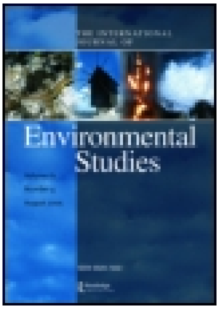

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STUDY OF POLLUTION OF THE RIVER GANGA IN THE MIRZAPUR REGION (INDIA) AND ITS IMPACT ON SEDIMENTS

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The paper presents the various sources of pollution in the Mirzapur region, an industralized town in eastern Uttar Pradesh, which lies on the right bank of the river Ganga (Ganges). Municipal and industrial effluents affect the sediment and water of the river. An analysis of the bank sediments revealed the presence of toxic metals, some of them present in greater concentration than those recorded in average shale. The maximum concentrations of Cu, Pb, Ni and Zn in the region, 931, 226, 24 and 717 ppm, respectively, were recorded near the Oliar ghat (landing steps), whereas 138 ppm of Cr was found at the same ghat. Likewise, the maximum value of Co (20 ppm) occurs opposite to the Fathua ghat. These metals present no direct danger to the ecosystem as long as they are tightly bound to the sediments. However, due to a change in the physico-chemical conditions, viz. pH, salinity, redox condition, etc., of the aquatic milieu, these metals from the sediments may pass into the water phase and thus may cause a health hazard.

KEY WORDS: Sediment, water, pollution, Ganga.

INTRODUCTION

Any environmental programme aimed at conserving river water quality would be incomplete without the proper study of its sediments, as they are an integral and inseparable part of the river ecosystem.

When the effluent-loaded water meets the river, reactions start taking place, and a large part of the effluent in one form or other settles down and adheres or is adsorbed by the river sediments depending upon the physico-chemical conditions and on the species of the pollutant nutrients or trace elements under consideration. The suspended sediment particles carrying the contaminants settle onto the basinal sediments and with time get buried in the sediments. Thus sediments may act as a scavenger (anti-pollutant) in the aquatic ecosystem. However, the toxic metals and many hazardous chemicals in the sediments may be released as a result of changes in the aquatic milieu.

As a result of remobilization of the toxic metals from the sediments, the water may become contaminated, or its contamination may increase, making it not only unfit for drinking purposes causing health hazards but also rendering it unsuitable for other purposes as well. In this case the sediment acts as a pollutant.

Keeping this in mind, the study of sediments of the river Ganga in the Mirzapur, an industrialized zone in eastern Uttar Pradesh (India) has been undertaken. This paper presents the various sources of pollution in the Mirzapur region and the effect of sewage, domestic and industrial effluents on the Ganga sediments in the region. The chemical analysis of the bank sediments revealed the presence of toxic metals, viz. Cu, Co, Pb, Ni, Cr and Zn; some of these are in greater concentration than those recorded in average shale, a threshold value.

THE RIVER GANGA

The river Ganga occupies a unique position in our country. This river, no doubt, is one of the most important rivers of our country. It has a large drainage basin comprising an area of 861,404 sq. km. encompassing a large part of Himachal Pradesh, Panjab, Haryana, Uttar Pradesh, Rajasthan, Madhya Pradesh, Bihar, West Bengal and union territory of Delhi with an annual flow of 468.7 billion cubic metres, and accounts for 25.2% of the India's total water resources. The river has served as the cradle of Indian civilization and is interwoven with India's history, culture, religion and philosophy. Besides being a source of supply of drinking water to the people inhabiting the cities, towns and villages situated on its banks, it is also being used for navigation, irrigation, bathing, washing, fishing and for industrial purposes.

However, during the past few decades, the water of this river, which has been considered as "nectar" and carried to far off places for drinking and religious purposes, has been polluted. In a recent United Nation report, the name of this river is at the top of the polluted rivers of the world. At several places the river has been converted into a network of cesspools and drains by the industries and municipalities in the region. On the one hand, with the increasing growth of population and development of industries along it, the demand of water has increased, while at the same time the silt content (the sediment load of the river often rises to a level of 2 gm/litre of water), because of deforestation is shallowing and narrowing the river channel. Also, the withdrawal of water through canals for irrigation purposes has substantially affected the stream flow.

