Exposure of Indian environment and human population to POPs: Scope for new chemical management policy

Brij Mohan Sharma[a,], Girija K. Bharat[b], Luca Nizzetto[c,d], Shresth Tayal[a,b], Pavel Čupr[d], Thorjørn Larssen[c]*

[a]TERI University, 10 Institutional Area, Vasant Kunj, New Delhi 110070, India
[b] The Energy and Resources Institute (TERI), Darbari Seth Block, India Habitat Center, Lodhi Road, New Delhi 110003, India
[c] Norwegian Institute for Water Research, Gaustadalleen 21, Oslo 0349, Norway
[d] Research Centre for Toxic Compounds in the Environment, Masaryk University, Brno 62500, Czech Republic

❑ Introduction

Human and environment exposure to POPs is of great concern due to high toxicity and bioaccumulative properties of POPs. Developing economies are considered as hotspot of POP contamination as of their rich history of POP production and use. Due to rapid economic and agricultural development, India is one of the top producers and consumers of pesticides and various other toxic chemicals for agricultural and industrial purposes, enforcing a threat to human population. Being India one of the parties to Stockholm Convention, most of the POPs have been banned in India, however, few of them are still in use or banned recently. Thus, recognizing the importance of regulating use, manufacturing, and import of POPs and similar toxic chemicals in a democratic industrialized country like India, it is very important to critically evaluate the scenario of contamination levels and chemical management, both. This review study is an attempt to examine (a) POPs levels in various environmental matrices and biomarkers, (b) the risk factors to human population on the basis of past contamination levels, and (c) critically evaluating chemical management regulation of India.

❑ Methodology

We collected studies from peer-reviewed journals and government reports published between November 2012 and 1980 on POP contamination in environment (surface water, ground water and aquatic organisms), human milk and blood.
Human health risk associated to POP exposure is calculated with respect to the risk of developing cancer, considering past studies on levels of POP in surface water, ground water and food basket. The exposure model of Renwick et al., 2003 was applied which is based on the EPA baseline risk assessment approach (EPA 1989, Gaylor 1997).
Exposure results are compared with carcinogenic benchmark level; namely an exposure posing upper bound lifetime excess cancer risk of 1E-6 (i.e. one cancer occurrence over one million people in population). An exposure exceeding a risk factor of 1E-6 is considered as significant. Cancer risk above 1E-4 is considered as unacceptable, identifying possible epidemiological outcomes of high priority (EPA, 2013).
Indian Policy framework was critically evaluated keeping EU's framework for chemical management as refernece.

❑ Environment and human Exposure

DDT and HCH were the most commonly reported and abundant POPs in the environment.

SURFACE WATER

❑Most of the studies were focused on urban and semi-urban areas implying that available data may reflect large extent of active primary emission sources rather than background exposure.
❑Compared to the snowfed rivers of North India, low concentration of POPs were detected in the rainfed rivers of southern India (Kumarasamy et al., 2012; Sarkar et al., 2003). Indicating glaciers as a potential sources of POP distribution.
❑Incredibly high concentrations (thousand fold higher than guideline value) of DDT and HCH were detected in small streams of Ganges river and ponds in West Bengal and Assam (Purkait et al., 2009; Mishra and Sharma, 2011).
❑ Small water bodies near tea gardens in West Bengal were also highly contaminated by heptachlor (4300 ng/l) (Bishnu et al., 2009).
❑ Meta-analysis of time trend was performed using the literature data on POPs (namely ΣDDT and ΣHCH; Fig 1) Analysis did not show any decline trend for DDT with time.
❑Conversely for HCHs a significant ($p<0.005$) decline trend in the meta-data was observed with average concentration value decreasing of about 3-4 order of magnitude.

