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Persistent organic pollutants in Indian environment: a wake-up call for concerted action

CONTENTS

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Introduction

Persistent organic pollutants (POPs) are a class of toxic pollutants that can persist in the environment for a long time; migrate to air, water, soil, or to the sediment, and accumulate to levels harmful to the environment, wildlife, and human health. There is enough scientific evidence today to show the ill-effects of chemicals such as dichlorodiphenyltrichloroethane, popularly known as DDT. The promising invention of DDT as an insecticide revolutionized the agriculture sector; however those gains came at a price, as DDT proved toxic to many more organisms other than those it was intended to kill.

The initial public warning about possible dangers of POPs came from their effects on the local environment in the early 1960s and grew stronger in the 1970s. Yet, compounds such as hexachlorobenzene (HCB), hexachlorocyclohexane (HCH), and DDT were among the most widely used pesticides in the world during 1970–80. India, being an agrarian and emerging economy, is one of the leading pesticide manufacturers in Asia. A number of studies have pointed to high levels of POPs in the environment in India because of poor management of e-waste and municipal and industrial wastes. Considering the fact that about 80% of India's population lives in malaria-prone areas,

Box 1: The 'Dirty Dozen'

- Aldrin
- Chlordane
- Dichlorodiphenyltrichloroethane (DDT)
- Dieldrin
- Endrin
- Heptachlor
- Hexachlorobenzene
- Mirex
- Toxaphene
- Polychlorinated biphenyls (PCBs)
- Polychlorinated dibenzo-p-dioxins (dioxins)
- Polychlorinated dibenzofurans (furans)

Box 2: The 'New POPs'

- α-, β-, γ-hexachlorocyclohexane
- Chlordecone
- Brominated diphenyl ethers (tetra- and penta, hexa- and hepta)
- Pentachlorobenzene
- Hexabromobiphenyl
- Perfluorooctanesulfonic acid, its salts and perfluorooctanesulfonyl fluoride
- Pentachlorobenzene
- Technical endosulfan and its related isomers
- Hexabromocyclododecane
- Chlorinated naphthalenes (di- to octa-)
- Hexachlorobutadiene
- Pentachlorophenol and its salts and esters

India has been exempted from the ban of DDT as a result of the Stockholm Convention (SC) and is allowed to produce and use DDT—but only for the control of vector-borne diseases. India was also allowed to use DDT for termite control until March 2013, although DDT was banned for agricultural use.

Persistent organic pollutants were initially termed the 'Dirty dozen' (Box 1) at a convention held in Stockholm in 1995; the term was used for describing twelve important POPs thought to be toxic to the environment and human health. These POPs were characterized by four features: persistence, bioaccumulation, potential for long-range environmental transport, and toxicity. Later the convention added more chemicals to the initial list (Box 2). The Stockholm Convention on Persistent Organic Pollutants was adopted and opened for ratification in 2001 and came into force in 2004, nearly a decade after the call for global action on POPs by the United Nations Environment Programme in 1995. The Stockholm Convention sought to prohibit or limit the use, production, and release of selected chemicals including polychlorinated biphenyls (PCBs), dioxins, furans, and a range of organo-chlorine pesticides (OCPs) in countries signatory to the convention. India had been using PCBs, one of the industrial POPs, since the 1950s until the1990s, the year the ban came into force. Although PCBs were never produced in India, they were imported for use in electrical components for power generation, in steel mining, and in the production of cement, fertilizers, and lubricants. The major use of PCBs in India has been in transformer oils (MoEF 2011). India banned PCBs very recently, through a gazette notification issued by the Ministry of Environment, Forests and Climate Change (MoEF & CC 2016). Poor management of waste PCBs and OCPs and processes resulting in the formation of furans, dioxins, and other hazardous chemicals has been a major contributor to the high levels of these toxic chemicals in local environments near the releasing sources, potentially affecting local health and the environment (Figure 1).

