THE IMPACT OF TOXICS ON BIODIVERSITY IN INDIA

A Secondary Literature Review Undertaken for

NATIONAL BIODIVERSITY STRATEGY AND ACTION PLAN (NBSAP)

by

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List of Tables

I. **Introduction**

In the 1960s, as many of us know already, Carson shook up much of the western world when she linked up the deadly DDT with the disappearance of happily singing birds in the Spring, in her book, " Silent Spring."

This was a watershed. It pointedly, eloquently and sorrowfully questioned the consumptive living in ways that had never been done earlier. In the years that have gone by after this book, there has been a great concern at the popular level about the impact of toxics, on human health as well as the environment. Toxics : the word itself an all encompassing euphemism for pesticides, organchlorines, heavy metals, toxic sludge- an entire undesirable community of poisons. In the US, where Carson lived and wrote, the toxics movement has become a powerful one, with communities and citizens creating alliances with the medical and scientific community to create well informed movements demanding, literally, a right to life and a clean environment. One weft in this rich tapestry tells the story of how biodiversity, particularly wildlife, has been severely, often irreversibly, impacted.

Startling scientific studies have unfolded example after example, but in the popular imagination, it was a 1996 masterpiece, *Our Stolen Future,* which created international ripples. The book showed how toxic chemicals were irreversibly damaging both wildlife nd the human species itself. The authors - Theo Colborn et al-can be seen as fitting heirs of Carson for bringing into the public domain these startling landscape.

But that's in the US.

India, don't forget, has a dubious double distinction. Firstly, Coast to coast, the country is being discovered to be pitted with toxic hot-spots. Endosulfan in Kerala, pesticide poisoning of Peacocks in Morena, Madhya Pradesh, and Sarus Cranes in Bharatpur, Rajasthan, being poisoned as birds who come into fields as crop raiders, foraging for food, mass mercury pollution by Hindustan Levers operations in Kodaikanal, toxic PVC plastic recycling across the country, incineration and open burning of waste and chlorinated compounds everywhere in India, backyard lead recycling, poorly dumped waste that seeps in to poison the groundwater : these and more are a part of India's toxic present.

And then, policy is mostly playing quack. There has been no attempt to reduce and phase out, on priority, toxics from the production and consumption cycle, nor any concrete tangible action seen to protect people from such exposure.

Meanwhile, India is also a throbbing bio-diversity feast across its various geographical and ecological zones. That is why invoking Carson, is important.

What does this cocktail portend?

There are already strong indications. A potent example can be found in the studies across the country which show how a range of foodstuffs - meat, milk and fish - diets for most of us, are contaminated with a variety of pesticides. Many of these organochlorine pesticides (in fact, 40% of all insecticides used in India are organochlorines) will bioaccumulate and be magnified, and their all pervasive toxicity will increase exponentially, leading to deadly health problems. When food, a fundamental building block of life, is polluted, what happens to the species themselves?

It's possible to hazard a guess, and it is precisely such guesswork that is the basis of interest in this issue. If, for example, organochlorines are impacting polar bears in the Arctic and Alligators in the Great lakes, then why should we be wrong in assuming similar damage in India? More over, as the understanding of toxicology changes, we realize that even at very small doses, many chemicals impact the living system in ways we could not even have imagined in the 1980s. Now, it turns out that even small doses can be very harmful for the species and its young ones, if and when they are born at all.

However, given the complexity of ecological systems, meticulous field studies become very important. It is on the basis of such an understanding that the National Bio-diversity Strategy and Action Plan felt the need for bringing out this issue further. This exercise has been undertaken on the understanding that it is likely that bio-diversity in India is being impacted by various kinds of pollutants. The first stage in addressing this is to draw out a picture of the scientific studies done in this area, and what they tell us about the scenario.

This paper is the first step in this kind of exercise. It is a secondary literature review of available literature in India pertaining to the impact of toxics on wild-bio-diversity.

The available literature will be examined through two prisms. First, as a body of literature itself, and what it is able to tell us about the problem we are addressing. Secondly, about how the issue itself is viewed by the scientific community as a whole and the lacunae in this. Despite the generic use of the term toxics in the previous paragraphs, these chemicals have been classified into groups, sometimes overlapping, for the purpose of the study. Although a great deal of international attention has been focused on organochlorines, given their particularly pernicious nature as bio-accumulators, endocrine disruptors and reproduction impairers, this study considers other chemicals too. Given the international POPs (persistent organic pollutants) treaty, which India has signed, it has become strategically important to make clear the links between such pollutants and bio-diversity conservation.