When the effluent-loaded water meets the river, reactions start taking place, and a large part of the effluent in one form or other settles down and adheres or is adsorbed by the river sediments. The heavy (toxic) metals of the effluents—industrial and domestic—adsorbed in the sediments present no direct danger to the ecosystem as long as they are tightly bound to the sediments. However, the toxic metals and many hazardous chemicals in the sediments may not necessarily remain in that condition but may be released as a result of changes in the aquatic milieu.[1]

The paper describes the various sources of pollution and their discharge which have affected the sediments of the region. Although the pollutant have been described under four major heads—urban wastes, industrial wastes, leachates from agricultural fields and others—it may be stated that the various nalas can't be categorised as sewage nala or industrial effluent nala; several of them carry the wastes and effluents of city sewage as well as effluents of the industries.

AREA UNDER STUDY

The area studied is a plain tract and falls in the Middle Ganga Basin. It lies between the Ganga bridge to downstream up to Belavan along the right bank, and opposite to the Ganga bridge to downstream up to Kishanpatti along the left bank of river in the Mirzapur district (Figure 1). The city of Mirzapur (25°9'N, 82°35'E), the central point of the area, is connected with all the important cities of the country by highways and railways. It is 717 km from New Delhi on the Howrah-Delhi main line of the Northern Railway and lies on the right bank of the river Ganga in Uttar Pradesh between two important pilgrimage cities, viz. Allahabad and Varanasi.

The river meanders in the area and flows eastward at an elevation of 90 m from the mean sea level. The river marks the northern boundary of the district of Mirzapur. The annual flow of the Ganga in the area is 380,380 million m^3, the highest and lowest stream flow being 97,142 million m^3 and 3362 million m^3, respectively,