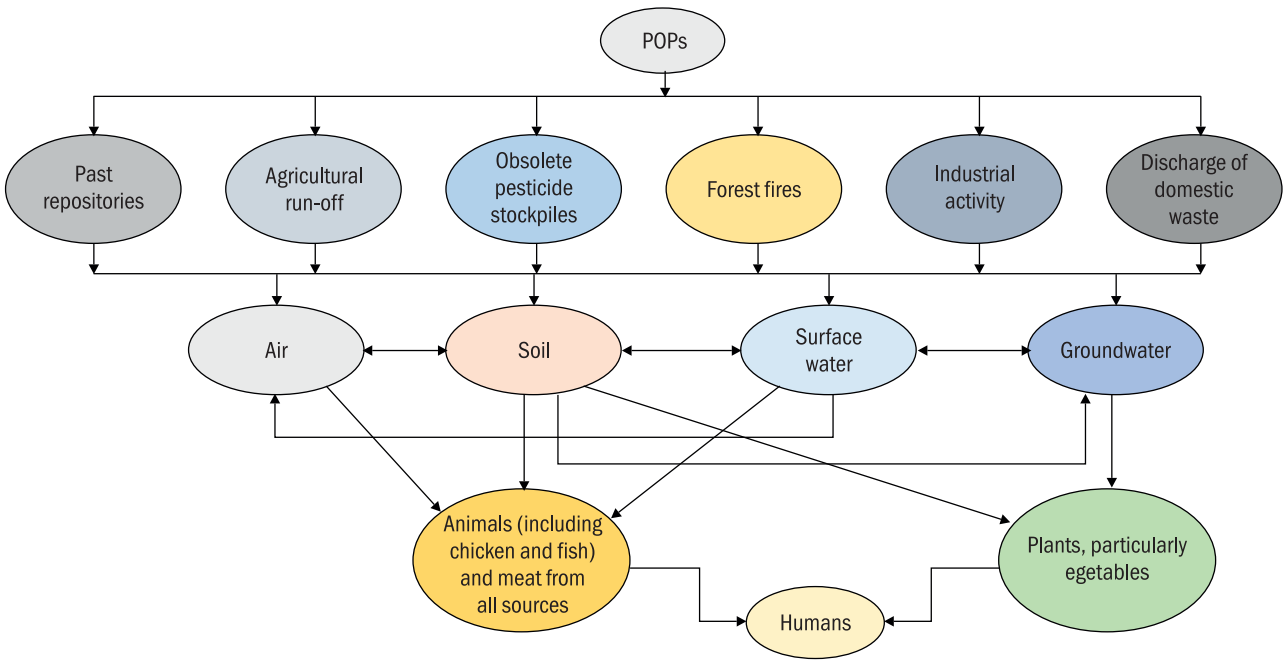


Figure 1: Sources and pathways of human exposure to persistent organic pollutants

Persistent organic pollutants persist in the system for decades causing health problems such as cancer, birth defects, learning disabilities, and immunological, behavioural, neurological, and reproductive disorders in humans and animals. Rivers such as the Ganges, which pass through vast industrial and agricultural areas with huge fish-eating populations, are at high risk from contamination with POPs (Table 1), and especially vulnerable are children, the elderly, and those with diseases that suppress the immune system.

Table 1: Exposure pathways through various contact media

Exposure pathways	Indoor exposure pathways	Contact medium
Oral	Dust ingestion	Dust
	Drinking contaminated water	Groundwater and surface water
	Consumption of fish and meat	Fish- or meat-based diet
	Consumption of contaminated milk	Milk
	Consumption of contaminated foot	Eggs, fruit, vegetables, etc.
Inhalation	Air inhalation	Indoor/outdoor air
	Air-borne dust inhalation	Indoor/outdoor air-borne dust
	Inhalation of water vapour while bathing or swimming	Drinking water
Dermal	Dust contact	Dust
	Contact with water while bathing or swimming	Drinking water, swimming pool water

Safe and sustainable management of POPs in India would be the key to achieving the targets of the Sustainable Development Goal (SDG)12, one of the sustainable development goals set by the United Nations, and requires a strong national framework for sustainable consumption and production that is integrated into national and sectoral plans, sustainable business practices, and consumer behaviour, together with adherence to international norms of the management of hazardous chemicals and wastes such as POPs.

Current status of persistent organic pollutants in India

India is an industrialized country and the chemical sector provides a dynamic environment for the development of legislation related to the management of chemicals with diverse, and often conflicting, positions expressed by different stakeholders. Recognizing the importance of regulating the manufacturing, import, or use of POPs and other toxic chemical substances, the Government of India has been supporting capacity building and providing technical assistance to industrial stakeholders. Since 1970, India has signed many international and regional environmental treaties and enacted a number of provisions aimed at controlling the risk of chemical contamination and protecting human and environmental health. In India, both legal and management aspects related to protection from chemical risks are part of the responsibilities of the central government, which are discharged through state ministries and a range of governmental agencies that manage various aspects of chemical pollution. The resulting legislative and executive frameworks are comprehensive but fragmentary, because different stages of the management of chemicals (registration, production, import, etc.) are under the jurisdiction of different authorities.