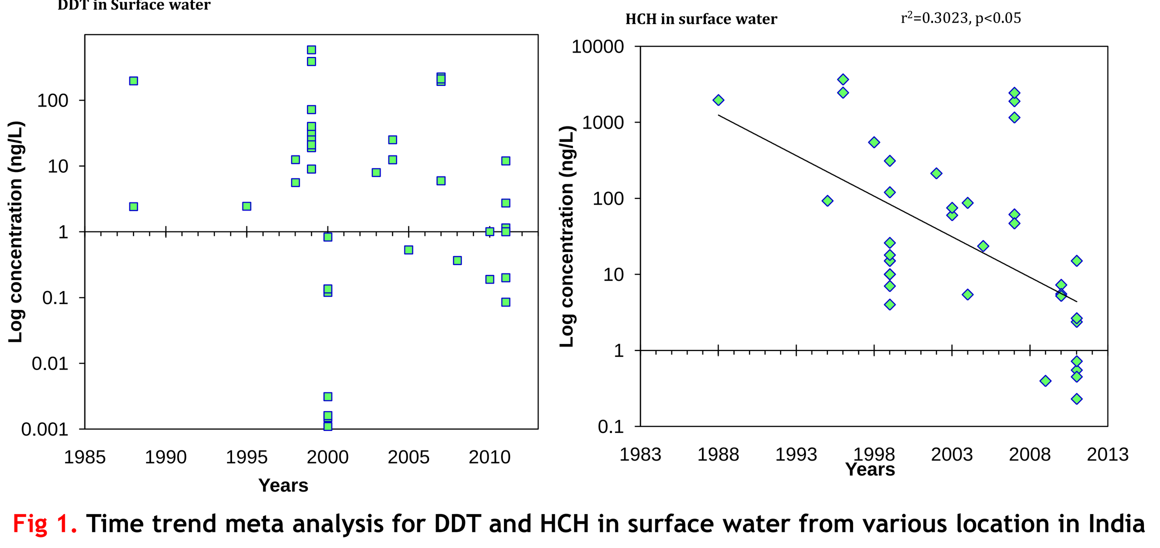

Fig 1. Time trend meta analysis for DDT and HCH in surface water from various location in India

GROUND WATER

❑Elevated levels of DDT, HCH, aldrin, dieldrin, heptachlor and endosulfan in **ground water** were detected from various regions of India reflecting past and extensive use in agricultural and industrial activities.
❑Illegal use of DDT and HCH in many regions of India is one of the reasons for their present elevated concentrations in various environmental media (Imphal Free Press, 2008).
❑Opposite to surface water, non-significant declining time trend was observed from meta-analysis (Fig 2).

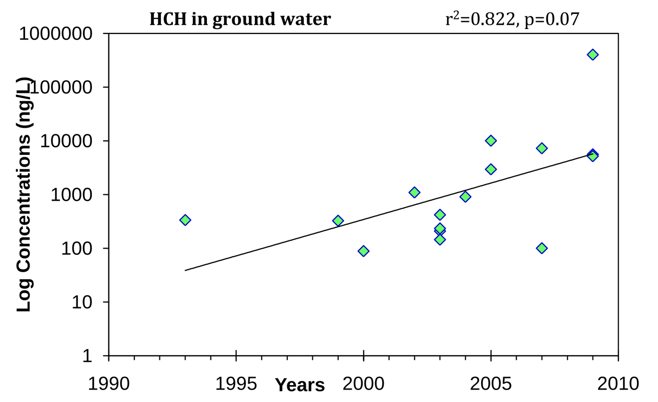

Fig 2. Time trend meta analysis for HCH in ground water from various location in India

AQUATIC ORGANISMS

❑Monitored species were from different trophic levels and both, marine and fresh water organisms. High levels of POPs were detected in majority of marine and fresh water samples.
❑levels of DDT and HCH in fish tissues from Ganges River were thousand times higher than the permissible limits of USEPA.
❑POP levels in Indian mussels were higher than in green mussels collected from Philippines and lower than Thiland (Tanabe et al., 2000).
❑Levels of HCH in different marine species from Mumbai ranged 0.87-33.73 while DDT ranged 0.38-34.1 ng/g; lower than temperate regions.
❑Study on DDT and HCH in dolphins from Bay of Bengal reveals higher levels when comparing with other Asian regions.
❑Time trend meta-analysis was performed by excluding top predators and benthic organisms. The analysis of the data (N=30) on only marine coastal and fresh water fish did not provide any evidence of time dependent trends for DDT and HCH.