This study will be the basis upon which further steps may be discussed, debated and embarked upon. Some of these have been recommended here, while others are expected to come out of discussions based upon this work. It must be pointed out here, though, that while research is of critical importance, it needs to walk arm in arm with the Precautionary Principle, because the issues we address are so simultaneously fragile and explosive , that it would be suicidal to leave them unattended till scientific data pours in.

Chintan, already interested for a long time in these issues, has decided to undertake this initiative as it has within it expertise on toxics, as well as bio-diversity. This experience would also enhance the analysis in the paper. It hopes to use the findings to promote wider public understanding about the issue and create networks that will support each other in common goals for the future.

Bharati Chaturvedi

II.Methodology

a. Period of Study

In order to ensure contemporary relevance in our review, it was decided to utilize only studies carried out since 1995 in India, ie, the last 8 years, to give a more contemporary focus to the review. Besides, the years after 1995 also witnessed a growing concern about the issue of toxics in India. In the case of International studies, this deadline was not adhered to as many landmark studies were undertaken in the late 1980s, since toxic chemicals and their impact on human heath and bio-diversity was an issue of concern much earlier in Europe and the United States.

b. Categories of Toxics

While this review did not pre-determine the types of toxics that would be studies, the outcomes have also been discussed through demarcated chemical categories. These categories were based upon findings in the studies themselves. Broadly, these include pesticides, heavy metals, organochlorines not including pesticides and miscellaneous effluents.

c. Mode of Work

The present review comprised collection of information through three primary means :

- A large number of libraries in Delhi and the Wildlife Institute of India, Dehradun were surveyed for literature on this issue. The list of libraries consulted in Delhi has been listed in Annexure 2. The list of scientific journals that were consulted has been given in Annexure 1.
- Important web-sites on this issue were found via internet searches and relevant information was downloaded from these sites. A list of selected useful web sites has been listed in Annexure 3.
- Information was also obtained through personal communication with a variety of researchers and activists working in the field.

d. Limitations

The chief limitations of the study were perceived as follows:

- The response to requests over email was far from satisfactory. In fact, no information was received in the first few emails sent out. Hence, it is possible that information not commonly available or published is not reflected in this review.

- Since it was possible to visit only Dehradun, apart form Delhi, this study will reflect the geographical limitations of the survey. For example, it was not possible to visit either the Bombay Natural History Society (BNHS) or Salim Ali Centre for Ornithology and Natural History (SACON) or libraries where flora is also adequately represented. Hence, this study is also biased towards zoological species.
- This study is meant to be a preliminary indication of trends in scientific research on the impact of toxics on bio-diversity. It is by no means comprehensive, given that literature was collected over a short period.
- The work was further limited due to the fact that much information or data had not been written up or published, but merely based upon informal discussions of laboratory sampling. Hence, some well known studies could not be traced back to a paper or anything more definite than a quote or conversation.

III.Framework of the Report

The report has been divided into the following parts.

1. 'Methodology' lays out the means by which the study was carried out.
2. 'Findings' contains our major findings and focuses on following aspects:

    - Discussion of the outstanding studies done on the subject in India and attempting to place them in a context.
    - Assessment of key areas and nature of research in the field, based on means used for the study, taxonomic groups under focus, physiological aspect covered, representation of bio-accumulation studies and categories of toxics investigated.
    - Discussion of the lacunae in our current knowledge.

3.'Recommendations for Research' comprises recommendations that have been based on the chief findings of the study. In addition, detailed recommendations have been made for crucial changes necessary at policy making and implementation levels in 'Policy Recommendations'.
4.In 'References', the references that were utilised in the review have been listed in bibliographical fashion.

IV. Findings

The findings of the review are described in detail below

Over 200 articles were studied using the above-described methods. Of these, only 47 were found to be of direct relevance to the issue of toxics and bio-diversity in India. Other useful studies were found to be indicative of the levels of toxics present in the natural media. The following analysis has therefore been confined to these two types of studies.