India is home to a population of almost 1.21 billion, with an extensive agriculture sector and a rapidly growing industrial sector. Despite India's regular participation in various treaties and conventions aimed at protecting environmental and human health from the risk from chemicals (MoEF 2011), available information on environmental and human exposure to major classes of chemicals of concern including such legacy POPs as dioxins, furans, and polybrominated diphenyl ethers (PBDEs) remains fragmentary: in fact, a review of historically available data on POPs (Sharma et al. 2014a) showed that the structure and the amount of available data are inadequate for ascertaining whether the levels of these strongly regulated contaminants are declining after the Stockholm Convention was adopted.

Most of the POPs that are pesticides have been banned for intentional use in India since 1983. Because 80% of the country's population lives in areas at risk from malaria (MoEF 2011), India is authorized to produce on average 5000 tonnes of DDT annually for the control of vector-borne disease. Similarly, although banned for agricultural use, lindane (γ-HCH) was also allowed, specifically for termite control, up to 24 March 2013 (CIBRC 2014). Between 1980 and 2012, India produced about 4500 tonnes of endosulfan a year, making the country one of the biggest producers and consumers of this pesticide (Sharma et al. 2014b). Import and export of wastes or articles contaminated with PCBs are prohibited under the Hazardous Waste (Management and Handling) Rules,

1989, which are part of the Environment (Protection) Act, 1986. As mentioned earlier, major sources of emissions of PCBs in India are power generation, steel mining, and production of cement, fertilizers, and lubricants as well as the ship-breaking industry (MoEF 2011), and, at one time, inventories recorded about 10 000 tonnes of PCBs (MoEF 2011). The Government of India also developed an action plan to comply with the obligations of Article 5 of the SC, related to the release of polychlorinated dibenzodioxins and furans (PCDDs/Fs); the quantities of PCDDs/Fs released during 2009–10 were estimated at about 9000 g of toxic equivalent quality (TEQ), the major sources being incineration of waste (66%), production of ferrous and non-ferrous metals, heat and power generation (MoEF 2011).

On 13 January 2006, the Government of India ratified the SC. As a party to the convention, India is active in developing and promoting non-POPs alternatives to reduce intentional and unintentional emissions of POPs. The manufacture, use, and import into India of most of the pesticides that are listed as POPs in the SC are banned under the Insecticide Act, 1968 and Insecticide Rules 1971. In 2011, India submitted its National Implementation Plan (NIP) on POPs, which gives information on the inventories of twelve legacy POPs. Box 3 presents the priorities and the strategies as drawn up in the plan.

However, the NIP is yet to be updated to include the POPs newly added to the SC. Among the fourteen new POPs (Fernández-Cruz et al. 2017) more recently included in the SC, bromodiphenyl ethers (BDEs) and perfluorooctane sulfonate (PFOS) are used extensively as industrial chemicals in India. Because PFOS is commercially used and produced in India, the chemical is among the most dominant perfluorinated compounds (PFCs), followed by perfluorooctanoate (PFOA), in surface sources of water in India (Yeung et al. 2009). Polybrominated diphenyl ethers are also on the list of widely used industrial chemicals in electronics and in upholstery, transport, furniture, and textile industries; as a result, samples of human milk from urban areas were found to be high in PBDEs (Devanathan et al. 2012).

The exposure of India's population to POPs and their presence in the environment can be taken as symptoms of ineffective management and delayed action. Although at present India lacks the capacity to monitor and assess the emissions and stocks of most of the new POPs, the lessons learnt and data from international cooperation in this matter offer a unique opportunity to review existing approaches to the regulation and management of chemicals to meet the challenge of reducing the risk to the environment and to people from the multitude of harmful chemicals that continue to enter the environment in large amounts.

