Vol 3 Issue 5 June 2013

ISSN No : 2230-7850

Monthly Multidisciplinary Research Journal

Indian Streams Research Journal

Welcome to ISRJ

RNI MAHMUL/2011/38595 **ISSN No.2230-7850**

Indian Streams Research Journal is a multidisciplinary research journal, published monthly in English, Hindi & Marathi Language. All research papers submitted to the journal will be double - blind peer reviewed referred by members of the editorial Board readers will include investigator in universities, research institutes government and industry with research interest in the general subjects.

Address:-Ashok Yakkaldevi 258/34, Raviwar Peth, Solapur - 413 005 Maharashtra, India
Cell : 9595 359 435, Ph No: 02172372010 Email: ayisrj@yahoo.in Website: www.isrj.net

Indian Streams Research Journal
Volume 3, Issue. 5, June. 2013
ISSN:-2230-7850
Available online at www.isrj.net
ORIGINAL ARTICLE

CHALLENGING THE FATE OF PERSISTENT ORGANIC POLLUTANTS

NEELU SINGH AND VARTIKA SINGH
National Centre For Antarctic and Ocean Research, Goa
Birbal Sahni Insitutte of Palaeobotany , Lucknow

Abstract:

The green revolution beginning during the late 1960s resulted in a quantum jump in agriculture production the world-over. Indiscriminate and inappropriate use of chemical fertilizers and pesticides to boost the agriculture production has done more harm to the environment and especially to the human health than could have been envisaged when they were first introduced. Persistent Organic Pollutants (POPs) concentrate on different forms this is one of the characteristics which has earned them the sobriquet of pollutants. In this article, we review the present nature of our knowledge on the POPs in India as well as internationally including the response of our country towards POPs convention. The article also highlights the need for a holistic research on the source-to-sink aspects of these compounds.

KEYWORDS:

POPs , Gloal Distribution, Polar Region

INTRODUCTION:

Persistent Organic Pollutants (POPs): A Background

Persistent Organic Pollutants (POPs) are chemical substances that originate from man-made sources associated with the production, use, and disposal of certain organic chemicals, produced commercially for pest and disease control, crop production and industrial use. Some of the POPs such as pesticides and polychlorinated biphenyls (PCBs) are intentionally produced, while others such as dixion and furans are unintentional by-products of industrial processes or result from the combustion of organic chemicals. As their name indicates, POPs share four common properties:

Properties	Specification
Persistence	1. The half-life of the chemical in water is greater than two months, or the half life in sediment and soil are greater than six months. 2. Other evidence that the chemical is sufficiently persistent to justify its consideration.

Bioaccumulation	1. Evidence that the bioconcentration factor or bioaccumulation factor in aquatic species is greater than 5000. 2. The logarithm of the octanol -water partition coefficient (Log K_{ow}) is greater than 5.
Potential for long range environmental transport	1. Measured levels of the chemical in locations distant from the sources of its release that are of potential consideration. 2. Monitoring Data showing that long range environmental transport of the chemical, with the p otential for transfer to a receiving environment, may have occurred via air, water, or migratory species. 3. Environmental fate properties demonstrate that the chemical has a potential for long –range environmental transport through air, water or migratory species. 4. The half-life in air is greater than two days.
Adverse Effect	1. Evidence of adverse effect to human health or to the environment that justifies considerations 2. Toxicity or eco -toxicity data that indicate the potential for damage to human health or to the environment.

Table1: Identification criteria of Stockholm Convention for POPs (UNEP, 2001; http://irptc.unep.ch/pops/) [1]

The above characteristics of the POPs are precisely what make these compounds so dangerous, with the long-range transport of these substances to regions where they have never been used or produced and the consequent threats they pose to the environment of the whole globe. The international community has now, at several occasions called for urgent global actions to reduce and eliminate releases of these chemicals. The first step in this direction was the signing of the Stockholm Convention on Persistent Organic Pollutants in May 2001 by many countries. The Convention identified a list of 12 POPs on the basis of their unique and different characteristics (summarized in Table 1) and put them on priority for global restriction and ban in order to limit their impacts over the global environment

The Stockholm convention on Persistent Organic Pollutants came into force on 17th May2004. In 2004 12 POPs were listed in annexes 2 to the convention and termed as 'Dirty Dozen'. To date twenty one chemicals (12 initial 3 and 9 new 4) have been recognized as POPs which are causing adverse effect on humans and the ecosystem. These 21 POPs can categorized in three category: pesticides, industrial chemicals and by-products (Table 2)

Categories	Initial 12 POPs	Nine new POPs
Pesticides	Aldrin Chlordane, Dieldrin, Endrin, Heptachlor, Hexachlorobenzene (HCB), Mirex, Toxaphene, DDT	Chlordecone, α -Hexachlorocyclohexane, β-Hexachlorocyclohexane, Lindane, Pentachlorobenzene
Industrial Chemicals	Polychlorinated biphenyls (PCBs) and HCB	Hexabromobiphenyl, Hexabromodiphenyl ether and Heptabromodiphenyl ether, Pentachlorobenzene, Perflourooctane sulfonic acid, its salts and Perflourooctane sulfonyl fluoride, Tetrabromodiphenyl ether and Pen tabroodiphenyl ether
By-Products	Polychlorinated dibenzo -p-dioxins (dioxins), Dibenzofurans (furans)	α-Hexachlorocyclohexane, β-Hexachlororcyclohexane and Pentachlorobenzeze