GANGA AT MIRZAPUR

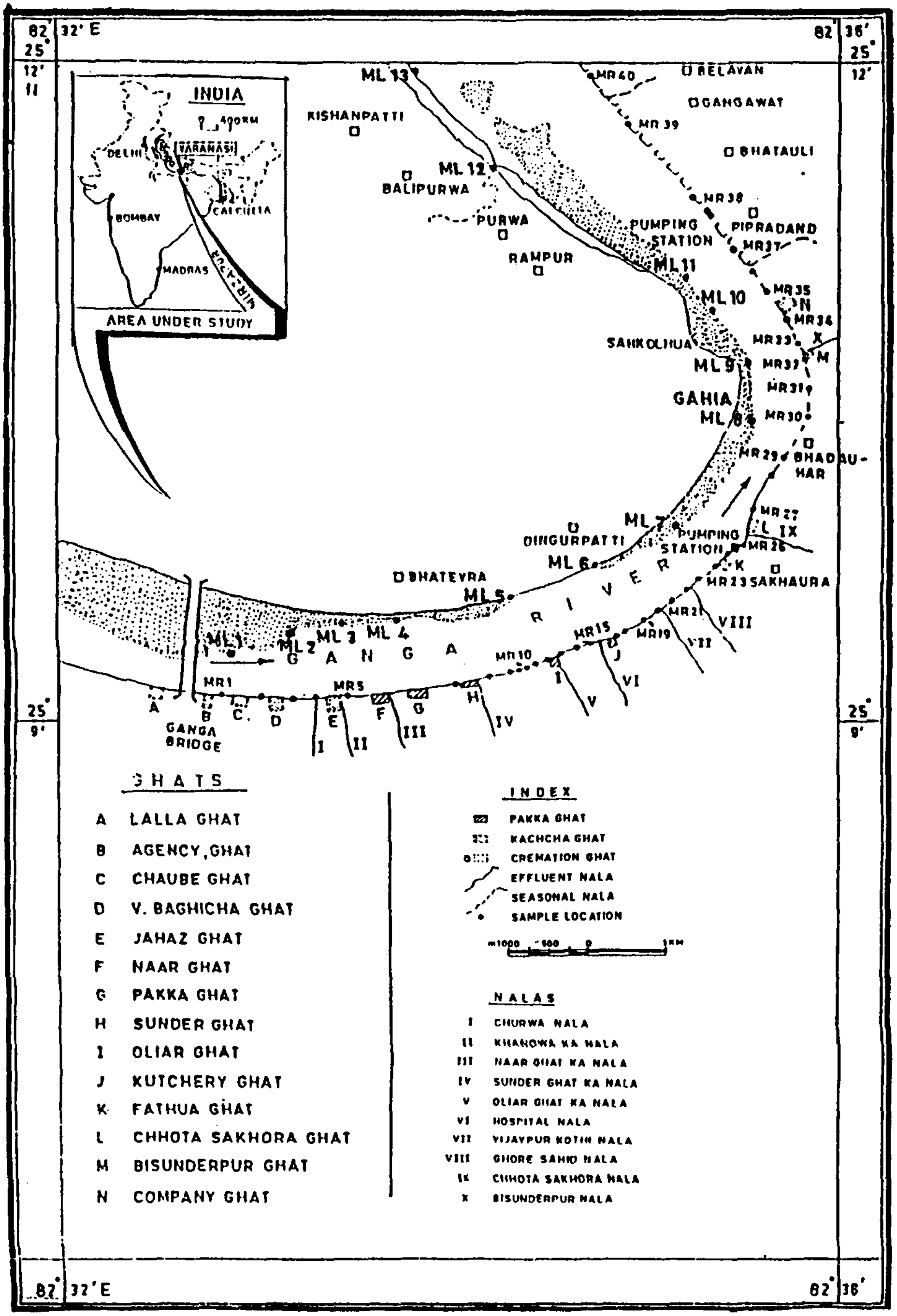

Figure 1 Map showing ghats, nalas and location of samples.

during the monsoon and summer seasons, whereas the mean seasonal rate of flow is 3627 m^3/second. The river is subjected to floods annually, its intensity varying from time to time. The flood plain of the river occupies 4.97% area of the district with elevations varying and sloping very gently southwards.

SAMPLING

Keeping account of the nature and amount of the pollution load being added to the river at a particular site, the monitoring stations were selected along both the banks, and sediment samples were collected in the region from the Ganga bridge to Belavan along the right bank, and opposite to the Ganga bridge to Kishanpatti along the left bank of the river. Close sampling was carried out mainly along the right bank, along which the city of Mirzapur is situated. This bank is much affected by several municipal, industrial and hospital outlets. The left bank is uninhabited and comparatively less polluted. Near and around the confluence of the nalas with the river, the sampling interval was closer. The location of collected samples is shown in the Figure 1.

POLLUTION OF SEDIMENTS OF GANGA IN THE REGION

1. *Urban Wastes*

The urban wastes comprise municipal sewage containing human and animal excreta, domestic effluents, burnt wooden materials, filth, pieces of old clothes and solid wastes, etc. It is reported that more than 50% of the urban population has no adequate toilet facilities and in the rural areas the people use open fields as toilets. In the absence of a proper sewage system in the urban areas the outdated bucket type latrine system for the disposal of night soil is prevalent; this is carried by tractors, trolleys, bullock-carts and handcarts. Moreover, no appropriate dumping site is available in the city area. The prevalent system of carrying the night soil is not only a site of nuisance but causes health hazards too, thus deteriorating the hygienic condition of the city.

2. *Industrial Wastes*

The city is famous for carpet, woollen, aluminium, non-ferrous metals and dyeing industries. These industries pour their effluents into the river water. According to the latest data, the number of small industries with a capital less than 20 lacs is 33, and large and medium industries with a capital more than 20 lacs is 9. Besides, the number of unregistered factories is approximately 4000. These industries are carpet making and non-ferrous utensils manufacturing. They discharge various pollutants, such as oils, grease, strong acids, scrap, various chemicals, etc.

3. *Leachates from Agricultural Fields*

The use of chemical fertilizers and pesticides in agricultural fields in the area has added to the problem of sediment pollution. The agricultural fields in the area are deficient in phosphorus and nitrogen and rich in potash and lime. The consumption of nitrogenous fertilizers in the region is fairly high and is followed by that of phosphorus and potassium. Some nutrients added to the soil/sediment through fertilizers eventually enter the river ecosystem, which accelerates the growth of aquatic plants, algae and phytoplankton in the water, the excess of which leads to "eutrophication," i.e. natural aging process of the aquatic system. A large variety of chemicals are being used by farmers in the fields to eradicate various types of agricultural pests, including insects and other organism. The use of organochlorine pesticides in the region is higher than those of organophosphorous pesticides. Organochlorine pesticides are highly toxic and chemically more stable than the fertilizers residue. These pesticides also find their way into the river Ganga through farm waste water. It was stated[2] that traces of pesticides in water may even cause a total annihilation of aquatic fauna.