For a comprehensive understanding of the various aspects of current research in the field, each of the studies found was classified under each of the following categories :

a. Laboratory or field studies.
b. Taxonomical coverage: The animal taxon to which the study organism belonged, was tallied.
c. Physiology: The aspect of physiology studied in relation to toxic impacts was tallied.
d. Category of toxic chemical whose effects were investigated. Furthermore, the studies were discussed in the context of pollution in other media, such as soil, water etc, in order to build up a larger picture. Here, it was not only studies that were discussed, but also observations of various persons in the field and other studies that point to the contamination of our natural environment.

a. Laboratory /Ecotoxicological (Field) Studies

Most of the studies that examine the toxicological effects of chemicals upon various species were laboratory studies. This suggests that the purpose of undertaking those studies was not linked with conservation. Out of 47 case studies , only (7) 15% were found to be field studies and the rest, i.e., 85% (40) were are laboratory studies (see Table 1).

Table 1 Distribution of Studies In Terms Of Laboratory and Field Studies.

Sr. No.	**Types of Studies**	**No. of Studies**
1	Field Studies	7
2	Laboratory Studies	40
3.	**Total**	**47**

b. Taxonomic Variety

In the Indian context, a very narrow range of animal species have been studied with respect to the effects of toxic chemicals. Table 2 suggests that among the cases undertaken in this literature survey, the major share of scientific attention has been devoted to studying fish species. This could be linked to the fact that fish serves as a good indicator species, it is a crucial part of the food chain, it is easy to catch and test etc.

Table 2 Distribution of Case Studies According to Species

Sr.No.	Classes of Animals Studied	No. of Case Studies
1	Molluscs	2
2	Fishes	22
3	Crustaceans	7
4	Mammals	12
5	Birds	4
6	**Total**	**47**

There are 12 studies on the impact of toxicity on mammals. These studies are mainly on rats and are laboratory studies. Seven studies are on crabs. Hence, the total number of studies on aquatic organisms is 29, which is more than 60% of the total collected case studies in this literature survey. Thus there is poor representation of natural biodiversity in the range of species studied for impacts of toxics.

There is, however, no study done on either large mammals or endangered species. The latter, being at the top of the food chain, could be repositories for a variety of pollutants that might be impacting them in ways not yet understood due to a lack of available data.

c. Physiological Aspects Covered

In terms of physiological investigation, Table 3 shows that a wide variety of physiological aspects have been studied in the context of their vulnerability to toxics.

Table3 Physiological Distribution of Studies.

Sr. No.	**Physiology**	**No. of Case**

		Studi es
1	Mortality	3
2	Blood Parameters	12
3	Respiratory System	5
4	Liver	7
5	Embryology	2
6	Reproductive System	4
7	Development	5
8	Endocrine, Thyroid, Thymus, Ovary, Testes etc.,)	3
9	Skin (Epithelium)	4
10	Excretory System	4
11	Skelo-Muscular	4
12	Brain	1
13	Digestive System	1
14	Immune System	1
15	Oxidative Stress	4
16	Chromosomal Aberration	1
17	**Total**	**61**

This also reflects how toxins are still understood in India. The shift in perception from mortality to hormone disruption and damage to the reproductive system and hence, the next generation, has not been a wide one. This is also reflected in the fact that almost none of the studies view toxics in their wider context and implications to the species per se. It remains important, therefore, to re-examine how the an understanding of toxins is created through educational and research institutions and various debates, and the manner in which appropriate interventions can be made.

d. Chemicals

Table 4 Toxicological Distribution of Studies.

Sr. No.	**Toxic Agents**	**No. of Case Studies**
1.	Organophosph ate	11

2.	Organochlorine	14
3.	Heavy Metals and Effluents	21
4.	Carbamates	2
5.	Synthetic Pyrathroids	3
6.	Miscellaneous	8

As has already been mentioned earlier, a majority of the case studies are laboratory studies. Table.4 suggests that toxicity of heavy metal and effluents have been extensively studied in India. There are 21 cases on the effects of heavy metals and other effluents on wildlife. This amounts to more than 40% of the cases that we have considered here in our review. However, Organochlorines and Organophosphates taken together amount to more than 50% of case studies done on toxic effects. A plausible reason behind this large number could be the widespread use of these pesticides in India as well as a higher awareness of their toxicity.

