SPATIAL AND TEMPORAL TRENDS OF PERSISTENT TOXIC SUBSTANCES IN INDIA

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1. Abstract

In the Asian region, India's role as a major contributor of classical persistent organic pollutants (POPs) has been well known. India's geographical location, tropical climatic conditions, excessive population, diseases, increasing industrialization and urbanization and heavy usage of several chemicals makes it an area of great concern, while evaluating the global pollution status of persistent toxic substances. The efforts of our institute for the past more than two decades collecting environmental samples (air, water, soil and sediments) and also biological matrices covering mussels, fish, birds, food stuff and terrestrial and marine mammals including human subjects from the coastal areas, metropolitan cities, towns and villages, municipal dumping and e-waste recycling sites for the analysis of classical organochlorines (such as DDTs, HCHs, PCBs, CHLs, HCB), dioxins and furans, brominated flame retardants (PBDEs and HBCDs) and also many trace elements provided us an invaluable data base on the pollution status of India and its role in the global pollution by these chemicals. We explain in this paper, the invaluable insights that could be observed in our results on the possible sources, spatial and temporal variations, transport and distribution, global comparison, risk assessment, etc. of these chemicals on a global scale.

2. Introduction

India is the seventh largest country in the world supporting over 15% of the world population in an area of 2.4% of the globe. It is a mega-biodiversity nation having over 75,000 animal species many of which are vulnerable to pollution, especially by the organic pollutants. Further, the country is a typical agrarian state and also among the industrially developing countries in recent years. As a result, huge quantities of chemicals are currently in use in agriculture and vector control (e.g. HCHs, DDTs, CHLs) and also in industries (e.g. PCBs). Apart from these, it has been found that from the last decade open dumping sites in the suburban areas of its metropolis and other cities are contributing to the PTS load by the unintentional production of chemicals (e.g. PCDDs/DFs).

Most recently, India, an already grown software giant has been contributing the novel POPs chemicals like brominated flame retardants (BFRs) such as polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecanes (HBCDs) to the global environment via processing and recycling the wastes which are the outcome of their huge electronic industry. Considering its expanse, huge population, rapid industrial development, carrying-out recycling of e-wastes imported from developed nations, the quantum of usage of chemicals should be always enormous. The expanse of usage of chemicals in India is so vast to the extent that Macdonald and co-workers[1] found global use of technical HCH and historical measurements of <-HCH concentration in the atmosphere of Arctic region showed two significant declines, one in 1983 when China banned the use of technical HCH and another around 1990 when India banned technical HCH usage in agriculture.

Moreover the geographical position of India climatic conditions there facilitate its role as a global contamination source for volatile and semi-volatile organic pollutants such as persistent toxic substances (PTS). Through the more than two decades of study by our group and our collaborators from several countries, on persistent chemicals in India, it can be told that India is becoming a hub of various persistent chemicals. The present paper explains our findings on the spatial and temporal variations of some of the legacy and novel POPs in India in the past two decades.

3. Persistent Toxic Substances in India

3.1 Legacy POPs

The first ever pioneering sampling by scientists from Ehime University in India in 1987 and in subsequent years revealed the widespread presence of some of the classic OCs such as HCHs, DDTs, PCBs, CHLs and HCB in the environmental and several biological matrices like mussels, fish, birds, terrestrial and marine mammals, food stuff, human milk, etc., HCHs being predominant in several cases **(Fig. 1)**[2]. Our other studies also reveled that India was a dominant source of HCHs and DDTs, at least before their ban for agricultural use[3,4].

Our studies on human matrices, especially human milk collected from India in the early 2000s exhibited spatial variations among the major cities, villages and dumping sites revealing location specific usage pattern of POPs chemicals[5-8]. Temporal decrease of these chemicals, especially the two prominent pesticides, HCHs and DDTs in the food stuff and human milk samples were noticed when our data collected during these two subsequent decades were compared [6] **(Fig. 2)**.