Table 2 Chemicals currently listed as POPs in the Stockhlom Convetion [5]

Sources and Global Distribution Mechanisms of POPs

Globally, chemicals are used by all major industrial sectors. A number of these chemicals are POPs that are released intentionally or unintentionally into the environment through various anthropogenic sources for example, from incinerator stacks to air, as industrial discharges to rivers, as pesticides sprayed onto crops and soil and as losses from a variety of consumer products, by-product of combustion etc. (Table 3)

Categories	Sources
Pesticides	- Agricultural spraying for soil and crop pests - Spraying/ land application (e.g., disease vector control, livestock)
Industrial Chemicals (PCBs and HCB)	Solid waste incineration - Sewage sludge - Ship breaking industry

By-products (dioxins ,furans and PCBs)	-By-products in manufacture of pesticides and industrial chemicals -Industrial, thermal and medical incineration processes - Transportation systems -Biomass burning -Forest fires/other wood combustion - Sewage sludge

Table 3: Sources of POPs

POPs can be encountered in the Gas phase, in association with the atmospheric particles or distributed according to their semi volatile characteristics (Pv between 10 –4 and 10 –11 atm at 25o C)6 .Physico-chemical properties such as temperature govern their environmental fate in the atmosphere. Low temperature affects vapour pressure and Henry's law constant of these compounds, while increase temperature affects their tendency to condense and accumulate in surfaces like atmospheric particles, soils, vegetation, and aquatic ecosystems, from where they can enter into the food chains 1. Different POPs on the basis of their volatility condense at different ambient temperatures which results their fractionation in the Earth 7.

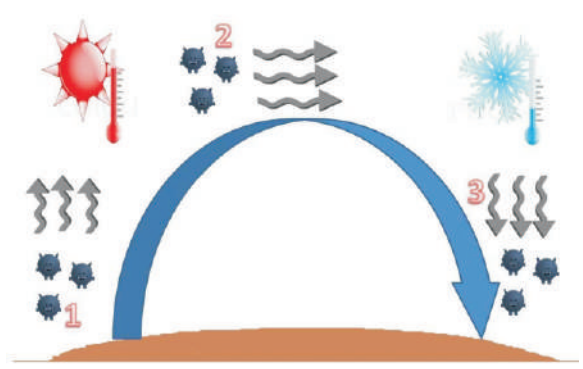


Fig 1: Evaporation Transportaion and Depostion of POPs at Low and High Temperature [7]

When POPs enter the atmosphere, they can be carried with wind currents and transported within a specific region and across international boundaries transferring among air, water and land 2. POPs make their way into and throughout the environment through a cycle of long-range atmospheric transportation, deposition, revolatilization, collectively called the “grasshopper” or the “global distillation” processes 8. Through atmospheric processes POPs condense out of the atmosphere whenever the temperature drops, eventually reaching highest concentrations in circumpolar countries and deposited onto land or into water ecosystems where they accumulate and cause potential damage[3] .

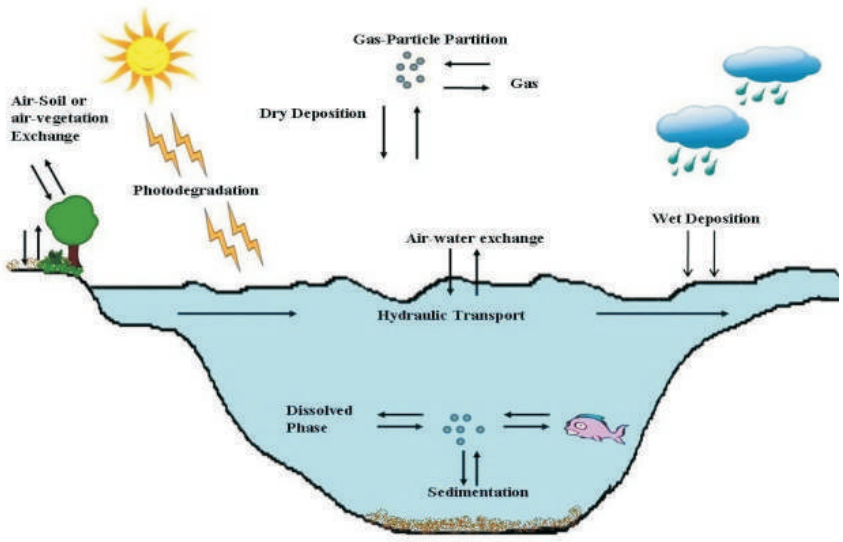


Fig 2 : POPs pathway for movement within the ecosystem [6]

