried out using two methods, namely *in-situ* and *ex-situ* conservation, wherein arboretum being one of the methods favored for *ex-situ* conservation of species. Arboreta are scientifically laid out collection of arboreal plant species like trees, shrubs and woody lianas, serving various purposes such as germplasm collection, horticultural studies, landscaping, etc. Well organized and aesthetically organised arboreta also play an important role in generating awareness about the plant world and promoting conservation education among the society. *Ex- situ* conservation and mass propagation of rare species at the arboreta are complimentary to *in-situ* conservation.

At present there are about 35 botanical gardens/arboretums in India, varying greatly in term of size and number of species. It is seen that most of these botanical gardens in the country are located in the tropical and sub- tropical regions. There are non-existent such *ex-situ* plant conservation facilities in the north- western Himalaya except a few small scattered locations, noteworthy being the PN Mehra Botanical Garden (Punjab University, Chandigarh), Arboretum of FRI (Dehradun), Shalimar Garden of Kashmir University (Srinagar) and NBPGR Botanical Garden (Delhi University).

The Wildlife Wing, Himachal Pradesh Forest Department (HPFD), consequent upon diversion of some forest land due to Parvati Stage-II Hydroelectricity Project, has stipulated both *in- situ* and *ex- situ* projects for the state in consultation with the Wildlife Institute of India (WII). *Ex-situ* component of the project includes exploring the prospects for setting up a Temperate Arboretum for display, education and propagation of tree flora and their subsequent reintroduction in the wild. With the aim of *ex situ* conservation of temperate Himalayan tree flora including endemic and endangered species, an arboretum is being established near Shimla. The project is being implemented by the Wildlife Wing of the State Forest Department, with the technical assistance from the Himalayan Forest Research Institute, Shimla. The basic purpose of this arboretum will be to conserve the gene pool and it will have a vital role in the rehabilitation of species affected by the numerous developmental/hydro- projects, mushrooming in the state.

Keywords: Biodiversity, Temperate Arboretum, sustainable development, Himalayan tree flora.

Introduction

Biodiversity conservation is basically carried out using two methods, namely *in-situ* and *ex-situ* conservation, wherein arboreta being one of the methods favored for *ex-situ* conservation of tree species. Arboreta are scientifically laid out collection of arboreal plant species like trees, shrubs and woody lianas, serving various purposes such as germplasm collection, horticultural studies, landscaping, etc. Well organized and aesthetically laid out arboreta also play an important role in generating awareness about the plant world and promoting conservation education among the society. *Ex-situ* conservation and mass propagation of rare species at the arboreta are complimentary to *in-situ* conservation.

At present there are about 35 botanical gardens/arboretums in India, varying greatly in term of size and number of species. It is seen that most of these botanical gardens in the country are located in the tropical and sub-tropical regions. There are very few botanical gardens and *ex-situ* plant conservation facilities in the western and north- western Himalaya except a few localities, (Samant *et al.*, 1998). Noteworthy being the PN Mehra Botanical Garden at Punjab University campus, Chandigarh, Arboretum of Forest Research Institute (FRI), Dehradun, Shalimar Garden of Kashmir University, Srinagar and the NBPGR Botanical Garden at Delhi University.

The Wildlife Wing, HP Forest Department (now on HPFD), consequent upon diversion of some forest land due to Parvati Stage-II Hydroelectricity Project (HEP), has stipulated both *in- situ* and *ex- situ* projects for the state in consultation with the Wildlife Institute of India (WII). *Ex- situ* component of the project includes exploring the prospects for setting up a Temperate Arboretum for display, education and propagation of tree flora and their subsequent reintroduction in the wild.

With the aim of *ex situ* conservation of temperate Himalayan tree flora including endemic and endangered species, the temperate arboretum is being established near Shimla. The project is being implemented by the Wildlife Wing of the State Forest Department, with the technical assistance from the Himalayan Forest Research Institute (now on HFRI), Shimla. The basic purpose of this arboretum will be to conserve the gene pool and it will have a vital role in the rehabilitation of species affected by the numerous developmental/hydro-projects, mushrooming in the state.

Site Selection

A standard arboretum should have the following infrastructure and natural setting. (a) adequate area, (b) permanent source of water, (c) aesthetically appealing landscape, (d) altitudinal and topographic variation, (e) space for interpretation and visitor centre, (f) facilities for glass house, mist chamber, polyhouse and nurseries, (g) space for taxonomical and botanical themes such as medicinal plants, germplasm collection centre, pinetum, etc.

Keeping these points in view, a few candidate sites around Shimla were surveyed, viz., (i) Kufri, adjacent to High Altitude Zoological Park, (ii) Naldehra near Golf Course, (iii) Mashobra and (iv) Potter Hill, near Shimla town, which was finally selected. In addition, some provision will be made to extend this programme for a part of Kufri Zoological Park, near Shimla, so that additional germplasm and species of aesthetic value could be retained at the latter site, which experiences an influx of tourists throughout the year.

Potters Hill is located at about seven kilometers west of Shimla town at altitudes ranging between 1750 and 2250 amsl and is an ideal site due to its moderate climate and location. This site spreads over a 100 ha area and lies adjacent to the HP University Campus. Administratively, the area falls under Totu Block in Taradevi Range, Shimla Forest Division. The area is naturally rich in temperate flora and a rapid survey of the site during July-September revealed that this site harbours more than 360 species of flowering plants (Rawat and Jishtu, 2005 [WII Report, Annexure-5.6]. It supports temperate conifer forests (*Cedrus deodara* - *Pinus roxburghii*), broadleaf forest (mainly *Quercus leucotrichophora –Rhododendron arboreum*), secondary scrub and grassy glades in addition to other prominent arboreal species like *Pieris ovalifolia, Benthamidia macrophylla*, *B. capitata, Pyrus pashia, Populus ciliata, Prunus cerasoides,* etc. In addition, the very popular

'Chadwik Falls', a major attraction for the tourists who visit Shimla, falls in easy access of the selected site of Potters Hill.

Arboretum and its Role in Plant Conservation

For the foreseeable future, increasing demands for natural resources will continue to degrade habitats and push an increasing number of plants toward extinction. A critical and fundamental role of *ex situ* institutions is to combat extinctions (Maunder and Byers 2005). One such institution is the arboretum, which by definition, is an outdoor collection of trees, shrubs and other woody plants systematically and aesthetically arranged for the purposes of demonstration, research, and education. It is a "living museum" where visitors are welcome throughout the year, to walk about, enjoy and learn more about trees. The design and landscaping of the arboretum at Potter Hill would be such that it would aesthetically merge with the landscape and generate awareness about the native tree species among the visitors. The ultimate goal is to encourage the planting and conservation of trees for a greener, healthier, and more beautiful tomorrow.

Plants in the Arboretum will be grouped into separate habitats (providing the near best conditions to their natural habitat). These will be marked with clear wooden signs. The information (natural habitat, local use, ecological importance, threat status, morphology, and other attributes) on the species planted will be documented in all respect at the time of planting. The arboretum would house almost all the representative tree species of temperate region (over 160 species belonging to 50 families) in a phased manner. Initially, focus will be on the rare and lesser known tree species and the conifers of the state. The seedlings will be collected from the various nurseries, spread over the state and where possible to collect few seedling specimens from the wild. Rare and uncommon species can be raised in the nursery developed at the site, or through some research organizations. For rarer tree species at least five individuals would be planted. To begin with, '*Flora Simlensis'* (Collet, 1902) would be taken to select the species for plantation. '*The woody elements largely predominate in the Flora of Simla with one hundred and thirty seven species belonging to eighty three genera and thirty six orders. All earlier travelers, including Lady Dalhousie, were struck by the variety of trees of the different altitudinal zones of vegetation'* (Botting Hemsley, Introduction to '*Flora Simlensis'* in Collet, 1902). The '*Flora of Himachal Pradesh'* (Chowdhery and Wadhwa, 1984) will be consulted to locate regions of occurrence in other temperate areas of the state. The main role of the arboretum in general would be to:

- Establish a living repository of temperate Himalayan tree flora.
- Set up a facility for *ex- situ* conservation of rare and threatened tree *taxa*.
- Exchange of plant propagules within the Himalayan States and to promote conservation education among the school children and common public.
- Create opportunities for recreation and aesthetics, and
- Create a database on the individual plant species, and establish international and national affiliation for further research.