Box 3: Priorities and strategies in India's National Implementation Plan on Persistent Organic Pollutants

- Environmentally sound management and final disposal of PCBs
- Environmentally sound management of medical wastes
- Development and promotion of non-POPs alternatives to DDT
- Implementation of the best available technology and the best environmental practices and strategies for eliminating unintentional emissions of POPs from the priority industry sectors identified in the NIP
- Management of PVC plastic waste to avoid incineration or dumping into landfills to prevent the release of dioxins and furans due to burning
- Capacity building; demonstration of production and promotion of bio-botanical neem-derived bio-pesticides as viable, eco-friendly, and bio-degradable alternatives to POPs pesticides
- Identification of sites contaminated by POPs and of the remediation process at potential hotspots
- POPs and pesticides management in India
- Inventorization of newly listed POPs
- National POPs monitoring programme
- Strengthening of institutions and capacity building for effective and efficient implementation of the NIP in India

Research on persistent organic pollutants in India

A project titled *Climate-induced mobilization of POPs in the Ganges river*—funded and supported by The Research Council of Norway (RCN) and carried out by The Energy and Resources Institute (TERI), the Norwegian Institute of Water Research (NIVA), and the Regional Centre for Toxicology (RECETOX), the Czech Republic—turned up some noteworthy facts about the status of POPs in India. The methodology of this research study is shown in Figure 2 and the study area, in Figure 3. During the dry season, water from the melting of glaciers can be an influential secondary source of PCBs and high-molecular-weight polyaromatic hydrocarbons (PAHs) in the higher ranges of the Ganges, whereas in the middle ranges, sink processes – the settling of contaminated particles in the upper part of the floodplain course of the Ganges in particular – contribute to low exposure levels, especially

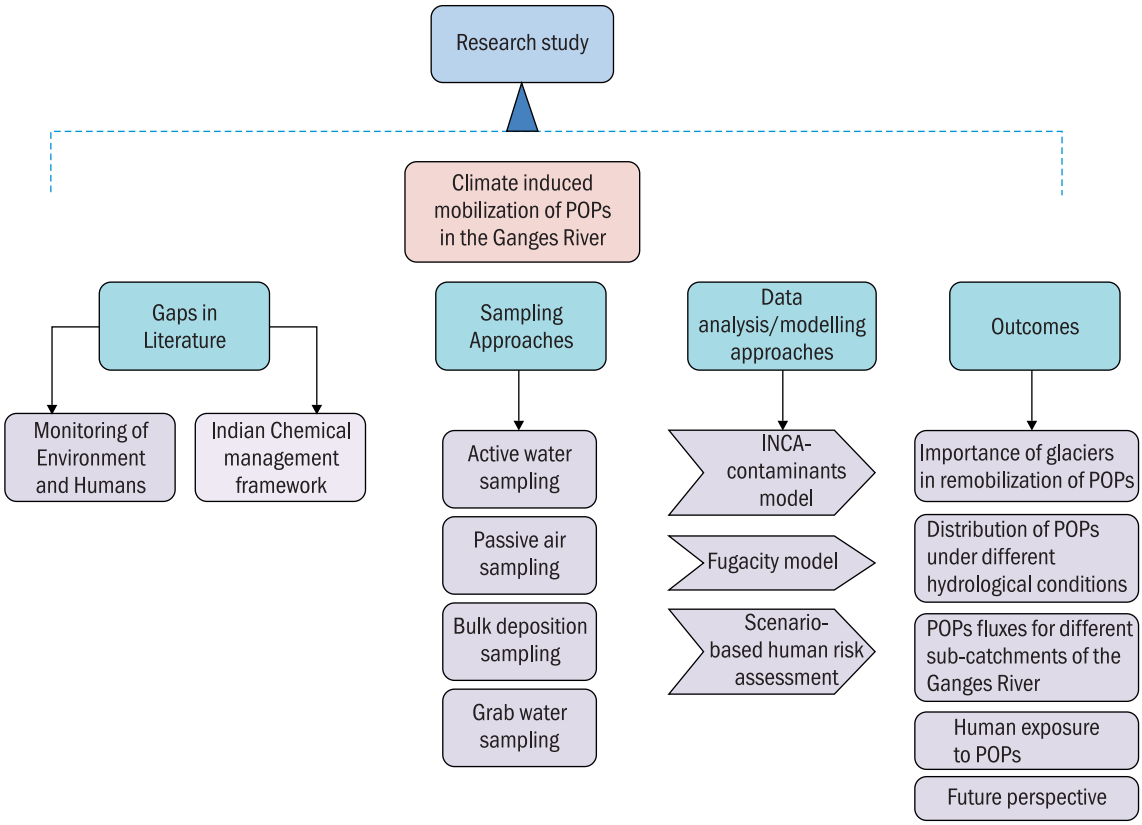
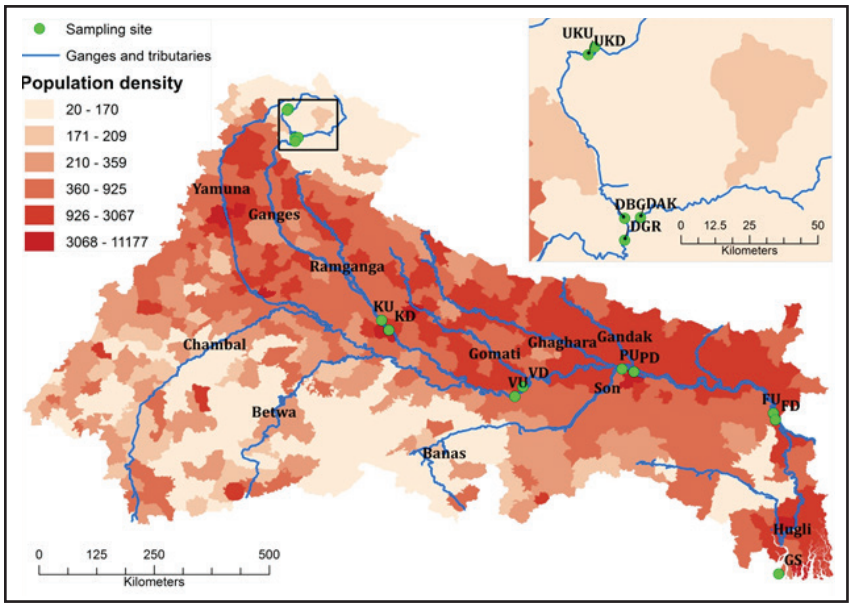