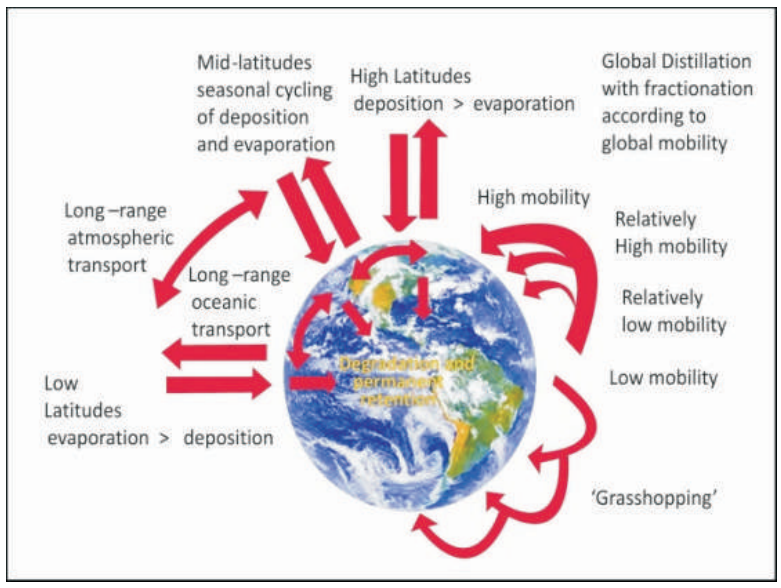


Fig 3: Transportation of Pollutants through Global Distillation Process [39]

POPs in Polar Region:

Polar Region's environments are among the most extreme on the planet, with limited sunlight, extreme temperatures, short growing seasons, sea ice, snow cover, glaciers, tundra and permafrost. Polar regions were considered to be pristine until the contamination by anthropogenic compounds was documented in the 1960s and 1970s9,10 . Since then, there is a continuing concern about the potential effects of POPs on polar environments. Concentration of POPs in soil, sediment, water, air, snow and in biotic samples of different segment has been detected by various scientists and proves their presence in remote Polar Regions - Arctic and Antarctic. Arctic is frozen sea surrounded by continents and Antarctic is a snow covered continent surrounded by ocean. POPs can reach Antarctica only via the transport of air mass as it is isolated by Southern Ocean. While in Arctic they can reach by air mass and also via water current.

Polar Regions are exposed to persistent organic pollutants (POPs) through long-range atmospheric transport by 'global distillation' process, thousands of kilometres far from their original source of release. According to global distillation process POPs ultimately accumulates in the Polar Regions due to the low temperatures and winter darkness. The polar ice caps serve to prevent air-water exchange of

gaseous pollutants and the major removal pathway of pollutants in surface ice is via transport to lower layers of the ice cap. Ice can entrap POPs for a longer period and release them in the environment through ice melting where they enter the trophic webs, bioaccumulate in the tissues of organisms, and biomagnify[11]

Adverse effect of POPs on human health and wildlife

Food intake is the most common route of exposure to most humans. A number of populations whose diets are mainly fish, shellfish, or wild foods etc which are high in fat and locally obtained, is at particular risk of POPs exposure12. Indigenous populations, inhabiting Arctic and sub-Arctic regions are good example of this kind of exposure because they are mainly depend on Arctic marine mammals as a major food source. Because of their food habit indigenous population are one of the most at risk groups for long-term POP-related illnesses (Arctic Council 2004)13. Various studies proved that POPs are very harmful and dangerous for human health. These include effects on the nervous system, problems related to reproduction and development, cancer, and genetic impacts etc.

POPs in biota can accumulate upto higher levels even though there environmental exposures are very less. POPs enter into the food chain of aquatic environment through active uptake of POPs contaminated particulate matter by filter-feeders and plankton14 and make their way upward, step by step, until they reach at elevated concentrations in the largest predators, such as whale, polar bears and humans. POPs concentration in tissue can increase or biomagnify at each level of the food chain, because it takes more time to degrade/ metabolize the concentration. That is why top predators may have a million times greater concentrations of POPs than the water itself. Biologists have recorded health effects on individuals at the upper end of the food chain, with cases of low fertility, immune deficiency, disruptions to the endocrine system, genetic mutations (genotoxic effect) and malformations etc15 (Table 3)

Category	Chemical	Adverse effect
Pesticides	Aldrin	Carcinogenic, Malaise, Dizziness and Nausea
	Chlordane	Carcinogenic
	DDT	Cancer of Liver, immune system
	Dieldrin	Liver and Biliary cancer
	Endrin	Cancer
	Heptachlor	Cancers, mutation, birth defects, foetal and embryo toxicity, nervous disorder, liver disease
	Mirex	Acute toxicity, possible cancer
	Toxaphene	Carcinogenic , chromosome abreactions chromosome abreactions, liver and kidney problem
Industrial Chemicals	PCBs	Cancers mutations, birth defects, foetal and embryo toxicity, neurological disorder and liver damage
Byproducts	Dioxin	Peripheral neuropathics, fatigue, depression and liver problem, embryo toxicity
	Furan	Peripheral neuropathies, embryo toxicity, liver problem

Table 4: Adverse effect of POPs Source: UNEP 2000; The World Bank A CIDA 2001[16,17]

POPs in India:

India as a developing country with a population over one billion, faces many problems related to the environmental issues. Rapidly growing population of India along with a move towards urbanization and industrialization has placed significant pressure on India's infrastructure and its natural resources. Since ancient times the population of India depended mainly on agriculture. Human lifestyle gradually changed after independence, 1947 and new sources of income were searched for better survival. With the cooperation of government from 1981 and last three decades Indian private firms or industries increased vastly18. This fast growing industrialization has lead to lots of environmental issues by its uncontrolled emissions.