However, with the successful setting up of the arboretum, certain other functions will indirectly benefit plant conservation in the region. These beneficial functions would include habitat protection, conservation of associated herbaceous flora, research, etc.

Habitat Protection

No significant areas have been designated as parks and special areas which provide statutory protection for the habitats of our diverse flora and fauna in the north western part of the country. By designating and landscaping such special areas, it compels the general public to recognize the scientific importance of these sites and to ensure that due consideration to plant conservation is given. The major part of the forest land at the Arboretum site is to be maintained in its natural state. Only, where ever possible, crucial management decisions regarding constructions and landscaping will be made to maintain the region, which will be an added plus for habitat protection. As a result of habitat protection the diversity of insects, butterflies, birds and even some smaller mammals will increase.

Conservation of Herbaceous Flora

The flora of the temperate Himalayas is diverse in character with numerous species of the European flora being seen here at the limit of their northern distribution range. '*Simla* district has a smaller area than the country of Sussex, in which about 1000 species of flowering plants grow' (Collet, 1902). Many species of plants are noteworthy for their contributions to the medicinal and aromatic industry.

Research at the Arboretum

Seed collected from rare, threatened and endangered trees will be germinated at the arboretum and grown for eventual planting in the nearby appropriate recovery habitat. This program will be developed under a program, involving school children and other members of the community. This will be a regular educational program designed to bring students, teachers, conservation groups and private nurseries together to grow native trees for community projects. In addition to creating awareness, these 'hands on' activities, will also teach the children how to germinate, grow and plant trees.

Landscape Management

Since, the lower part of the forest is dominated by Chir Pine (*Pinus roxburghii*), the forest floor during the drier months of April – June is littered with the dried pine needles. These pine needles when dry pose a fire hazard since it is highly flammable. Thus, forest fire will be a major hazard to the arboretum, as it bedevils the management for about three months each summer. Here comes the involvement of villagers who are engaged to collect the dried needles for use as a cushion for the cattle, which on an average, is replaced once in a week. The removal of the Chir Pine needles reduces the risk of fire during the summer season and also helps the growth of many useful herbaceous species.

Another important aspect in the management of the landscape would be to avoid invasive introductions, since the invasive species have been recognized as a serious threat to biodiversity, second only to habitat loss (Wilcove *et al*., 1998). At present the proposed site has several exotic species which will be gradually replaced by the native species.

Garbage is another problem and one of the major tasks of the management is to collect litter left by the visitors which is mainly in the form of plastic and glass. With such problems in mind, the management has planned to put up eco-friendly garbage collection units and also place litter bins located strategically throughout the arboretum.

Administration

As proposed the arboretum is being managed by the Wildlife Wing of the HP Forest Department. An Advisory Committee, under the chairmanship of the Chief Wildlife Warden, HP has been set up. The Advisory Committee includes, the Director of HRFI, Shimla, the Director of GB Pant Institute at Mohal, Kullu, the Conservator of Forests, Shimla Circle, Head of Department of Botany, HP University, the Head of

Department of Forestry, Dr YS Parmar University of Horticulture & Forestry, Nauni, Solan, and the Director of National Bureau of Plant Genetics and Research (NBPGR), Shimla. Non official members include two prominent citizens of Shimla, with interest in the conservation of Shimla's native flora. Director HFRI, Shimla serves as the Secretary to the Advisory Committee.

The development, implementation, monitoring and database is being undertaken by HFRI, which is functioning as the institutional anchor of the arboretum. HFRI is also responsible for commissioning and supervision of various studies/researches connected with the arboretum. Local inhabitants from adjacent villages are being hired as skilled labourers, daily wage workers, Malis and guides, etc. The Wildlife Wing has entered into a Memorandum of Agreement (MOA) with the HFRI, for smooth functioning of the project.

Funding

The Government of HP has approved the Strategic Plan for ***Conservation of Endangered Wildlife in Himachal Pradesh*** by the Wildlife Institute of India (WII), Dehradun. This entire plan, developed by the WII, is to be funded to the tune of rupees twenty crores by National Hydro Power Corporation (NHPC) (HEP Parvati Stage-II) over a period of ten years. The Temperate Arboretum at Potter's Hill is an approved item of activity under this plan, (WII HPFD Consultancy Report, 2005; *pp.235 -247*). It is therefore proposed that the establishment and maintenance of the TABG would be steered by the Wildlife Wing of HPFD and executed by the HFRI, Shimla. For the various items of work as proposed hereunder, the Wildlife Wing would place at the disposal of HFRI, adequate funds on a year to year basis. Further, because the proposed TABG would is proposed to be notified as a conservation reserve under the Wildlife Protection Act, 1972, it would become eligible for Government of India (GoI) funding under the Centrally Sponsored Scheme for Conservation of Protected Areas.

The critical concern here will be to ensure the future financing of the arboretum, once established. Firstly, the role of the home unit or HPFD (Wildlife Wing) in this case will be the key to the future functioning of the arboretum. Later upon when it will look to move from the governmental control and/or support will need to replace that segment of their financial support by increasing the memberships, donations, trusts or other similar financial management. Collaborative efforts may be encouraged with sister institutions and with organizations both within and if possible, outside the country.

Secondly, the charitable donations need to be increased as such projects have a few advantages. Aesthetically laid arboreta are places of beauty and education and supporting them makes life better for everyone, a goal most people generally understand. Earned income is another critical component of most arboreta. Since most efforts to earn funds depend on people visiting the garden, the weather and other externalities can disrupt income flow (sometimes dramatically, like during the wet monsoons). Diversification is therefore the key to success and initiatives have been set up for developing a garden's business operations, which may be critical to success in earned income areas. The initiatives may be in the form of gift shops, souvenirs, posters and live plants sale, guided tours, etc.

With the belief that gardens are essential, relevant institutions for an advanced society, all efforts need to be made to adequately fund their operations. The fact that critical work conserving the world's plants has fallen by default to arboreta and botanic gardens only adds to the importance of their mission (Olin, 1995).

Conclusions

Plants are arguably the single most important group of organisms in shaping the habitats and determining the physical environments that all other species require for survival, and as such significantly influence total biodiversity richness. Recent studies predicting that climate change could result in the extinction of up to half the world's plant species by the end of the century. Such mass extinctions will have catastrophic effects for humanity (Belinda *et al.,* 2008).

If *ex situ* conservation is to play an effective role in conserving wild plant diversity and supporting habitat conservation, appropriate levels of infrastructure and capacity need to be established (Maunder *et al*., 2004). Moreover, an integrated plant conservation advocates for the protection of plants in their native habitats with an *ex situ* conservation program to provide a safety net against extinction in the wild. The botanic gardens and arboreta of the world are now unmatched *ex situ* collections of plant biodiversity (Janice *et al*, 2010). They provide the tools, resources, and research for better management of wild populations (Kayri, *et al*., 2006).

The arboretum at Shimla, once established, would be the first *ex-situ* plant conservation facility in the region, and one of the few conservatory – type gardens in the north western Himalaya. It will provide a homeport, research and propagation facility for the amateur as well a professional gardening community in the region. Establishing an arboretum is a great step towards looking after our forests and other forms of natural vegetation. Besides conservation, it is the understanding and explanation of our plant diversity which is aesthetically undertaken by such *ex-situ* plant conservation facilities.