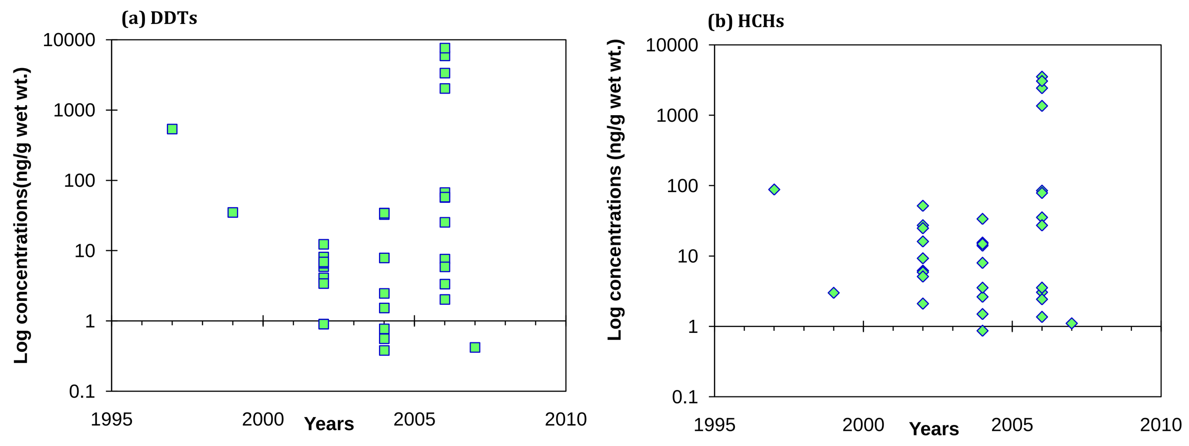

Fig 3. Time trend meta analysis for DDT and HCH in aquatic organisms from various location in India

HUMAN BLOOD AND MILK

❑DDT and HCH concentrations were found to be higher in rural and semi-urban populations as of their extensive engagement in agricultural activities.
❑High concentrations of PCBs and PBDEs were detected in human populations from urban areas where management of municipal and e-waste is a big issue such as Kolkata and Delhi (Jit et al., 2011; Someya et al., 2010; Banerjee et al., 1997).
❑Available data on human blood contamination (n=18) spreads over 3.5 order of magnitude and don't show any trend for DDT and HCH (Fig. 4). Concerning human milk samples, the total available dataset (n=23) for both DDT and HCH shows a significant increase for DDT and a non-significant increase for HCHs (Fig. 4).