The rapid increase in economy, industrialization, deforestation, use of insecticides and pesticides for agriculture, rampant burning of fossil-fuel and other have led to the degradation of the quality of the environment and human health in India.

India is one of the few remaining countries who are still engaged in the large scale manufacture, use and export of some of the POPs such as organo chlorinated pesticides19 for agriculture and public health programs. These chemicals were banned in the late 1990's for agriculture practices but still substantial amount are still being used to decimate the vector borne diseases such as malaria and filarial[20].

More than past two decades various scientists of India noticed temporal and spatial trends of contamination in the environmental and biotic samples including human matrices by the POPS such as such as dichlorodiphenyltrichloroethane (DDT), hexachlorocyclohexanes (HCHs), chlordanes (CHLs), hexachlorocyclohexane (HCB) and PCBs. These contaminants are detected in many sectors – air, water, sediment21-29, biota and humans 30-35 .

The Indian response to POPs:

India has signed the Convention on 14th of May, 2002 and ratified it on the 13th of January, 2006. It came into force on 13th April, 200636. The Government of India (GOI) has expressed its strong interest to play a role as a Party to the Stockholm Convention. The Ministry of Environment and Forests (MOEF), GOI is the nodal agency for planning, promoting and coordinating environmental programmes in India. In all compartments-air, water and soils, POPs show considerable contamination even though they are banned in country. DDT and dieldrin have been detected in several soil sediment samples indicating the possibility of pilferage from agricultural use, run off from the soil and have eventually been detected in water and sediments.

Most of the POP pesticides in India are legally restricted/ banned from use, production and import. India has registered specific exemption on DDT for acceptable purposes for Disease Vector control only as per World Health Organisation (WHO) guidelines till viable alternatives are found[37]

The identified sources of POPs in India include production units, stockpiles of obsolete pesticide stocks. Except for DDT, which continues to be used in vector control seven other pesticide POPs listed in the Stockholm Convention are banned for manufacture and use in the country. However, stockpiles of unused POPs are a cause of concern mainly because in many places they still remain unidentified38.

CONCLUSION:

Even though the use of chemicals in the agricultural and industrial sector has had a positive influence on the world food production and its availability, disease control and other conveniences, paradoxically, the very same chemicals are now threatening to wreak havoc on the environment, wildlife, and human health across the globe. POPs that have been stored in sink of soil, water and ice are released back into the atmosphere through the melting of the ice which is induced by climate change. Once released back into the atmosphere the POPs can be carried far and wide on the wind and ocean circulation systems, potentially causing ripple effect worldwide. And if they re-enter the food chain and start bioaccumulating once again, the results could be disastrous for wildlife and humans.

To understand and fulfil the knowledge gaps further efforts are needed to solve the questions like, how climate change affects the fate of POPs which are cycling in our ecosystem and stored in glacier and ice caps ? Are they release from primary sources or they are the result of re-volatilization process induced by climate change? What other alternatives can be used to replace harmful POPs which are still directly or indirectly in use to increase the growth of crops and to control the disease.

REFERENCES

1.http://chm.pops.int/Convention/ThePOPs/The12InitialPOPs/tabid/296/Default.aspx
2.Stockholm Convention ;
http://chm.pops.int/Convention/ThePOPs/TheNewPOPs/tabid/2511/Default.aspx
3.Fernández, P. and Grimalt, O.J., On the Global Distribution of Persistent Organic Pollutants. Chimia,