Figure 2: Methodology of the study titled Climate-induced mobilization of POPs in the Ganges river

in the case of less soluble compounds. Inputs from the rain-fed tributaries, at least during the dry season, do not compensate for these losses from the water stream and hence fail to dilute the contaminant loads. It is very likely that these results can be generalized for the whole of the Gangetic Plain during the dry season, because the Ganges receives glacier-fed tributaries throughout its course. Meltwater-derived inputs of PCBs and of high-molecular-weight PAHs are therefore expected to remain relevant even further downstream during periods



DAK = Devprayag Alaknanda
DBG = Devprayag Bhagirathi
DGR = Devprayag Ganga River
FD = Farakka downstream
FU = Farakka upstream
GS = Gangasagar
KD = Kanpur downstream

KU = Kanpur upstream
PU = Patna upstream
PD = Patna downstream
UKD = Uttarkashi downstream
UKU = Uttarkashi upstream
VD = Varanasi downstream
VU = Varanasi upstream

Figure 3: Sampling locations and population density (km^{-2}) in the Ganges basin. Top right: sampling locations in higher ranges magnified.

of drought. During the rainy season, the situation can obviously be very different. Heavy and continual rains dilute the glacial source, increase direct atmospheric depositions throughout the catchment, and lead to run-off of contaminants stored in the catchment soils. In addition, the changed flow of the river also mobilizes contaminated sediments, probably leading to a much higher contribution from diffuse sources compared to that from the melt. Nevertheless, water from glaciers is fundamental for many uses including drinking and food production during a large part of the year in northern India. These observations point to the importance of legacy chemicals as contaminants recycled from melting glaciers and emphasize that the source deserves serious consideration when analysing seasonal changes in the ecosystem and in human exposure to POPs in this region.

In the Gangetic Plain, which accounts for approximately 7% of the world's population, surface water –including the contribution from glaciers – is the main source of irrigation and drinking water. The sources of surface water face many threats including contaminants from urban, agricultural, and industrial effluents. Climate change, through melting of glaciers, increases exposure by recycling the pollutants accumulated in the ecosystem. Understanding the nexus between exposure and climatic or hydrological drivers may help to inform sound management and mitigation measures required to safeguard environmental and human health in this region.

Management of persistent organic pollutants in other countries

India's approach to the management of harmful chemicals, which consists mainly of restrictions and bans, is generally retrospective. The limitations of this approach are clear because it does not anticipate any uncontrolled risk, such as that from new substances entering the market, and relies instead on actions taken only *after* the impacts of those substances on people or on the environment become evident—which may take several decades, as in the case of POPs.