Protecting threatened plants is not just a research and forestry issue. As administrators, it is important to present a balanced assessment of the costs and benefits involved, yet still find room to guarantee plant conservation. Here, biodiversity conservation tools like the arboretums can help quash the often misguided hysteria associated with the more strident opponents of the conservation programmes. We must convince others, including our leaders, that having a diverse and healthy gene pool from which horticulture, agriculture, and the environment can benefit is good for everyone, especially our future generations.

To summarize, the arboretum mission attempts to delicately make the point that *ex situ* conservation can make a big difference in improving native tree species survival of the temperate region. All of these efforts require help from a dedicated team of researchers, core of volunteers, commitment of the administrators and a strong will of the leaders, without which we would fail to meet our conservation goals.

"When we plant trees, we plant the seeds of peace and seeds of hope."

(Wangari Maathai, Nobel Peace Laureate. 2004).

References.

Belinda Hawkins, Suzanne Sharrock and Kay Havens 2008. Plants and Climate Change. Which Future? *Botanic Gardens Conservation International*, Surrey, UK.

Bramwell, D 2007. The Response of Botanic Gardens to Climate Change. *BG Journal* 4 (2). 3-8.

Chowdhery, H.J. and Wadhwa, B.M 1984. *Flora of Himachal Pradesh.* Vol.1-3.Botanical Survey of India, Calcutta.

Collet, H 1921. *Flora Simlensis* - A Handbook of the Flowering Plants of Simla, Revised Thacker Spink and Co., Calcutta.

Janice Golding, Sabine Güsewell, Holger Kreft, Victor Y. Kuzevanov, Susanna Lehvävirta, Ingrid Parmentier and Marco Pautasso 2010. Species-richness patterns of the living collections of the world's botanic gardens. a matter of socio-economics? *Ann. Bot.,* March, 2010.

Kayri Havens, Pati Vitt, Mike Maunder, Edward O. Guerrant Jr and Kingsley Dixon 2006. *Ex Situ* Plant Conservation and Beyond. *Bioscience*, 56(6).525-531.

Maunder. M, Guerrant EO, Havens K, Dixon KW 2004. Realizing the full potential of *ex situ* contributions to global plant conservation. Pages 389–418 in Guerrant EO, Havens K, Maunder M, eds. *Ex Situ Plant Conservation. Supporting Species Survival in the Wild*. Washington (DC). Island Press.

Maunder.M,Byers.O.2005.The IUCN technical guidelines on the management of *ex situ* populations for conservation.Reflecting major changes in the application of *ex situ* conservation.*Oryx* 39.1-4.

Peter, J. Olin 1995. Funding Botanic Gardens and Arboreta in the 21st Century.*Botanic Gardens Conservation, International.* Vol. 2; No. 5.

Rawat, G. S and Jishtu Vaneet 2005. Establishment of Temperate Arboretum and Botanical Garden (TABG) in Himachal Pradesh. Challenges and Strategies for Future. In *Strategic Plan Project – II. Conservation of Endangered Wildlife in H.P.* pp 238.

Raven, P. H. 1987. The scope of the plant conservation problem world-wide. In Botanic Gardens and the World Conservation Strategy (eds. D. Bramwell, O. Hamann, V. Heywood, and H. Synge), *Academic Press*, London, pp. 19-29.

Samant S. S., U. Dhar and L. M. S. Palni 1998. Medicinal Plants of Indian Himalaya.Diversity Distribution Potential Values, *Gyanodaya Prakashan*, Nainitial.

Thomas, C., Cameron, A., Green, R., Bakkenes, M., Beaumont, L., Collingham, Y.,Erasmus, B., Ferreira de Siqueira, M., Grainger, A., Hannah, L., Hughes, L., Huntley, B., van Jaarsveld, A., Midgley, G., Miles, L., Ortega-Huerta, M., Townsend Peterson, A., Phillips, O. and Williams, S'2004. Extinction Risk from Climate Change. *Nature*, 427. 145-148.

Warren, D. M 1992. Indigenous knowledge, biodiversity conservation and development. Keynote address at the International Conference on Conservation of Biodiversity in Africa. Local Initiatives and Institutional Roles, 30 August - 3 September 1992, Nairobi, Kenya.

WII-HPFD Consultancy Report 2005. *Strategic Plan Project – II. Conservation of Endangered Wildlife in H.P.*

Wilcove, D. S, Rothstein D, Dubow J, Phillips A, Losos E. 1998. Quantifying threats to imperiled species in the United States. *Bio Science* 48. 607–615.

Wilson, E. O 1988. The Current State of Biological Diversity. In E. O. Wilson [ed.].*Biodiversity*. National Academy Press. Washington, D. C. Pp. 3-18.

Sacred Trees with Multiple Uses

Anita Tomar

Silviculture Division,Forest Research Institute

Dehradun. Uttarakhand, India

Abstract

Tree worship is an age old practice in India as seen from the seals of Mohenjodaro and Harrapa that have impressions of sacred Peepal and willow trees. Trees are prominent in the Bhagvad Gita, the Bible and the holy Koran. During ancient times tree are associated with certain deities and are said to be abode of Gods and Goddesses. Old Buddhist and Hindu sculptures display prominently Baniyan, Peepal, Siras, Sal, Mango, Ashok, Nag Kesher, Champa, Kadamb etc . For example, *Mangifera indica* has traditionally been used for various religious functions .Its leaves are used to cover the pitcher used in pooja as an auspicious omen. Mango wood and branches are preferred in all the sacrificial fires. *Ficus religiosa* is held sacred to Hindus and Buddhists. *Ficus bengalensis* is known as Akshay vat i.e long lasting or immortal. It is said to be dwelling places of the souls of 'pitter' our ancestors. *Aegle marmelos* leaves are offered to God Shiva.

As it was noticed that the species related directly or indirectly with deities or mythological figures are having multiple uses so to explore the better utilization of sacred trees present check list of sacred trees having multiple uses has been compiled from the observation made by the author as well as reports in literature. Some of the striking examples are, *Mangifera indica, Saraca asoca, Ficus religiosa, Ficus bengalensis, Aegle marmelos, Azadirachta indica, Santalum album, etc.*

In the present paper 7 sacred trees with multiple uses belonging to different families are dealt with. A new approach can be adopted in fostering love for trees. These trees will not only provide much needed fuel, food, fodder, timber, medicine etc but will also contribute towards improvement of environment. Their planting and conservation is thus recommended.

Keywords: Tree worship, deities, mythological figures, multiple uses

Introduction

Trees have become part of our lives. They are represented in legends and myths, both from our culture and from others. Trees have also become deeply integrated in symbolism and are used in a variety of ways to convey messages related to the qualities that certain trees possess. The tree also appears in religion, where it is worshipped directly or used as a place around which to worship.

It is mentioned of the Kalpavriksha and Chaityavriksha in the ancient scriptures indicating that the worship of the tree is indeed an ancient Indian practice. The Ancient Aryans worshiped nature. Plants, trees and the other elements were always revered and several rituals were connected to them. Tree worship continues to be an element of modern Indian traditions. It is also evident from our ancient scripture that tree worship was widely practiced in India as seen from the seals of Mohenjodaro and Harrapa that have impressions of stylized Peepal and Willow trees. There are many trees which are considered sacred. A few are highlighted here.