2003, 57, 514–521.
4.Persistent Organic Pollutants: Northwest terrotries contaminats fact sheets http://www.aadnc-aandc.gc.ca/DAM/DAM-INTER-NWT/STAGING/text/ntr_pubs_pop_1330463522734_eng.pdf
5.The North American Mosaic: An Overview of Key Environmental Issues. Persistent Bioaccumulative Toxic Substances ; http://www.cec.org/Storage/32/2361_SOE_PBTs_en.pdf
6.Corosolini, S., Kannan, K., Imagawa, T., Focardi, S. and Giesy, P. J., Polychloronaphthalenes and Other Dioxin-like Compounds in Arctic and Antarctic Marine Food Webs. Environ. Sci. Technol, 2002, 36, 3490-3496.
7. Risebrough, W. R., Walker II, W., Schimdt, T.T., De Lappe, W.B. and Connors W. C., Transfer of chlorinated biphenyls to Antarctica. Nature., 1976, 264, 738 – 739.
8. Fuoco, R., Colombini, M. P., Abete C., Evaluation of pack melting effect on polychlorobiphenyl content in sea water samples from Terra Nova Bay - Ross Sea (Antarctica). Ann Chim , 1991, 383-394.
9.Persistent Organic Pollutants: A Global Issue, A Global Response
http://www.epa.gov/international/toxics/pop.html
10. Draft Fact Sheet: Persistent Organic Pollutants (POPs). Arctic Council, 2004; http://www.arctic-council.org/acap_pop.asp
11. Thomas, K.B., Colborn, T., Organochlorine endocrine disrupters in human tissue. In: Colborn, T., Clement, C. (Eds.), Chemically-Induced alterations in sexual and functional development: The wildlife:human connection. Princeton Sci. Pub, 1992, 365–394.
12. Persistent Pollutants in the Polar regions sheet n°20; www.educapoles.org
13. The World Bank and CIDA. 2001. Persistent Organic Pollutants and the Stockholm Convention: A Resource Guide. Washington, DC: CIDA. 2001
14. United Nations Environmental Program (UNEP). 2000. Report of the Intergovernmental Negotiating Committee for an International Legally Binding Instrument for Implementing International Action on Certain Persistent Organic Pollutants on the Work of its Fifth Session, Geneva: UNEP/POPS/INC.5/7.
15. Indian Pollution;http://www.indyatour.com/india/environment/indian_pollution.php
16. Santillo, D., Johnston, P., Stringer, R.,A catalogue of gross contamination: Organochlorine production and exposure in India. Pesticides News, 1997, 36, 4-6.
17. Subramanian, A. and Tanabe, S., Temporal and spatial variations of persistent organic pollutants in Indian brest milk. Envis Centre Newsletter, 2009.
18.Kumarasamy, P., Govindarai, S., Vignesh, S., Rajendran B. R., James A. R. Anthropogenic nexus on organochlorine pesticide pollution: a case study with Tamiraparani river basin, South India. Envi. Moni. and Assess, 2012, 184, 3861-3873
19.Guzzella, L., Roscioli, C., Vigano, L., Saha, M., Sarkar, S. K., Bhattacharyya, A. Evaluation of the concentration of HCH, DDT, HCB, PCB and PAH in the sediments along the lower stretch of Hugli estuary, West Bengal, northeast India. Environ. Internatl., 2005, 31, 523-534.
20.Zhang, G., Chakraborty, P., Li, J., Sampathkumar, P., Balasubramanian, T., Kathiresan, K., Takahashi, S., Subramanian, A., Tanabe, S., Jones, K. C. Passive atmospheric sampling of organochlorine pesticides, polychlorinated biphenyls, and polybrominated diphenyl ethers in urban, rural, and wetland sites along the coastal length on India. Environ. Sci. Technol.,2008, 42, 8218-8223.
21.Chakraborty, P., Zhang, G., Li, J., Xu, Y., Liu, X., Tanabe, S. and Jones, K. C. (2010).Selected Organochlorine Pesticides in the Atmosphere of Major Indian Cities: Levels, Regional versus Local Variations, and Sources. Environ. Sci. Technol., 2010, 44, 8038–8043.
22. Chakraborty p., Zhang G., Li Jun., et al. Selected organochlorine pesticides in the atmosphere of major Indian cities: levels, regional versus local variations, and sources. Environ. Sci. Technol., 2010, 44 (21), pp 8038–8043
23.Kumar, B., Lal, R. B., Kumar, S., Sharma, C. S., Mukherjee, D. P. Monitoring of pesticide residues (DDT, HCH & endosulphan) in cauliflower from West Bengal (India). Der Pharma Chemica, 2011, 3, 89-96.
24. Devi, N. L., Qi, S., Chakraborty, P., Zhang, G. and Yadav, I. C. (2011). Passive air sampling of organochlorine pesticides in a northeastern state of India, Manipur. Journ. Environ. Sci., 2011, 23, 808-815.
25. Mukherjee, D. P., Kumar, B., Kumar, S., Mishra, M., Gaur, R., Prakash, Dev, Singh, S. K. and Sharma, C. S. Occurrence and distribution of pesticide residues in selected seasonal vegetables from West Bengal. Arch. of Appl. Sci. Res., 2011, 3, 85-93.
26.Pozo, K., Harner, T., Wania, F., Muir, D. C. G., Jones, K. C., Barrie, L. A. Toward a global network for persistent organic pollutants in air: results from the GAPS Study. Environ. Sci. Technol., 2006, 40, 4867–4873.

27. Senthil Kumar, K., Kannan, K., Subramanian A. N. and Tanabe, S. Accumulation of persistent organochlorine pesticides and polychlorinated biphenyls in sediments, aquatic organisms, birds, bird eggs, and bat collected from South India. Environ. Sci. Poll Res., 2001, 8, 35-47.
28. Mishra, M., Kumar B., Akolkar P., Sharma C. S. and Makhijani S.D. (2008). Study on organochlorine pesticides in body tissue of invertebrates collected using artificial substratum from water sources in and around Delhi, India. Organohalogen Compounds., 2008, 70, 1784-1786.
29. Devanathan, G., Subramanian, A., Someya, M., Sundaryanto, A., Isobe, T., Takahashi, S., Chakraborty, P. And Tanabe, S. Persistent organochlorines in human breast milk from major metropolitan cities in India. Environ Pollutn., 157, 148-154.
30. Someya, M., Ohtake, M., Kunisue, T., Subramanian, A., Takahashi, S., Chakraborty, P., Ramachandran, R.,Tanabe, S. (2009). Persistent organic pollutants in breast milk of mothers residing around an open dumpsite in Kolkata, India: specific dioxin-like PCB levels and fish as a potential source. Environ Intern, 2009, 36, 27-35.
31. Kumar, B. and Mukherjee, D. P. Organochlorine residues in vegetables. Int. J. Veg. Sci, 2012, 18, 121-136.
32. Kumar, B., Kumar, S., Goel, G., Gaur, R., Mishra, M., Singh, S. K., Dev Prakash, Chakraborty P., and Sharma, C. S. Distribution of polychlorinated biphenyls in agricultural soils from NCR, Delhi, India. Annals Biol. Res., 2011, 2, 247-254.
33. National Implementation Plan Stockholm Convention on Persistent Organic Pollutants: Government of India; 2011, http://envfor.nic.in/
34. National Implementation Plan Stockholm Convention on Persistent Organic Pollutants: Government of India; 2011, http://envfor.nic.in/
35. Country Situation on Persistent Organic Pollutants (POPs) in India International POPs; www.ipen.org
36.Wania F. and Mackay, D. Tracking the distribution of persistent organic pollutants. Environ.Sci.Technol., 1996, 30, 390-396.