4. *Pollution Due to Other Sources*

Besides the sources mentioned above, bathing, washing, cremation at the ghats and hospital effluents also increase sediment pollution in the region. In the city, the Chaube ghat is used for cremation. Besides, people also throw the dead bodies of animals in the river. Skinning of dead bodies of animals at the Kutchery ghat for tannery purpose is also practised.

In the area, thousands of people take a bath on festival days, use detergents and also wash clothes. Effluents of the Government Hospital is also poured into the river through a small drain at the Kutchery ghat. Pollutants from atmospheric fallout released from different industrial chimneys in the area and vehicular exhaust also pollute the sediments.

5. *Sewage and Effluent Water Courses Nalas*

A major part of the wastes and effluents of urban sewage and of industries flows through a system of open and covered nalas, which discharge their effluents into the river without treatment. The important effluent nalas are Churwa, Khandwa, Naar ghat, Sunder ghat, Oliar ghat, Hospital, Vijaypur Kothi, Ghore Sahid, Chhota Sakhora and Bisunderpur nalas.

Of these, the Oliar and Naar ghat nalas are prominent and together carry about 70% wastes of the city. The Khandwa nala discharges its effluents towards the upstream direction of the city. Its polluted water flows along the ghat where a number of people take baths. In some areas, the drains are not functioning satisfactorily, thus the waste water stagnates and spreads on the road and side path. In about 20–30% of the road drains, water logging occurs under dry weather flow conditions. This leads to poor hygienic conditions. A very unsatisfactory situation is found at the Civil Lines, specially around the slaughter houses. The siltation of road drains and minor nalas are also caused due to the bad condition of the roads and unpaved embarkments.

The roadside open drains carry the liquid wastes to the river Ganga. These drains were originally constructed to carry storm water, but with the lapse of time people started connecting their toilets to these drains. The siltation levels in the system have been found between zero and fifty per cent of the total height of the nala. The general condition of the covered main nalas and smaller nalas is worse. These main nala are of a brickwork construction, covered with sand slabs. These slabs have larger irregular joints causing erosion of the upper layers which result in a silting up of the

Table I The average discharge and pollution of the three main nalas

Name of the nalas	Average discharge in LPM (litre per minute)	Biochemical oxygen demand (BOD) in (mg/l)
Khandwa nala	2,020	153
Naar ghat nala	950	202
Oliar ghat nala	1,320	162

nalas, the siltation level often reaching up to 100%. Some of the important nalas, their discharge and pollution (BOD) are given in the Table I.

It is known that the maximum value of the Biochemical Oxygen Demand (BOD) for potable water is 2 mg/l and that for bathing is 3 mg/l. The BOD values given in the above table indicate the high degree of pollution.

WATER QUALITY IN THE REGION

The status of water is judged on the basis of several parameters, particularly its DO (oxygen dissolved in the water, sewage, etc.) and BOD (the quantity of oxygen required for the oxidation of organic matter by bacterial action in the presence of oxygen, coliform bacteria and pH).

Based on these values, the quality of water[3] for various uses† is presented in the following Table II.

The overall water quality of the Mirzapur has been designated as "D" grade. The various parameters determined[2] for the Mirzapur are tabulated in Table III.

The high BOD of the degraded water is due to the effluents coming from the various sources of pollution, as mentioned above. The effluents also affect the sediments, either by direct deposition or due to physicochemical reactions taken place in the aquatic basin.