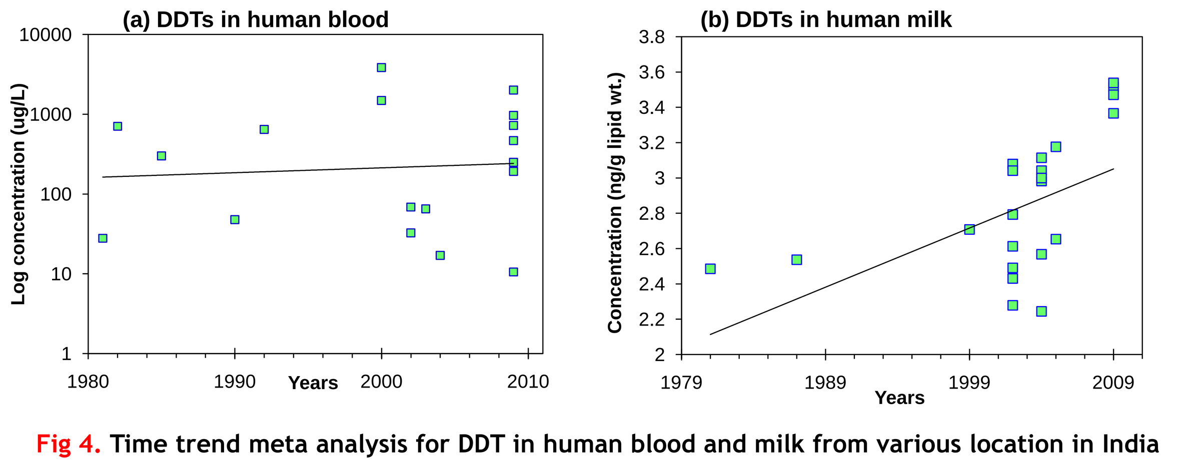

Fig 4. Time trend meta analysis for DDT in human blood and milk from various location in India

REMARKS

❑Available data were highly fragmentary, studies were never performed with same methodology making it difficult to compare the data or evaluating time trend.
❑There is a scarce of studies on background contamination of POPs in India (studies from remote and Himalayan regions).
❑Data are abundant only for DDT and HCH; however other POPs including the newly listed chemicals to Stockholm conventions were missing from the literature.
❑India is unarguably a hotspot of DDT and HCH contamination.
❑Meta-analysis of collected data suggests that there is no significant decline in POP levels.
❑Elevated environmental exposure is reflected by data from human monitoring.
❑Scarce of epidemiological studies to evaluate the human risk assessment from POPs.

❑ Environment and human Exposure

Present analysis predicted that ground water may be one of the major drivers of POP related cancer risk in Indian human population (Fig. 5).
❑Chronic daily intakes (CDI) via ground water consumption were ranging from 2.02E-07 to 9.18E-04 mg/kg/day for DDTs (**Risk factor:** 4.16E-08 to 3.12E-04) and from 1.08E-06 to 4.90E-03 mg/kg/day (**risk factor**: 1.19E-06 to 5.37E-03) for HCHs.
❑Risk factor due to surface water consumption (e.g. during swimming) were obviously lower (1.22E-14 to 1.82E-04 for DDT and 9.53E-11 to 2.65E-04 for HCH) (Fig. 5) than ground water; leaving most of the values in acceptable range of risk factor.
❑As expected, consumption of contaminated food is another potential pathway of human exposure to POPs in India (Table 1). Very high values of CDIs of HCHs and DDTs were calculated in this analysis. CDIs were ranging from 9.0E-07 to 1.24E-04 mg/kg/day for DDTs (**risk factor:** 3.06E-07 to 2.29E-04) and 9.43E-06 to 7.76E-03 mg/kg/day for HCHs (risk factor: 1.04E-05 to 8.50E-03).