Asoka Tree

Systematic position

Kingdom: Plantae Division: Magnoliophyta

Class: Magnoliopsida Order: Fabales

Family: Caesalpiniaceae Genus: *Saraca*

Species: *asoca*

Asoka is a sanskrit word meaning without grief or that which gives no grief. Asoka is one of the most legendary and sacred trees of India, and one of the most fascinating flowers in the Indian range of flower essences. The tree has many other names in local languages as well. One such name means the tree of love blossoms. The Hindus regard it as sacred, being dedicated to Kama Deva, God of Love. The tree is a symbol of love. Its beautiful, delicately perfumed flowers are used in temple decoration. There are also festivals associated with this flower. The asok tree is considered sacred throughout the Indian subcontinent. It is often found at gates of Buddhist and Hindu temples. Ramayana also mentions this tree as the Asok vatika where Hanuman first meets Goddess Sita. Lord Mahavira, too, renounced the world under the Asoka tree in Vaishali.

The Asoka tree has a symbolic importance in Buddhism. Queen Maya of Sakya is said to have given birth to the Buddha under an Asoka tree in a garden in Lumbini. According to tradition, the queen walked in the garden until she came to an Asoka tree to take a rest. Then the tree magically bent down for her and she grasped a branch. At that moment the Buddha emerged from her right side.

The juice obtained from boiling the bark of Asoka tree is used to cure some ailments of women, and a pulp of the blossoms is one of the remedies used for dysentery. Bark used in uterine infections, as an astringent and in excessive menstruation. Flowers are uterine tonic and are used in "Pitta", leaves juice mixed with cumin seeds are used in stomachalgia.

Banyan Tree

Systematic position

Kingdom: Plantae Division: Magnoliophyta

Class: Magnoliopsida Order: Urticales Family: Moraceae

Genus: *Ficus* Species: *benghalensis*

The name was originally given to *F. benghalensis* and comes from India where early travellers observed that the shade of the tree was frequented by *banias* or Indian traders. In Hinduism, the leaf of banyan tree is said to be the resting place for the God Krishna, who, after consuming all the universe during the time of destruction, absorbs everything created and turns himself to a child as small as he could fit into the tiny leaf of the banyan tree and keeps floating in the void space, until he himself decides to recreate everything back out from him. Also in Hindu culture, the banyan tree is also called kalpavriksha meaning 'wish fulfilling divine tree' Like Peepal tree, the Banyan tree also symbolizes the Trimurti-Lord Vishnu, Lord Shiva and Lord Brahma. The tree also symbolizes life and fertility in many Hindu cultures. That is the reason, banyan tree is worshiped by those who are childless and this tree should never be cut. The tree can grow into a giant tree covering several hectares. The Great Banyan in the Indian Botanic Garden, Howrah, is considered to be the largest tree in the world. Lord Dakshinamurthy, who is worshiped as the "ultimate guru", is usually depicted beneath a banyan tree. He symbolizes Lord Shiva and is seen as the destroyer of ignorance and embodiment of knowledge.

Banyan trees have been used or investigated for a wide variety of uses, from paper and rubber to hair conditioners and ornaments. The banyan yields an inferior rubber, and the sticky milk is used to make bird lime. The wood of banyan is suitable for the paper pulp, and in Assam and Madras, paper has been prepared using the bark. Fiber is also made from its bark and aerial roots of banyan in India are used to make rope for tying bundles of wood. Lac is sometimes collected on the tree. The fruit is eaten in times of scarcity and is greedily devoured by birds and monkeys. The leaves and twigs are a favourite fodder for cattle and elephants.

Bael Tree

Systematic position

Kingdom: Plantae Division: Magnoliophyta

Class: Magnoliopsida Order: Sapindales Family: Rutaceaec

Genus: *Aegle* Species: *marmelos*

In Hinduism, the Bael (Bilwa) tree is very sacred. It is today mainly used in the worship of Shiva. Hindus believe that Lord Shiva will be pleased with Bilwa (Bael) Pattra (leaf) Puja (worship). The importance of this tree in worship of Lord Shiva is mentioned in several sacred books. Prior to wide availability of South Indian coconuts in North India, Bael fruits were also used in other deities puja rituals and crushed or offered in the same way as coconuts are today.

In the Hindu religion, the Tri-foliate leaves typical of the Bael are seen as the 3-pronged Trident (Trisula) that Lord Shiva holds in his right hand. The Trident symbolizes his three fundamental powers of will, action and knowledge. The Trident also symbolizes the past, the present and the future and also symbolizes the three functions of the Lord-the creation, preservation and destruction as well as his three eyes. Planting these trees around home or temple is sanctifying and is equivalent to worshiping a Linga with bilwa leaves and water. The offering of the leaves is a compulsory ritual while worshipping Lord Shiva all over India.

Almost every Hindu temple in India would have one or more Bael trees in their courtyards. The Skanda Purana interprets the significance of Bael tree and mentions that Goddess Parvati`s perspiration, which fell to the ground while she performed penance, gave birth to this tree. Hindu mythology also says that various incarnations of Parvati reside in each part of the Bael tree.

Beal tree is also sacred to the Jains. It is said the 23rd Tirthankara, Bhagwan Parasnathji attained "Nirvana" enlightenment under a Bael tree. Besides religious significance, almost all parts of the tree have medicinal qualities. Bael is an ingredient in many Ayurvedic and Siddha formulations. Moreover, it may be related Vishwakarma, as mucous that surround seed is put to use in building construction, varnishing etc.

Wood of Bael is used in construction. The pulp of the ripe fruit is a laxative and mixed with a little milk and sugar makes a very agreeable cooling sherbet. The unripe fruit, either boiled or roasted, is used as a specific for diarrhea and dysentery. The pulp is also used to strengthen mortar. The mucus with which the cells of the fruit are filled is used for adhesive purposes, and is often mixed with water-paints to add to their strength and brilliancy. Snuff-boxes are made of the shell of the fruit. The leaves are very bitter and are used as a febrifuge, they are also lopped for cattle fodder. Root and stem bark is used in fever. Root is one of the ingredients of Dasmula (ten roots).

Mango Tree

Systematic position

Kingdom: Plantae Division: Magnoliophyta

Class: Magnoliopsida Order: Sapindales Family: Anacardiaceae

Genus: *Mangifera* Species: *indica*

In Hindu religion, mango tree has a lot of religious importance. To the Hindus, it is an alteration of the God Prajapati, the Lord of all creatures. Further, the rooms in which marriage ceremonies are held are festooned with Mango leaves. The wood is also considered as sacred because it is included in funeral pyres. The Hindus also dedicate the flowers of the tree to the Moon on the second day of the Bengali month.

The significance of this finds mention in the Ramayana, Mahabharata and the Puranas. The mango as a fruit is a symbol of love and fertility. The leaf of the tree is used during most religious and social ceremonies of the Hindus. A "Purnakumbha" is a pot filled with water and topped with fresh mango leaves and a coconut and considered to be the "staphna" of the puja. The pot symbolizes mother earth, water is the life giver, coconut the divine consciousness and the mango leaves symbolizes life. The whole "Purnakumbha" is symbolizes Goddess Lakshmi and good fortune. On various auspicious occasions, mango leaves are used to adorn entrances at home to signify good fortune. Mango blossoms are used on Basant Panchami day to worship Goddess Saraswasti. The tree is also sacred to the Buddhists because it is believed that Lord Buddha performed during his lifetime the instantaneous creation of a large mango tree from the seed at a place called Shravasti.

The mango is the most popular and choicest fruit of India and occupies a prominent place among the best fruits of the world. Amchoor and pickles are prepared from unripe fruits. The green fruit is pickled, and is dried as an article of trade in Bengal. The pulp of the ripe fruit is dried in thin plates, which can be kept for months without losing flavor. Timber is used in building construction and as a fuel. Wood is made into planks, and is sometimes used for tea-boxes also. Doors and windows and sometimes cheap furniture are made of it. The bark is also styptic and is also use to stop vomiting and also used for diarrhea, dysentery.