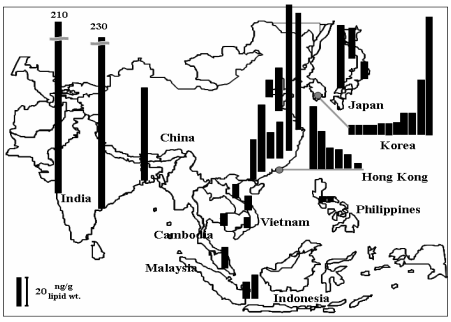

Fig. 1. HCHs in mussels from Asian countries [2]

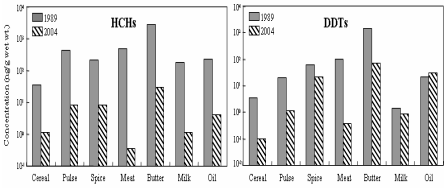

Fig. 2. Temporal trends of HCHs and DDTs in Indian food stuff [6]

3.2 Dioxins and Furans

Our additional efforts by analyzing the sediment and human milk samples from specialized areas like municipal waste dumping sites in the suburbs of the two metropolitan cities Chennai and Kolkata showed that India is now becoming a source of the some of the legacy POPs chemicals and also contain the mostly dreaded POPs chemicals PCDDs and PCDFs. The TEQs were significantly higher in many of these milk samples from the dumping sites than from the control sites, most of which was contributed by dioxin like PCBs than from PCDDs/DFs. The flux of dioxins in such dumping sites in India was also found to be comparable or even higher than in general soils or dumping sites in some other developing and developed nations [9] **(Fig. 3)**.

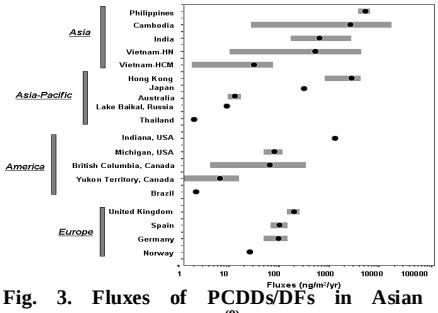

Fig. 3. Fluxes of PCDDs/DFs in Asian municipal dumpsite soils [9]

3.3 Brominated Flame Retardants

Our most recent studies showed the existence of two popular flame retardants, PBDEs and HBCDs in the mussels[10] and air, sediments and human hair samples of the e-waste processing areas of India, their levels being higher than in control areas. The levels of PBDEs observed by us in the soils of Indian e-waste processing areas were comparable to the levels found in Guyiu, China **(Fig. 4)**. Our joint research ventures with our scientific collaborators showed further that PBDEs do occur in the atmosphere of many Indian cities and villages[11]. Further, it was also found that perfluorinated compounds also occur, at least in low amounts in the human milk samples from India[12].

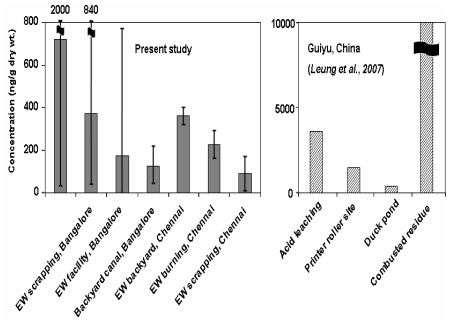

Fig. 4. PBDEs in soils from e-waste sites in India and China

4. Conclusion

India has become a classical example for explaining temporal decrease of legacy POPs and HCHs and increase in the novel POPs like PBDEs, HBCDs and PFOS **(Fig. 5)**, indicating that a continuous monitoring of the presently designated persistent organic pollutants (POPs) and also the chemicals that may be designated so in future (emerging POPs), for their spatial and temporal changes is absolutely necessary in a fast developing country like India, which may lead to clear understanding of the global pollution by these and related chemicals.

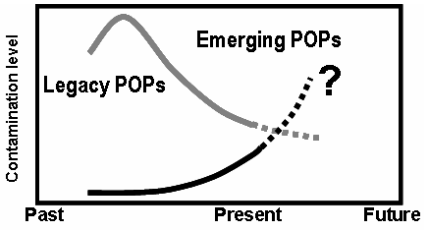

Fig. 5. Emerging POPs issue in India

5. Acknowledgements

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