Table and Figure:

Properties	Specification
Persistence	1. The half-life of the chemical in water is greater than two months, or the half life in sediment and soil are greater than six months. 2. Other evidence that the chemical is sufficiently persistent to justify its consideration.
Bioaccumulation	1. Evidence that the bioconcentration factor or bioaccumulation factor in aquatic species is greater than 5000. 2. The logarithm of the octanol -water partition coefficient (Log K_{ow}) is greater than 5.
Potential for long range environmental transport	1. Measured levels of the chemical in locations distant from the sources of its release that are of potential consideration. 2. Monitoring Data showing that long range environmental transport of the chemical, with the potential for transfer to a receiving environment, may have occurred via air, water, or migratory species. 3. Environmental fate properties demonstrate that the chemical has a potential for long –range envi ronmental transport through air, water or migratory species. 4. The half-life in air is greater than two days.

Adverse Effect	1. Evidence of adverse effect to human health or to the environment that justifies considerations 2. Toxicity or eco -toxicity data that indicate the potential for damage to human health or to the environment.

Table1: Identification criteria of Stockholm Convention for POPs (UNEP, 2001; http://irptc.unep.ch/pops/)

Categories	Initial 12 POPs	Nine new POPs
Pesticides	Aldrin Chlordane, Dieldrin, Endrin, Heptachlor, Hexachlorobenzene (HCB), Mirex, Toxaphene, DDT	Chlordecone, α-Hexachlorocyclohexane, β-Hexachlorocyclohexane, Lindane, Pentachlorobenzene
Industrial Chemicals	Polychlorinated biphenyls (PCBs) and HCB	Hexabromobiphenyl, Hexabromodiphenyl ether and Heptabromodiphenyl ether, Pentachlorobenzene, Perflourooctane sulfonic acid, its salts and Perflourooctane sulfonyl fluoride, Tetrabromodiphenyl ether and Pentabroodiphenyl ether
By-Products	Polychlorinated dibenzo-p-dioxins (dioxins), Dibenzofurans (furans)	α-Hexachlorocyclohexane, β-Hexachlororcyclohexane and Pentachlorobenzeze

Table 2 Chemicals currently listed as POPs in the Stockhlom Convetion [5]

Categories	Sources
Pesticides	- Agricultural spraying for soil and crop pests - Spraying/ land application (e.g., disease vector control, livestock)

Industrial Chemicals (PCBs and HCB)	Solid waste incineration - Sewage sludge - Ship breaking industry
By-products (dioxins ,furans and PCBs)	-By-products in manufacture of pesticides and industrial chemicals -Industrial, thermal and medical incineration processes - Transportation systems -Biomass burning -Forest fires/other wood combustion - Sewage sludge