Modern tools for the management of chemicals, including the registration, evaluation, and authorization of chemicals (REACH), a tool deployed in the European Union (EU), acknowledge the reality that most of the problems from hazardous chemicals have changed from visible and incontestably local (pollutant-specific) problems to invisible, uncertain, and irreversible global risks. REACH is a unique piece of regulation consisting of four elements: 1) *registration* (collection of data on chemical use and toxicity), 2) *evaluation* (examination by governments of the need to add, test, and regulate chemicals), c) *authorization* of chemicals (mandatory prior permission to use chemicals of high concern), and 4) *restriction* (ban on chemicals that cannot be used safely).

Following the example of EU, formulating more effective policies for the management of chemicals in India will enquire greater interaction between decision-makers and the research community. Cooperation, communication, and knowledge transfer should greatly promote the process of building an integrated framework for sustainable management of chemical pollution.

The risk management approach adopted by REACH and other modern regulations offers an opportunity for the developing countries that have a sizeable chemical industry, such as India and China, to develop sustainable management of chemicals. In fact, China has already seized that opportunity: in 2010, the Chinese Ministry of Environmental Protection released a revised version of the provisions on environmental administration of new chemical substances that replaced the old regulations. The revised regulation is similar in structure to that of EU's REACH, and focuses on the development of a risk-based approach to chemical assessment along with schemes to identify or screen priority chemicals.

Lessons in the management of POPs and other toxic chemicals vary across geopolitical regions because of various factors such as the level of socio-political awareness and the stage of economic and industrial development. When POPs were in extensive use in many countries including India and USA, EU had already banned these chemicals, and comprehensive and scientifically updated regulations, such as the REACH, for the management of chemicals were already in place.

India's approach to the management of such chemicals is *retrospective* in that a chemical is not banned unless it is shown to be toxic—by the time a chemical is declared toxic, it is already in the market and has contaminated the environment and put people at risk. However, REACH, which came into force in 2007, represents a *proactive* approach to regulation based on the principle of risk management. India certainly needs such type of regulations in its management plan.

The EU's Water Framework Directive (2000/60/EC-WFD) is another important regulation pertaining to the protection of water resources and considered the most extensive European legislation on the prevention and management of water pollution so far. The Pesticide Authorization Directives (PAD) and the Directive on Sustainable Use of Pesticides complete the scheme of major regulations related to the management of chemicals in EU. The Directive 2009/128/EC aims to achieve a sustainable use of pesticides in the EU by reducing the risks and impacts of pesticide use on human health and the environment and promoting the use of Integrated Pest Management (IPM) and of alternative approaches or techniques, such as non-chemical alternatives to pesticides.

The International POPs Elimination Network (IPEN), established in 1998 is a non-profit organization in Sweden and is comprised of hundreds of participating organizations in over 100 countries, primarily developing and transition countries. IPEN brings together leading environmental and public health groups around the world to establish and implement safe chemical policies and practices that protect human health and the environment. IPEN raises the profile of sound chemicals management as an economic development strategy around the world and raises the profile of toxics issues previously not on the agenda for global attention, such as nanomaterials, endocrine disrupting chemicals, lead in paint, and toxic chemicals in the lifecycle of electronic products.

The Strategic Approach to International Chemicals Management (SAICM) is a global policy framework to foster the sound management of chemicals, which was adopted by the International Conference on Chemicals Management (ICCM) on 6 February 2006 in Dubai, United Arab Emirates. The SAICM Secretariat is hosted by the UNEP and it supports the achievement of the goal that, by the year 2020, chemicals will be produced and used in ways that minimize significant adverse impacts on the environment and human health. It acknowledges the essential contributions of chemicals in the current societies and economies, while recognizing the potential threat to sustainable development if chemicals are not managed soundly. The scope of SAICM includes:

1. Environmental, economic, social, health and labour aspects of chemical safety,
2. Agricultural and industrial chemicals, with a view to promoting sustainable development and covering chemicals at all stages of their life-cycle, including in products.

A key feature of the SAICM process is the engagement of all sectors of society with an interest in chemical safety, including environment, health, agriculture, labour, industry and development.