TOXIC METALS AND THE SEDIMENTS

As a result of the effluents coming from the various sources of pollution as detailed above, sediments of the area have become enriched in toxic metals. The concentration of toxic metals, viz. Cu, Co, Pb, Ni, Cr and Zn in the sediment samples, collected

Table II The quality of water for various uses

Parameters→ Water ↓ classes	DO (mg/l) min.	BOD (mg/l) max.	Total coliform organism (MPN/100 ml) max.	pH
A	6	2	50	6.5–8.5
B	5	3	500	6.5–8.5
C	4	3	5,000	6.0–9.0
D	4	—	—	6.5–8.5
E	—	—	—	6.0–8.5

† A. Drinking water source without conventional treatment but after disinfection.
B. Organised outdoor bathing.
C. Drinking water source conventionally treated and then disinfected.
D. *Propagation of wildlife, fisheries.*
E. Irrigation, industrial cooling, controlled waste disposal.

Table III Seasonal variations of the mean concentrations of the indicators of organic pollution in the Ganga water (Mirzapur region)

Characteristics	DO (mg/l)			BOD (mg/l)			Total coliform organism (MPN/100 ml)		
	PM	W	S	PM	W	S	PM	W	S
Value	8.22	10.40	7.01	7.20	6.15	6.72	26,740	40,792	8,610

PM = Post-monsoon (Oct.–Nov.). W = Winter (Dec.–Feb.). S = Summer (March–June).
MPN = Maximum permissible number.

from the bank and from far and near the important nalas of the area, are given[4] in Table IV. The last row in the table gives the average values of trace metals in shale,[5] which is taken as a geochemical background value for the comparative study of the sediments of the Ganga.

DISCUSSION

The variation in the concentrations of metals Cu, Co, Pb, Ni, Cr and Zn in the various sediment samples is shown in Table IV. Cu ranges from 31–931 ppm, Co 6–20 ppm, Pb 14–226 ppm, Ni 6–24 ppm, Cr 42–138 ppm, and Zn 41–717 ppm. The maximum concentrations of Cu, Pb, Ni and Zn in the area were recorded near the Oliar ghat, whereas those of Cr at the ghat. However, these maximum concentrations of Cu, Pb, Cr and Zn at and around the Oliar ghat are approximately 21, 11, 1.5 and 7.5 times, respectively, of the values of these metals in the average shale.[5] These higher values may be attributed to the washing of non-ferrous metals by the non-ferrous industry at the same ghat. Besides, Co occurs in its maximum concentration (20 ppm) opposite to the Fathua ghat. This is slightly higher than the average shale value.[5]

Although most of the toxic metals (heavy metals) are present in all the samples collected, yet the sediments of a few places are more polluted than the others. Of these, the most polluted part is around the Oliar ghat with the highest concentration of Cu, Pb, Ni, Cr and Zn.

Table IV Toxic metals in Ganga sediments, Mirzapur region

Sl. no.	Sediment sample no.	Location	Toxic metals (in ppm) Cu	Co	Pb	Ni	Cr	Zn
1.	MR 2	Upstream of V. Baghicha ghat	90	12	47	14	129	110
2.	MR 9	Upstream of Oliar ghat	931	6	226	24	123	717
3.	MR 12	Oliar ghat	56	9	19	9	138	94
4.	MR 15	Upstream of Kutchery ghat	169	9	47	11	131	280
5.	MR 25	Fathua ghat	61	12	37	15	—	69
6.	MR 37	Pipradand	37	18	28	18	98	80
7.	ML 2	Opposite to V. Baghicha ghat	40	6	14	9	45	41
8.	ML 4	Opposite to Pakka ghat	48	—	19	6	46	44
9.	ML 7	Opposite to Fathua ghat	51	20	37	17	50	75
10.	ML 9	Opposite to Bisunderpur ghat	31	15	23	12	45	53
11.	ML 11	Opposite to Pipradand	56	12	28	9	42	73
Average shale value for metals[5]			45	19	20	68	90	95

CONCLUSION

As stated above, these metals may remain in the river sediments and be relatively harmless. However, as a result of remobilization of the metals from the sediments, water may be polluted to the extent that it may not only be non potable but also useless for other purposes.

In view of the pollution of sediments of the region, it is imperative that measures are taken to prevent sediment pollution. Dredging of the sediments or covering them with impervious materials in conjunction with the river regulation projects and recycling of the materials to reduce the discharge of polluting substances have been suggested.[6] These processes and techniques are yet to be examined for their economic viability with regard to space and time. The simplest course, however, is to divert the effluent nalas and drive the dirty water elsewhere, and/or to treat the harmful pollutants at the source.

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