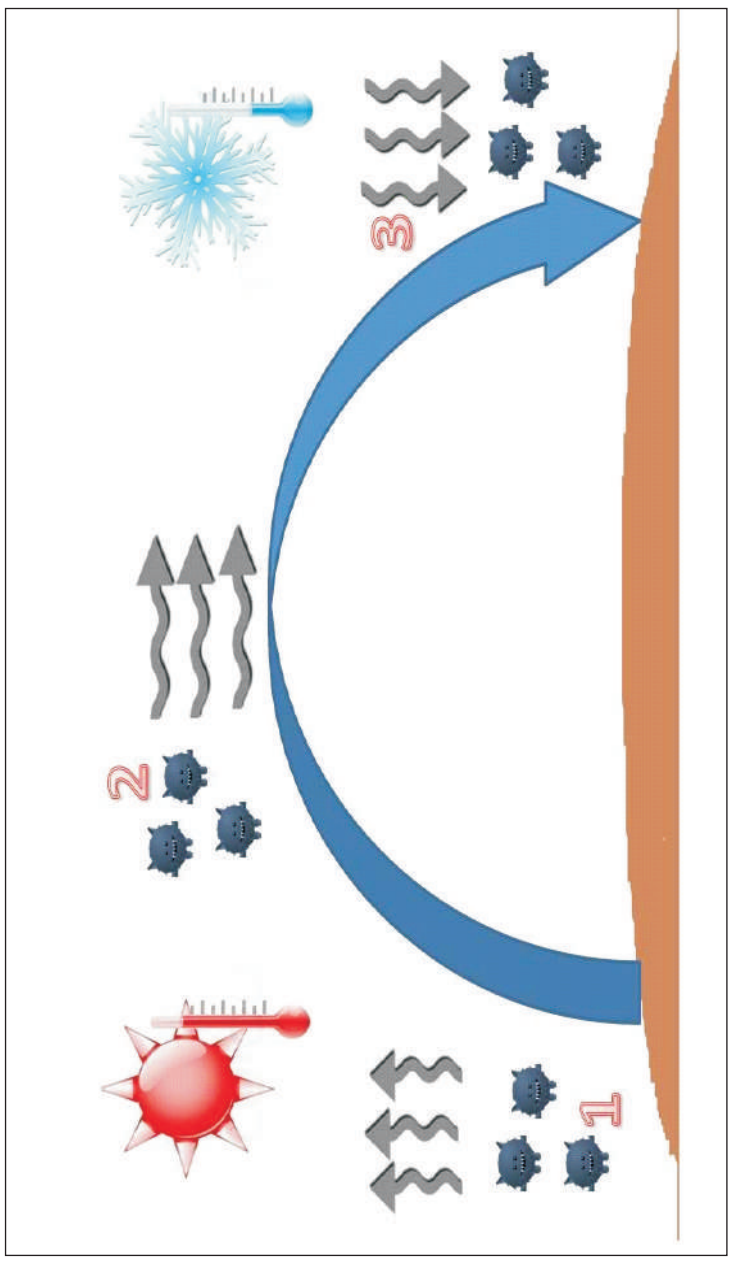
Table 3: Sources of POPs

Category	Chemical	Adverse effect
Pesticides	Aldrin	Carcinogenic, Malaise, Dizziness and Nausea
	Chlordane	Carcinogenic
	DDT	Cancer of Liver, immune system
	Dieldrin	Liver and Biliary cancer
	Endrin	Cancer
	Heptachlor	Cancers, mutation, birth defects, foetal and embryo toxicity, nervous disorder, liver disease
	Mirex	Acute toxicity, possible cancer
	Toxaphene	Carcinogenic , chromosome abreactions chromosome abreactions, liver and kidney problem

Industrial Chemicals	PCBs	Cancers mutations, birth defects, foetal and embryo toxicity, neurological disorder and liver damage
Byproducts	Dioxin	Peripheral neuropathics, fatigue, depression and liver problem, embryo toxicity
	Furan	Peripheral neuropathies, embryo toxicity, liver problem

Table 4: Adverse effect of POPs Source: UNEP 2000; The World Bank A CIDA 2001[16,17]