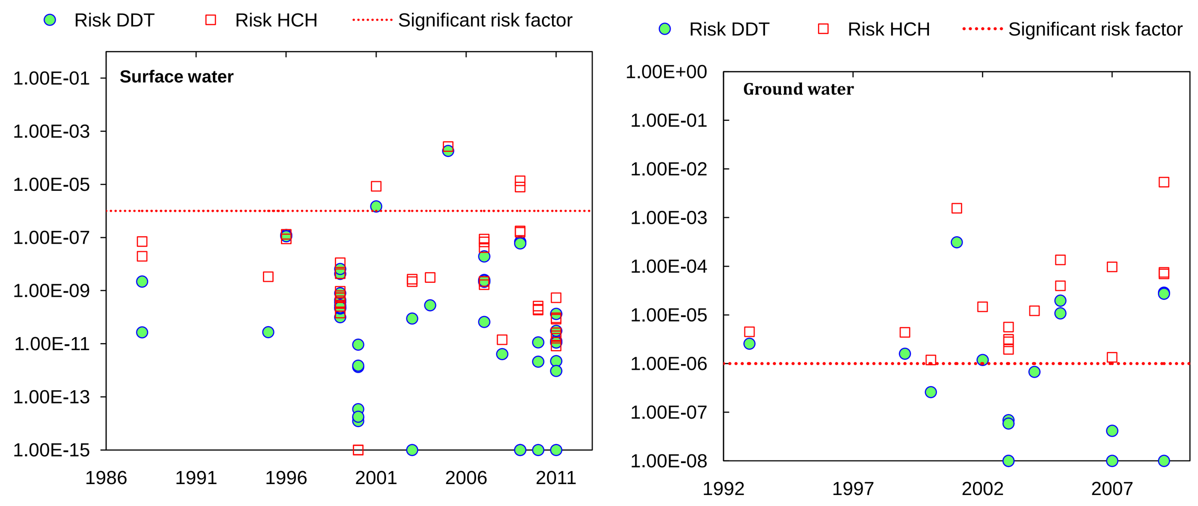

Fig 5. Risk factor developed from consumption surface water and ground water

Food group	IR-food (Battu et al., 2005)	DDT (mg/kg)	HCH (mg/kg)	Risk DDT	Risk HCH
Common to Vegetarian and non-vegetarian diet					
Cereals	0.47	0.195	2.69	1.92E-04	8.50E-03
Pulses and legumes	0.28	0.02	0.42	1.17E-05	7.92E-04
Vegetables*	0.21	0.045	0.055	1.99E-05	7.78E-05
Oils and fat	0.007	0.021	0.22	3.06E-07	1.04E-05
Milk and milk products*	0.58	0.189	0.09	2.29E-04	3.51E-04
Meat, Chiken and Eggs*	0.34	0.059	0.037	4.20E-05	8.56E-05
Total intake risk				4.94E-04	9.82E-03

*Median value from different studies

Table 1. Risk factor developed from consumption contaminated food

❑ Critical evaluation of POP management regulation in India

In India, both legal and management aspects concerned with protection from chemical risk generally cover POP management. These legal aspects come under the responsibilities of the central government through state ministries and a range of government agencies, which manage various aspects of POP pollution. Indian chemical policy package has about 20 pieces of regulations to control POPs covering: a) import and export, (b) manufacture, (c) transport, and (d) protection of environment and public health. However looking at the literature, high levels of POPs in the environment and bio-markers indicate ineffective and delayed management. The challenges with Indian chemical policy to manage POPs are:
❑Indian frame on chemical management with regards to restriction and ban on POPs and similar toxic compounds is generally based on retrospective approach.
❑It doesn't prevent the insurgence of uncontrolled risk, for example from new toxic substances entering into the market.
❑Regulation for systematic basin scale monitoring of pollution levels and impacts on human is missing. EU's Water Framework Directive (WFD) and daughter directive 2008/105/EF is an example of such successful effort.
❑Lack of a dedicated strategic-framework for monitoring and management of priority chemicals such as POPs.
❑Investments for analytical and emission reduction technology for "old" and "new" POPs.
❑Public participation and awareness
❑Policy for international scientific cooperation with developed economy
❑Elimination of double standard in Environmental protection level between India and developed countries.

❑ Conclusion

❑Elevated POP contamination in the environment and biomarkers and high risk factors from DDT and HCH exposure to human population from India demonstrate the absence of an integrated perspective approach to chemical regulation and pollution management.
❑The current fundamental retrospective vision has resulted in a difficult and ineffective implementation.
❑A large number of fragmented crop of acts, laws, rules etc. should be substituted by a unique, integrated and holistic system under a clean mandate of few designated authorities.
❑This system should include the reform of capacity building for scientific investigations and monitoring programs.
❑National policy should prioritize to attain environmental quality comparable to international standards on levels of toxic chemicals.

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