Neem Tree

Systematic position

Kingdom: Plantae Division: Magnoliophyta

Class: Magnoliopsida Order: Sapindales Family: Meliaceae

Genus: *Azadirachta* Species: *indica*

It is said that on the first day of Chaitra, after Amavasya, it is very essential to worship the neem and eat its leaves, mixed with pepper and sugar, as a safeguard from fever. The neem tree besides having various medicinal benefits is a highly revered tree among the Hindus because it is a manifestation of "Goddess Durga" or "Maa Kali". That is why the tree is sometimes referred to as Neemari Devi. The Tree is worshiped very intensely. Tamil Ladies, while worshiping Maa kali dress in red, carry branches of the Neem tree, and dance in public places swishing the branches as an act of exorcism and to purify the world. The multi-headed occult goddess Yellamma (a highly revered goddess in south India) sometimes assumes the appearance of a young neem tree. Young maidens worship this Goddess by cladding themselves all over in neem branches. In Bengal, neem is considered to be the tree which is the abode of "Sitala" (the great Pox-mother who can cause or cure disease). The customary treatment of pox is therefore to rub the body with neem leaves while making prayers to Sitala. It is also said that the smoke of burning neem protects both the living and the dead from evil spirits.

Being an evergreen shady tree, it is planted by the road side, in the courtyards and assembly places in the rural areas. It is well suited for the afforestation in arid regions and is a common avenue tree. Almost every part of the tree is bitter and is used in indigenous medicine. The wood is suitable for carving .The timber is used in house building and for making boards, panels, toys, ploughs etc.Wood is used in construction and for furniture, and makes good sonorous drums. The bark, leaves and fruit are used in medicine. The fruit gives oil which is considered very well for small-pox sores and is also used for burning. The leaves are much lopped for goat and camel fodder. Aroma of leaves has insecticidal properties therefore dried leaves are used to preserve clothes and books.

Peepal Tree

Systematic position

Kingdom: Plantae Division: Magnoliophyta

Class: Magnoliopsida Order: Urticales Family: Moraceae

Genus: *Ficus* Species: *religiosa*

Peepal tree also known as "Ashvattha" in Sanskrit is a very large tree and the first-known depicted tree in India. A seal discovered at Mohenjodaro, one of the cities of the Indus Valley Civilisation depicts the peepal being worshiped. According to the Brahma Purana and the Padma Purana, when the demons defeated the gods, Lord Vishnu hid himself in the Peepal tree and that is why it is believed that the Peepal tree is a symbol of Vishnu and is worshiped since past. There is another belief that the tree represents the Trimurti-the roots being Brahma, the trunk Vishnu and the leaves Shiva. Some says that Lord Krishna is believed to have died under this tree, after which the present Kali Yuga started. According to another belief, Goddess Lakshmi also inhabited the tree, especially on saturday and hence it is considered auspicious to worship it. Infact women worship the tree to bless them with a son tying red thread or red cloth around its trunk or on its branches. According to the Skanda Purana, to cut down a Peepal tree is considered a sin. Even Buddha is believed to have attained enlightenment under the Peepal tree and the Peepal is also sacred to Buddhist. Hence it is also called the Bodhi tree or "tree of enlightenment".

It is said that peepal tree protects mankind from the evil eye and also keeps away dreadful dreams. Mentions have been made about the holiness of Peepal tree in Vedas. Well, apart from its religious significance, Peepal tree is also known for its medicinal value.

Its leaves serve as a wonderful laxative as well as tonic for the body. It is especially useful for patients suffering from Jaundice. It helps to control the excessive amount of urine released during jaundice. The leaves of Peepal are highly effective in treating heart disorders. It helps to control the palpitation of heart and thereby combat the cardiac weakness. Ayurveda makes an extensive use of the leaves of Peepal due to the numerous benefits it provides. The leaves and branches are good for elephant fodder. The milky juice hardens into a substance resembling guttapercha. Peepal leaves are of great use in getting rid of mumps

Chandan Tree

Systematic position

Kingdom: Plantae Division: Magnoliophyta

Class: Magnoliopsida Order: Santalales Family: Santalaceae

Genus: *Santalum* Species: *album*

Besides being used in fragrance industry, fine woodworking and aromatherapy, Sandalwood is commonly used for incense and religious ceremonies. The red sandalwood tree is considered to be a very sacred tree and is like a sage among many people. It is said that all other trees are considered ordinary trees and are like ignorant men in front of a red sandalwood, Popularly known as Chandan, Sandalwood has an extraordinary fragrance. Sandalwood paste is used in all religious rituals. The paste is smeared on the foreheads of devotees of Vishnu and Shiva and it is said that the sandalwood paste is meant to cool and protect the "Agna chakra" present between the eyebrows. In India, the death pyre is made using sandalwood branches for centuries. According to legend, Lord Ganesha was created by Goddess Parvati out of sandalwood paste that she used for her bath and breathed life into the figure. According to Indian mythology, sandalwood tree is depicted as being entwined with serpents. Sandalwood remains cool and aromatic even when the poisonous serpent coils around it. This also has another meaning that the basic nature of an individual cannot change because of outer effects.

Sandal wood, its paste and oil are important in worship of gods. The Sandal tree is highly regarded in the Vedic texts, and the heartwood is considered to be sacred. It is said that chandana, or Indra's Sandalwood tree, scents the whole of paradise with its fragrance. Sandalwood is considered the epitome of excellence, imparting fragrance even to the axe that cuts it. For this reason anything that is excellent is referred to as Chandana.

Its oil from heartwood used in the symptomatic treatment of dysuria, in gonorrheal urethritis and cystitis. The oil from sandalwood is widely used in the cosmetic industry and is expensive. Paste of wood used as a cooling application to the skin for allaying heat.

Conclusions

One of the most significant ways in which trees are regarded is through their association with religion. Several races exist that revere trees, and there are some that use them as icons. Others used them to make representations of gods that they worshiped.

Vonmahotsava, farm forestry. social forestry and such other programmes have been launched to motivate farmers to plant trees. However, these programmes have not been fully successful. May be, if sacred tree worship as a ritual is indicated, the planting programmes can be successful. As highlighted above, all these sacred trees species are multiple uses. These trees will not only provide much needed fuel, food, fodder, timber, medicine, wood etc. but will also contribute towards improvement of environment. Adoption of such an approach will go a long way in fostering love for trees, their maintenance, conservation, protection and planting is thus recommended.

References

Aima, R., 2009.*A Pictorial Guide to the Plants of the Indian sub-continent*. Natraj publishers, Dehradun.. pp.555

Chopra, R. N., Nayar, S. L. and Chopra, I. C., *Glossary of Indian Medicinal Plants.,*Publication and Information Directorate. CSIR, New Delhi.1956.pp.318

Davies, D., *The Iconography of Landscape* – Cambridge University Press.1988

Kanjilal, U.N., *Forest Flora of the Chakrata, Dehradun and Saharanpur Forest Divisions*, Natraj Publishers, Dehradun. 2004. pp.593

Negi, S. S., Srivastava R. K. and Bisht, N.S., *Medicinal and Aromatic Plants.* Indian Forester*,* Dehradun.2007.pp.607.

Shah, R., Nature's *Medicinal Plants of Uttaranchal* (Trees, shrubs and climbers) Revised Volume-I . Gyanodaya Prakashan, Nainital. 2003. pp.527 www.http://en.wikipedia.org/wiki/.

Nature Based Tourism- A Source of Livelihood for Rural People

Sweta Priyam, H. B. Vasistha and Mridula Negi
Forest Ecology and Environment Division Forest Research Institute, Dehradun-248006

Abstract

Nature based tourism is a developing niche within the larger travel industry, with the potential of livelihood generation and sustainable development including protection and conservation of nature. This leads to an incentive for sustaining natural resources which in turn pave way for conserving biodiversity at local or regional level.