Figure: 1



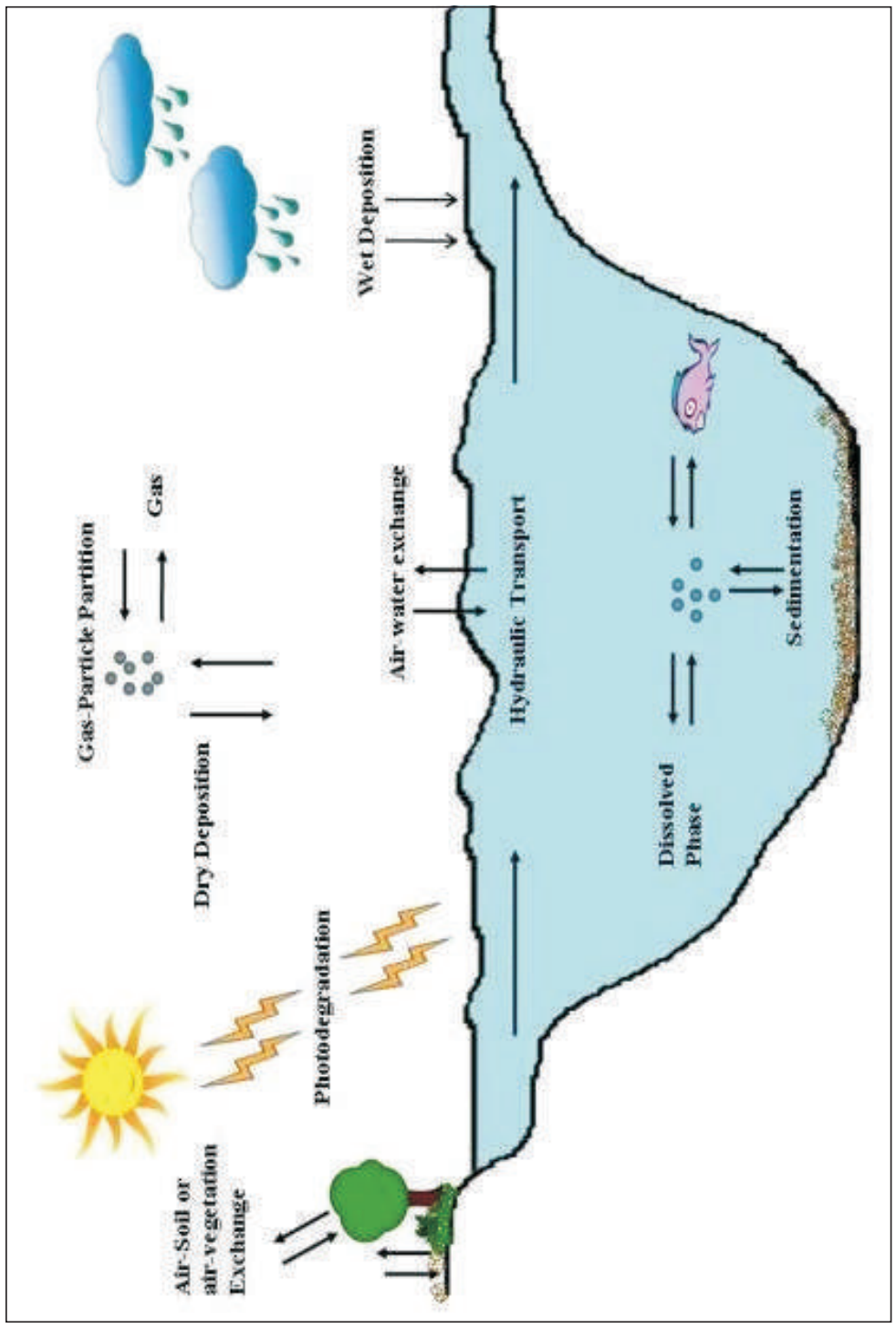
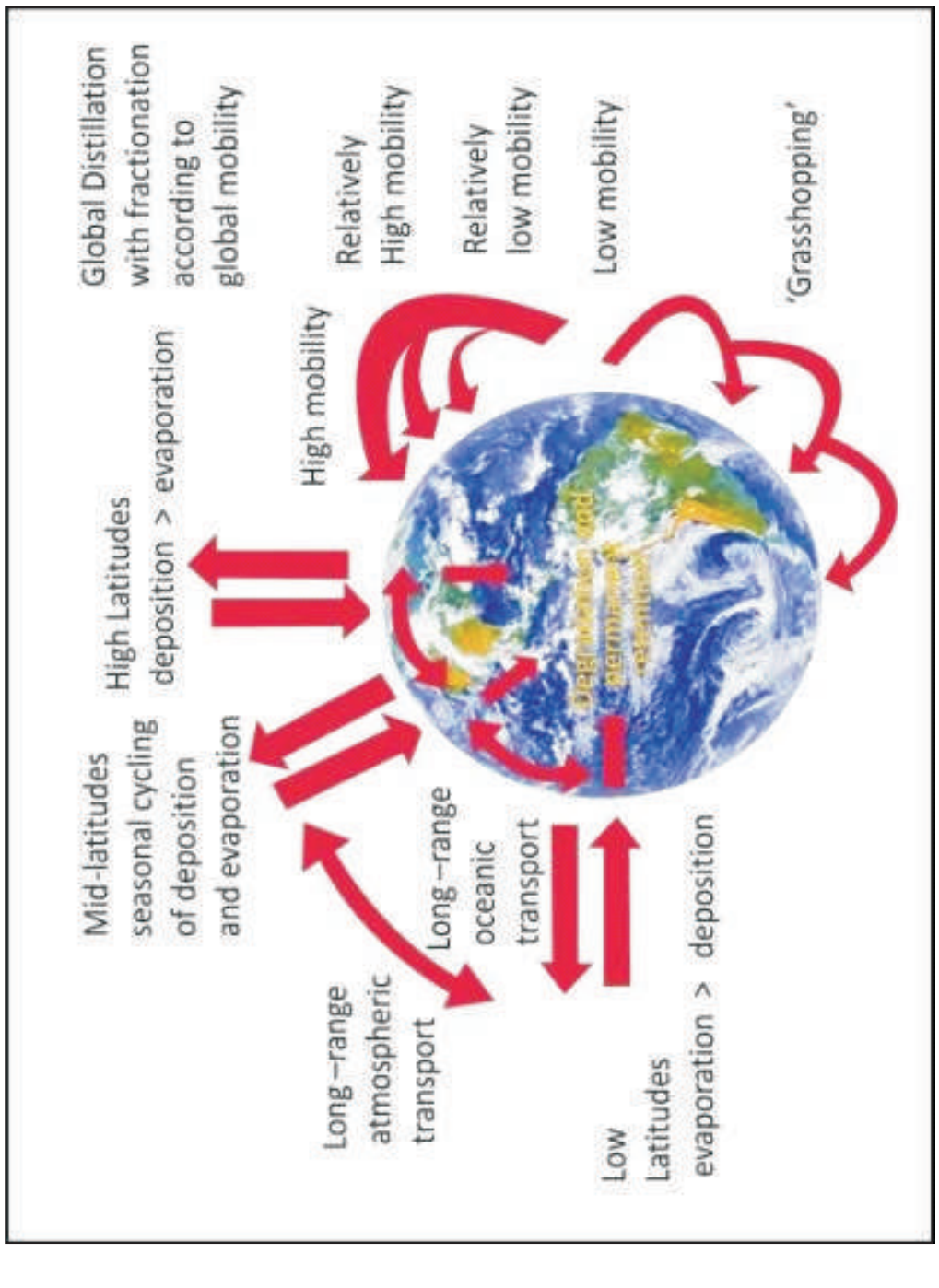

Wet Deposition
Gas-Particle Partition
Gas
Dry Deposition
Photodegradation
Air-Soil or
air-vegetation
Exchange
Air water exchange
Hydraulic Transport
Dissolved
Phase
Sedimentation

Figure:2

Figure:3


Global Distillation with fractionation according to global mobility
Relatively High mobility
Relatively low mobility
Low mobility
'Grasshopping'
High mobility
High Latitudes deposition > evaporation
Mid-latitudes seasonal cycling of deposition and evaporation
Long–range atmospheric transport
Long–range oceanic transport
Low Latitudes evaporation > deposition