India and the Stockholm Convention

As a party to the Stockholm Convention, India developed its National Implementation Plan (NIP) to demonstrate its obligations to implement the convention. Successful implementation of the Stockholm Convention depends on assistance from international as well as local government, NGOs, and private partners. To develop the NIP, the Ministry of Environment, Forests and Climate Change works closely with a number of ministries and other agencies of the government including the Central Pollution Control Board (CPCB); the Ministry of Agriculture, which is the nodal ministry for dealing with pesticides; the Ministry of Chemicals and Fertilizers, of which the Department of Chemical and Petrochemicals is responsible for policy, planning, development, and regulations related to the chemical, petrochemical, and pharmaceutical industries; the Ministry of Power, which deals with PCBs in the power sector; the Ministry of Health and Family Welfare, which deals with the management of risk from chemicals in consumer products and foods; the health departments of state governments, which control the shipment, storage, and distribution of DDT authorized for use for public health purposes; and the Ministry of Science and Technology, through its research institutions. Although the situation on the ground of all twelve POPs was assessed during the preparation of the NIP, it has not been updated to include the new POPs added in the Stockholm Convention. The first NIP covers the period up to 2022.

Action plans to implement the NIP in India are divided into three components, namely (1) pesticides, (2) PCBs (3) dioxins and furans, and (4) contaminated sites and wastes.

Pesticides

3. Eliminate aldrin and dieldrin waste stocks.
4. Eliminate obsolete stocks of DDT.

5. Establish a management information system for regular reporting of DDT to the Stockholm Convention on POPs.
6. Develop and produce alternatives to POPs pesticides.
7. Develop and produce botanical alternatives to DDT.
8. Develop and produce biopesticidal alternatives, especially Bt-based biopesticides, to DDT.
9. Develop and produce chemical alternatives to DDT.
10. Develop and produce alternatives pesticides to dicofol.
11. Dispose of DDT packaging material in an environmentally sound manner.

PCBs

1. Strengthen the policy and regulatory framework to comply with the obligations under the Stockholm Convention.
2. Build national capacity in institutional management of PCBs.
3. Dispose of 1700 tonnes of pure PCBs and 6000 tonnes of equipment contaminated with PCBs by the end of 2015 to start with, out of 9837 tonnes of PCBs and PCB-containing oils and a corresponding inventory of PCB-contaminated equipment and wastes.
4. Continue updating the nationwide inventory of transformers and capacitors in use that contain PCBs as well as of similar articles in the non-power sectors.
5. Manage PCBs and PCB-contaminated equipment and wastes.
6. Monitor PCB levels in soil, water, and sediment.
7. Monitor PCB levels in food crops, aquatic fauna, poultry, animal feed, and higher mammals including human beings.
8. Monitor sites contaminated with PCBs and undertake measures for the remediation of such sites.
9. Undertake research and development of (a) vegetable or synthetic liquids and (b) technology for environmentally sound management of PCBs and their destruction.

Dioxins and furans

1. Strengthen existing policies and regulations with regard to unintentional releases of POPs.
2. Inform, educate, and raise the awareness of the general public.
3. Augment analytical infrastructure for monitoring dioxin and furans released from the source categories listed in Part II and Part III of Annex C.
4. Upgrade and continue updating the inventory of unintentional POPs using indigenously developed tools to measure unintentionally produced POPs (UP-POPs) and estimate, using the upgraded tools, the current and projected releases more reliably.
5. Identify, based on more the realistic estimates, strategies to meet the obligations to reduce the amounts of UP-POPs being released.
6. Promote the application of available, feasible, and practical measures to discharge the above obligations and to eliminate sources of pollution.
7. Promote the development and use of substitute or modified materials, products, and processes to prevent the release of Annex C chemicals.
8. Promote and adopt best-available technologies and best environmental practices for new installations of industrial sources listed in Part II of Annex C.
9. Promote best-available technologies and best environmental practices for existing installations of industrial sources listed in Part II and III of Annex C.
10. Review every five years the strategies for reducing the amounts of UP-POPs being released and report such reductions regularly.

Contaminated sites and wastes

1. Ensure total disposal of obsolete stocks of aldrin and dieldrin in regional plant protection and quarantine station (RPPQS) in Mumbai; in Barmer, Bikaner, Sikar, Jaisalmer, and Kota in Rajasthan; in Imphal in Manipur, and in Palampur in Gujarat.
2. Initiate measures to contain and clean PCBs in the ship-breaking industry in Alang, Gujarat.
3. Enhance and continually update and upgrade the national inventory of POPs stockpiles and wastes.
4. Ensure secure storage of PCBs and equipment and wastes contaminated with PCBs in power generation or distribution units, industrial plants, and transformer repair sites to prevent further contamination of the environment.