This paper revolves around the impact analysis of nature based tourism on livelihood of villages in and around Kunjapuri temple in district Tehri Garhwal, Uttarakhand, situated at 1676m above msl, 35 km on Rishikesh- Gangotri National Highway. Four villages namely Badera, Pater, Kheragoan and Sonigoan are located in the vicinity of the temple and depend on adjoining forest around the temple for forest based resources. The invigorating environment, aesthetic beauty, serine atmosphere, diversity of avifauna, mountains clad with snow and telescopic display of panoramic view of Himalayas catch the attention of visitors. At the same time it offers attractive destination for trekking and adventure tourism like paragliding. The nature based tourism is becoming a major source of livelihood of villagers by selling of local goods, establishing small and medium shops of tea, grocery shops. To conserve biodiversity and developing perspective of nature based tourism which in turn sustains the livelihood of villagers, departments like Forest Research Institute and State Forest Department has initiated the activities like planting of aesthetic and multipurpose plant species.

The present paper discusses in detail the impact of nature based tourism on livelihood of villagers located in and around Kunjapuri, Uttarakhand.

Keywords. Nature-based tourism, livelihood, Kunjapuri, Rural people,

Introduction

Travel and tourism are among the world's fastest growing industries and are the major source of foreign exchange earnings for many developing countries. Nature- based tourism or ecotourism is a growing niche market within the larger travel industry, with the potential of being an important sustainable development tool. It is defined by its sustainable development results. conserving natural areas, educating visitors about sustainability, and benefiting local people. Yet while ecotourism has the potential to create positive environmental and social impacts, it can unfortunately be damaging as mass tourism if not done properly. Typically located in pristine, fragile ecosystem, ecotourism projects run the risk of destroying the very environmental assets on which they depend. The loss of biodiversity and wildlife habitats, the production of waste and polluted effluent in areas that have little or no capacity to absorb them are just some of the worries.

Recognizing the global importance of the issue, United Nations designated 2002 as the International Year of Ecotourism, and the Commission on Sustainable Development (CSD) mandated the United Nations Environment Programme (UNEP) and the World Tourism Organization to carry out activities for the year. Its goal was to review the lessons learned in implementing ecotourism, and to identify and promote forms of ecotourism that lead to the protection of critically endangered ecosystems, sharing the benefits of the activity with local communities and respecting local cultures.

Ecotourism has been defined as a form of nature-based tourism in the market place. The term ecotourism, therefore, refers on one hand to a concept under a set of principles, and on the other hand to a specific market segment. The International Ecotourism Society (TIES) (previously known as The Ecotourism Society (TES)) in 1991 produced one of the earliest definitions "Ecotourism is responsible travel to natural areas that conserves the environment and sustains the well being of the people".

Ecotourism as defined by IUCN (now called the World Conservation Union) states in 1996 that ecotourism "is, environmentally responsible travel and visitation to relatively undisturbed natural areas, to enjoy, study and appreciate nature (and accompanying cultural features both past and present), that promotes conservation, has lower visitor impact, and provides for beneficially active socio-economic involvement of local populations".

'Ecotourism' (also known as ecological tourism) is responsible travel to fragile, pristine, and usually protected areas that strives to be low impact and (often) small scale. Its purpose is to educate the travelers; provide funds for conservation; directly benefit the economic development and political empowerment of local communities; and foster respect for different cultures and for human rights. It is held as important by those who participate in it so that future generations may experience aspects of the environment relatively untouched by human intervention.

Ecotourism typically involves travel to destinations where flora, fauna, and cultural heritage are the primary attractions. One of the goals of ecotourism is to offer tourists insight into the impact of human beings on the environment, and to foster a greater appreciation of our natural habitats.

Responsible ecotourism includes programs that minimize the negative aspects of conventional tourism on the environment and enhance the cultural integrity of local people. Therefore, in addition to evaluating environmental and cultural factors, an integral part of ecotourism is the promotion of recycling, energy efficiency, water conservation, and creation of economic opportunities for local communities. In what way nature base tourism is driver in protecting and conserving habitats and sustaining livelihood of villagers, a study has been conducted in Kunjapuri, Tehri Garhwal, Uttarakhand.

Study Area

Kunjapuri is located in the district Tehri of Garhwal Himalaya, at an attitude of 1,676 m, and 35 km from Rishikesh on Rishikesh-Gangotri highway. Kunjapuri Siddhapeeth is one among the 52 Siddhapeeth in India and the temple is the abode of goddess “Kunja Devi”. It not only holds religious importance but also has immense ecological significance. It is a reservoir of biodiversity and also a source of non-wood forest products on which the surrounding villages namely Badera, Pater, Kheragoan and Sonigoan derive their forest based resources from the forests located adjoining to the Kunjapuri Siddhapeeth. The human population of these villages is about two thousand five hundred. People are mainly dependent on agriculture and rearing livestock for livelihood are generally below the poverty line. Climatically the area falls under temperate climatic zone, characterizing by the presence of Banj oak (*Quercus leucotrichophora*) forests.

Location

Kunjapuri is located at the peak of the mountain and thus provides a picturesque view of the area, it lends a panoramic view of snow clad Himalayan range in the north (Chaukhamba ranges) and an exhilarating view of the sacred river Ganga, Rishikesh, Haridwar, Doon valley and Shiwalik hills in the south.

Topography

Topography of Kunjapuri divides the area into two aspects i.e. Northern and Southern aspects. The north aspect is dominated by rich vegetation like *Quercus* spp., Bamboo etc. that helps in maintaining the aesthetic view of the area and provides cool, soothing and invigorating environment to the visitors visiting the area particularly during summers. South aspect has scattered bushy vegetation with various sunny faces where the tourists mass enjoy the full sunlight throughout the day particularly during winter.

Landscape

It encompasses three major ecosystem i.e forest, grassland and hill terraced ecosystem. The forest ecosystem is dominated by lush green forest of *Quercus leucotrichophora*. The hill-terraced ecosystem has an eye-catching view of terraced cultivation containing agro forestry system of cultivation. It gives a panoramic view of Bhagirthi and Gangotri range with snow covered mountains. Rishikesh and Surkunda Devi temple located in Dhanoulti can also be seen from the temple. Tourists visit this temple to see sunrise and sunset, it gives a beautiful view. 'Ananda', a five star hotel, earlier it was the palace of Tehri king is situated 12 Kms from the village.

Habitation

Kunjapuri hill is surrounded by clusters of rural villages namely Pater, Badera,Khera and Sonigaon. The forest and grasslands in and around the temple directly influence these villages. The human population of these villages is about 2000-2500. Agriculture and cattle rearing are their main source of livelihood hence, they are totally dependent on the forest and grassland for their daily requirement like for fodder, fuel, timber and leaf litter etc for organic manure.

Trekking

Kunjapuri offers attractive destination for adventure tourism like trekking, it has the trekking route starting from Tapovan (Rishikesh) to Kunjapuri and vice-versa. Taking all these points into consideration Uttaranchal Forest Department has planned to develop this place for ecotourism.

Paragliding

Kunjapuri also offers an attractive destination for various aero sports like paragliding etc, foreign tourists besides enjoying the beauty of the place also indulge themselves into various adventure sports. Taking off from Kunjapuri they glide down to Rishikesh enjoying the cool, invigorating climate and scenic beauty of the place.

Methodolgy

In order to assess the impact of nature based tourism in Kunjapuri on livelihood opportunity of villagers, a survey was conducted in immediate influenced village Badera; Demography and social status of villagers are key components in mobilizing in developmental activities in the region. Therefore, a descriptive cross sectional research design was used for the study comprising of questionnaire surveys with the villagers, shopkeepers and tourists. The methodology for the case study combined, structured questionnaire-based household survey, with participatory rural appraisals, and open-ended interviews with key persons. In village Badera questionnaire-based survey was done with villagers, shopkeepers and also with tourists. Questionnaire of villagers and shopkeepers consist relating to their family members, occupation, source of income, language and their perception about tourism in Kunjapuri. A total of 50 people were interviewed.

Results

The village is dominated by female population with agriculture as the major source of income with 3-4 ha of land, beside rearing cattle.

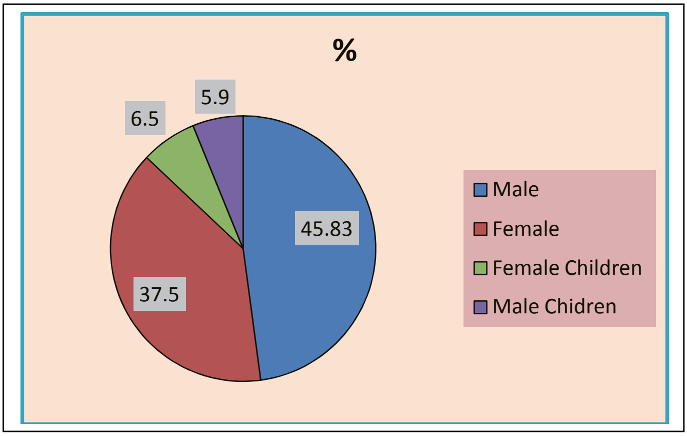


Figure 1. Percentage distribution population in village Badera.

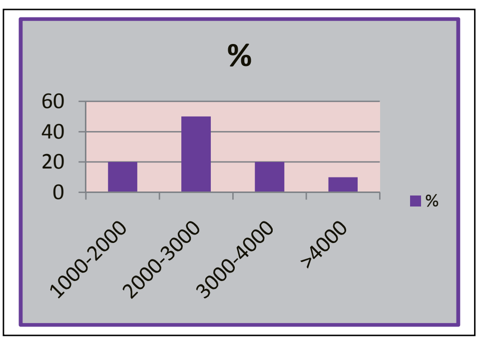


Figure 2. Percentage distribution of Income in village Badera.

The average income of village ranges between Rs 2000-3000. The village lacks the facility of electricity, sanitation and drinking water facility. It is well contacted by road. Nearest higher education is Rishikesh and medical facility is available in Narendranagar, 8 km away from the village. The inflow of tourists to the Kunjapuri temple is from all over the world.

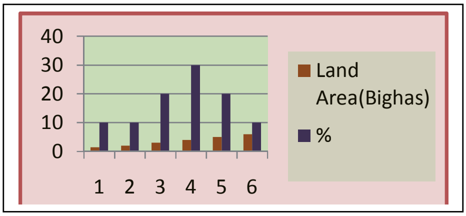


Figure 3.Percentage distribution of landholdings in village Badera.

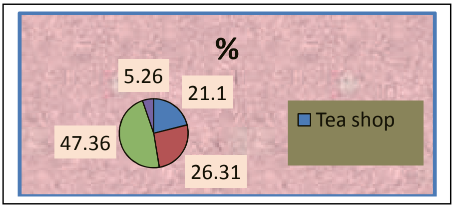


Figure 4. Percentage distribution of type of business .

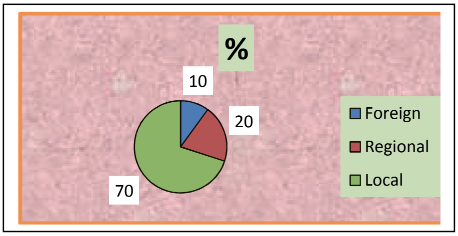


Figure 5. Percentage distribution of inflow of tourists in

Conclusions

The results show that agriculture is the main source of income and mostly they have unirrigated land in which paddy, wheat, vegetables, maize, ragi etc. are grown. They donot have facility of drinking water and irrigation. The villagers established shops like tea, grocery near the temple and depend upon tourists who visit the area for the sell of their goods but donot have much benefit from tourists. Regional or local tourists buy 'prasad' while foreign tourists are accompanied by guides who donot assist them to buy 'prasad'. Tourists visit this place to enjoy sunrise and sunset and to enjoy the panoramic view of mountains covered with snow and religious purpose. There is no facility for tourists to stay and lack facility of sanitation and drinking water. Kunjapuri being a place of interest as scenic beauty and wide prospect for nature based tourism, various Government Departments like Forest Research Institute, Dehradun, Uttarakhand Forest Department have launched a programme for habitat restoration and conservation of biodiversity in this region. In the line of conserving and maintaining biodiversity system sustainable, plants of multipurpose uses ranging from ornamental, fuel, fodder, timber, religious, horticultural etc were planted. With the efforts of these departments a significant enhancement in biodiversity and aesthetic view has developed in the area. *Arundinaria fulcata* and *Dendrocalamus strictus* planted in view to enrich diversity of the area may be used as a source of livelihood of villagers through making and selling handicraft products to the tourists.

Suggested Strategies to enhance ecotourism based livelihood in the Kunjapuri area

- The first and foremost there should be the awareness about the ecotourism and its importance among villagers of the area.
- The participation of local people is needed at all the stages of

ecotourism evaluation, planning and implementation.

- To promote effective participation efforts should be made to enhance local people's appreciation and awareness of about the potential tourism values of their natural surroundings, i.e. the local people should be made aware of what their natural surrounding has including environmental, cultural and other
- attractions etc. to offer to the potential tourists.
- Outside institutions from provincial to national (e.g. NGO's, National outreach groups, private sector firms and research and educational institutions) should be drawn upon to support tourism in Kunjapuri.
- A long awaited proposal of government of development of trekking route and ropeway construction from Tapovan (Laxmanjhula) to Kunjapuri be initiated and contruction.
- There is need to popularize the sacred grove in the area which has been developed by the Forest Research Institute, Dehradun so that people can know about the various important aspects of this area and about the work which is being carried out here in order to develop and maintain the beauty of this place.
- Basic features like electricity, telecommunication etc. and construction of tourists hut and rest houses should be provided to the people visiting this place.
- The information about Kunjapuri and its importance should be made available in all the hotels, tourists bungalows and ashrams etc. in Rishikesh and Haridwar as these places are close to this place and well known tourists spot.

- Incorporate Kunjapuri in the tourist map of Garhwal Himalaya.

These strategies would go a long way to promote Kunjapuri as a potential site for the ecotourism. To be viable, ecotourism should be community based and the needs of the community, their ideas of conservation be given prime importance. Local structures must receive patronage and promotion, so that ecotourism becomes a dynamic facet of economic development.

Refrences

Barkin, D. 2002. Eco tourism for sustainable regional development. *Current Issues inTourism*. 5(3–4).245–253.

Buckley, R. 1994. Research Note, a framework for ecotourism. *Annals of TourismResearch.* 21(3).661–669.

Ceballos-Lascurain, Hector. 1996.Tourism, Ecotourism and Protected Areas. *IUCN*.

Choudhary Manjula, Kamra K. K, Boora, Bhushan Ravi, Chand Mohinder and Taxak R. H 2007.Tourism Development Impact and Strategies. Department of Torism and Hotel Management, K. U. pp- 61

Rawat M, Vasistha H. B, Negi M2010, People's Perception on the Impact of Climate Change in Garhwal Himalayan Region. A Case Study from Kunjapuri Hills, in edition (Bhawana Luthra, Vijay Pratap Singh, Debajit Barkataki, Tara Mann, Rahul Singh) Reflections of Climate Change Leaders from the Himalayas.