5. Strengthen institutional capacities to undertake on large scale preventive measures required for the management of POPs being released from stockpiles and wastes.
6. Enhance the quality of temporary storage of DDT at various application sites wherever considered appropriate.
7. Wherever feasible, provide dedicated transport facilities for carrying DDT.
8. Develop policy and legal frameworks for the management of contaminated lands or sites.
9. Strengthen institutional capacities to mitigate the risk from contaminated sites.
10. Identify and accord priority to dealing with sites that are likely to be contaminated.
11. Select appropriate, low-cost, and environmentally sound technologies for remediation.
12. Undertake remediation of selected contaminated sites.

Critical action points

Recognizing the importance of regulating the use, manufacturing, and import of POPs and other toxic chemical substances, the Government of India supports capacity building and provides technical assistance. Besides the Stockholm Convention (to control and/or ban POPs), India is signatory to several other international treaties such as the Basel Convention (to manage transboundary movements of hazardous wastes) and the Rotterdam Convention (to provide prior informed-consent procedures for certain chemicals and pesticides in the chemical trade). As part of implementing international treaties and conventions, India has enacted about 35 pieces of legislation to manage POPs and similar toxic substances, which fall under the responsibility of various ministries. These regulations cover various aspects of the management of POPs including

- import and export,
- manufacture,
- transport, and the
- protection of environment and human health.

The ultimate goal of all such regulations is to ensure safe circulation, use, and disposal of chemicals and to empower each of the authorities responsible for dealing with the various chemicals to ban them or to restrict their use. Although various regulations that ban or control the use of POPs are in place, high levels of residues of POPs were detected in the environment and in people along the Ganges (Sharma et al. 2014a, 2014b; Sharma et al. 2015a, 2015b). This indicates that the current regulations in India have failed to keep up with the economic development of the country and need to be updated. Future policies to manage POPs and other toxic bio-accumulative chemicals in India have to consider the lessons from past incidents and be revised accordingly.

Policy recommendations

The following are the recommendations to the Government of India related to the articulation of policies related to the management of chemicals.

- Update India's National Implementation Plan (the current version is more of an inventory of POPs rather than guiding policies, regulations, and measures).
- Establish a dedicated strategic framework for the management of POPs.
- Compile details of the sources of POPs and other similar contaminants on priority as part of the environmental agenda of the country.
- Undertake systematic catchment-scale monitoring of pollution levels and the impacts of pollution on health.
- Monitor the concentration of POPs in the Himalayan region.
- Monitor POPs in human population adopting the epidemiological approach and using mother–child cohorts.

- Focus more on POPs newly added to the existing list of POPs covered by the Stockholm Convention in the monitoring programmes.
- Catalogue possible ways to phase out and tackle the new POPs.
- Involve the public (this was one of the key strategies in the EU to ensure sustainable use of pesticides).
- Adopt green chemistry.
- Undertake capacity building and see cross-boundary collaboration to do so.
- Upgrade analytical tools at the national level.
- Establish a separate cell for monitoring and follow-up of POPs in the environment.

Conclusion

India has a comprehensive apparatus of environmental laws. However, the lack of an integrated approach to the regulation of chemicals, poor management of pollution, and the fundamentally retrospective vision have resulted in ineffective implementation of the laws as demonstrated by the example of POPs in the environment.

Modern regulations on the management of chemicals, such as the EU REACH, are developed not only to mark the boundary of substances used but also to define new spaces for the markets of chemical substances within the overall frame of sustainable development: players unable to meet the demands from these markets will be eventually forced to leave them. India, as an industrial and technologically advanced nation in many fields, cannot afford to be an outsider in this area of scientific, technological, and policy development. The retrospective approach to pollution management needs to be replaced with that based on risk management, with policies formulated in the light of scientific knowledge, and the large but fragmented network of acts, laws, rules, etc. should be replaced with a unique, integrated, and holistic system supported by clear mandates for a limited number of designated authorities. The capacity to undertake scientific investigations and to monitor environmental pollution and its impacts need to be expanded to fill the gap in this regard found in the developing countries. Investment to attain environmental quality that meets international standards with reference to the levels of toxic chemicals has to be regarded as a national priority for India; combining such investment with international cooperation can be a fundamental tool to remove quickly the current defects in risk management and environmental quality.

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