Conributing Authors

Prafulla Soni

Retd.Scientist- G & Head

Ecology & Environment Division

Forest Research Institute,Dehradun

Presently Advisor Restoration ecology & Biodiversity Conservation sonip1405@gmail.com

Lal Singh

Forest Soil & Land reclamation Division

Forest Research Institute, Dehradun

lalsingh82@gmail.com

Anshumali

Department of Environmental Science and Engineering

Indian School of Mines Dhnabd-826004, Jharkhand anshumali@rediffmail.com

J.V. Tyagi

National Institute of Hydrology,Jal Vigyan Bhawan

Roorkee- 247667, Uttarakhand, India

tyagi@nih.ernet.in; jv_tyagi@yahoo.com

Rakesh Kumar

National Institute of Hydrology,Jal Vigyan Bhawan,

Roorkee- 247667, Uttarakhand, India

R.D.Singh

National Institute of Hydrology,Jal Vigyan Bhawan, Roorkee- 247667, Uttarakhand, India

Harender Singh

Entomology Research Lab,Department of Zoology,

M.S. (P.G.) College, Saharanpur; 247001

hslifescience@gmail.com

S.C. Dhiman

Entomology Research Lab,Department of Zoology,

M.S. (P.G.) College, Saharanpur; 247001

Salman Ansari

C.C.S. University, Meerut-250004

Biswajit Paul

Department of Environmental Science and Engineering,

Indian School of Mines, Dhanbad, Jharkhand, India

dr_bpaul@yahoo.com

C.M. Mathavan

Regional Fertilizer Quality Control Laboratory

Ministry of Agriculture

Madhavaram Milk Colony, Chennai-51

Tamilnaducmmathavan@gmail.com

Anuj Kumar Singh

Orissa University of Agriculture & Technology, Bhubaneswar

ksanuj@live.com,anujecologist@gmail.com

Jamaluddin

Department of Biological Science, Rani Durgavati University, Jabalpur

Ashish Rawat
The Louis Berger Group, Inc
Plot No. B-3-6, Sector 32, Gurgaon - 122001, INDIA
arawat@louisberger.com
Shikha Uniyal Gairola NOIDA, U.P.(India)
shikhaa.fri@gmail.com
Sanjay Sood & Sandeep Bhimta
CF Hamirpur, H.P.
sanjaysoodifs@gmail.com
Preeti Pandey Pant
Wildlife Division
Ministry of Environment and Forests
Government of India
Paryavaran Bhawan, C G O Complex, Lodhi Road, New Delhi.
preeti.fri@gmail.com
A.K. Tripathi
Ecology and Environment Division,
Forest Research Institute, P.O. New Forest, Dehradun
tripathiak@icfre.org
Nutan Gupta
Forest Research Institute, P.O. New Forest, Dehradun
environutan@gmail.com
N.S.K Harsh
Forest Pathology Division, Forest Research Institute, Dehradun
harshnsk@icfre.org

Ashok Kumar

Department of Biotechnology, HNBGU (A Central University), Srinagar-Garhwal-246174 (UK) INDIA

asokumr@gmail.com

B.S. Bisht

Badshahithaul Tehri-249199 (UK) INDIA

V.D. Joshi

Dept of Zoology, Govt. PG College Kotdwara Garhwal (UK) INDIA

Parth Sarathi Mahapatra

Ecology & environment division

Forest Research Institute,Dehradun-248006, India

+917377487707/ +919438300732

parth_mahapatra@yahoo.com

Ganesh Datt Bhatt

Global Open University, Nagaland

ganeshdattbhatt.iirs@gmail.com

Richa Arya

Department of Environmental Science,

Babasaheb Bhimrao Ambedkar University, Lucknow (U.P.)

richaarya09@gmail.com

Mohd. Muzamil

Department of Environmental Science,

Babasaheb Bhimrao Ambedkar University, Lucknow (U.P.)

M. Yunus
Department of Environmental Science,
Babasaheb Bhimrao Ambedkar University, Lucknow (U.P.)
A.K. Gupta
National Institute of Disaster management (GOI), New Delhi
envirosafe2007@gmail.com, anil.nidm@nic.in,
Peeyush
Disaster Mitigation & Management Center-Dehradun
peeyushgis@gmail.com
N.K.Bohra
Arid Forest Research Institute, Jodhpur (Rajasthan)
bohrank@rediffmail.com
J.K.Shukla
Arid Forest Research Institute, Jodhpur (Rajasthan)
D.K.Mishra
Arid Forest Research Institute, Jodhpur (Rajasthan)
Ram Chandra
Progressive Research Organization for Welfare (PROW),
B-28-29, Flat No. 203, Vishwakarma Colony,
M.B. Road, New Delhi (India) -110044
rchandradelhi@gmail.com
Govind Singh
Department of Environmental Biology, University of Delhi
govind029@gmail.com

Mihir Deb

Department of Geology, University of Delhi

Chirashree Ghosh

Department of Geology, University of Delhi

Vivek Dwivedi CEDAR, Dehradun

vivek.nature@gmail.com

T. S. Dange

Forest Research Centre, (ICFRE), Hyderabad, India-50014

dangeifs@yahoo.com

Y. Sridhar

National Research Centre for Soybean – Indore, India

R. Sundraraj

Institute of Wood Science and Technology, (ICFRE), Bangalore, India

M.K. Gupta

Forest Soil & Land Reclamation Division

Forest Research Institute, Dehra Dun

guptamk@icfre.org

Joystu Dutta

Forest Soil and Land Reclamation Division,

Forest Research Institute, Dehradun

joystu.dutta@gmail.com

Ramesh Madav

Terracon Ecotech Pvt. Ltd., 6th Floor, ‘Swagat’, Shraddhanand Road,

Vile Parle (East), Mumbai- 400 057, India,

ramesh@terraconindia.com

Gouri Keskar

Terracon Ecotech Pvt. Ltd., 6th Floor, ‘Swagat’, Shraddhanand Road, Vile Parle (East), Mumbai- 400 057, India

gouri.keskar@terraconindia.com

Nirmal Ram

Forest Ecology & Environment Division

Forest Research Institute, Dehradun

ramn@icfre.org

Pramod Kumar

Forest Ecology & Environment Division

Forest Research Institute, Dehradun

Neelesh Yadav

Forest Informatics Division

Forest Research Institute, Dehradun-248006

neeleshy@gmail.com

A.K.Raina

Forest Soil and Land Reclamation Division, Forest Research Institute, Dehra Dun-248 006, Uttarakhand, India

rainaak@icfre.org

S. R Baloch

Forest.Research.Institute. Dehradun

G. Singh

Forest Ecology Division AFRI, Jodhpur.

Arid Forest Research Institute, Jodhpur

singh_g_dr@yahoo.co.in

Vaneet Jishtu

Rain Forest Research Institute, Jorhat (Assam)

vjishtuv@gmail.com

Mohinder Pal

Himalayan Forest Research Institute, Shimla (HP)

Anita Tomar

CSFER, Allahabad

anitatomar@icfre.org

Richi Yadav

Forest Ecology and Environment Division

Forest Research Institute,

Dehradun-248006, India

tulipsric@gmail.com

Mridula Negi

Forest Ecology and Environment Division, Forest Research Institute,

Dehradun-248006, India

mridula@icfre.org

H.B. Vasistha

Forest Ecology and Environment Division, Forest

Dehradun-248006, India

vasisthahb@icfre.org

S. Rasaily
Director
Rajaji National Park
Dehradun
Suryapal Singh Bhandari
Forest Ecology and Environment Division,
Forest Dehradun-248006, India
S.K. Kamboj
Forest Ecology and Environment Division,Forest
Dehradun-248006, India
Sweta Priyam
Forest Ecology and Environment Division
Forest Research Institute, Dehradun-248006
swetapriyam@ymail.com