I. PESTICIDES

Our review suggests that pesticides predominate amongst all the chemicals studied for their impact upon wildlife. In this section, the various pesticide related studies have been discussed after being classified according to the type of pesticides. These pesticides include organochlorines , organophosphates and synthetic pyrethroids. The table below gives an idea about the consumption of various pesticides over one decade , till 1999. The data reveals that there been a very high consumption of DDT. Although it has been banned for agricultural purposes, DDT continues to be used for public health purposes, including maleria control, despite the fact that it is now considered ineffective even for this purpose.

Table 5 : Consumption Pattern of Pesticides in India

Pesticide Type	**Consumption (%)**	**Position**
Organochlorine	40	1
Organophosphate	30	2
Carbamates	15	3
Synthetic Pyrethroids	10	4
Others	5	5

Source : Trojan Horses : Persistent Organic Pollutants in India Srishti-Toxics Link , November 2000

From the Table 5 above, it is clear that organochlorines are still the most commonly used pesticides in India. In the context of this study, this information is alarming, because of the attributes of these chemicals and their impacts on wildlife, as seen across the world.

Table 6 :Trends in Pesticides consumption for public health between1998-99
(in MT)

	DDT (75%)	DDT (50%)	BHC (50%)	Malathion (25%)
1988-89	2500	13556	8048	
1989-90		10657	8764	1800
1990-91		12845	8464	1100
1991-92		11730	8999	1700
1992-93		11525	8072	100
1993-94		12750	7479	
1994-95		8482	6722	700
1995-96		10850	7584	350
1996-97		7606	3204	224
1997-98		7489		575
1998-99		5800		2200
Total	**2,500**	**162,078**	**67,336**	**8,749**

Source : State of India's Environment: The Citizen's Fifth Report, Part II
Statistical Database. Centre for Science and Environment(1999).

These pesticides have been found to bio-accumulate, through build-ups on sites where they have been used, disposal, run-offs, etc. in a variety of media- from human tissue to fish and milk. As studies from both India and other parts of the world have demonstrated, and have the potential to cause severe problems related to wild-biodiversity health. These have been examined below :

i. Organochlorine Pesticides

The long-term effect of toxic chemicals on the reproductive and immune systems has been an major concern in the decade. It is now known that because of their prolonged persistent nature and their ability to be stored in fat tissue, organochlorines are able to be present in an organism for long periods of time. Moreover, they have been found to permanently damage the reproductive and immune systems which ultimately affects the persistence of the species in the wild. Endocrinal disruption has been a significant aspect of scientific studies in recent years[i]in both India and other parts of the world. Studies carried out in other parts of the world show that the effects of toxics, particularly organochlorines, on wildlife species are varied – ranging from alligators born with abnormally small penises and birds with crossed beaks, to the sudden disappearance of entire populations. Wildlife researchers over the last few years have unearthed a variety of endocrine disrupter-related effects: interrupted sexual development; thyroid system disorders; inability to breed; reduced immune response; and abnormal mating and parenting behaviour. Species such as terns, gulls, harbour seals, bald eagles, beluga whales, lake trout, panthers, alligators, turtles, and others, have suffered more than one of these effects[ii]. Feminisation of male fish has also been a focal point of concern about endocrine disruption since the early 1990s.

Some are also steroid agonists and antagonists that bind to estrogen and/or androgen receptors; some alter the normal rates of synthesis of steroid hormones; and others interfere with the brain-pituitary-gonadal axis. A special concern exists during sex differentiation and development of the reproductive, immune, and nervous systems Hence, in this context, instead of focusing on mortality or a lethal dose, it becomes important to examine long term changes of both a single species and various species in an eco-system. This shift in perception is a critical one while examining the impact of toxics on the environment and bio-diversity.

In the Indian context, the organochlorine pesticides that could be found in use, despite bans on some of them, are DDT, Aldrin, Endosulfan, Lindane, Chlordane and Dieldrin.

- **Mortality**

In cases of mortality of wildlife species, it is sometimes very difficult to establish cause-effect relationships between the toxic chemical and animal mortality. However, it is possible that by impacting the immune system and weakening it, toxics are making an animal more susceptible to disease.

A case in point is the alarming decline in the population of vultures in recent years. The study of this phenomenon points to a complex relationship, which will not be apparent in laboratory studies. Taking the lead from the wildlife population study done by Dr. Vibhu Prakash of BNHS, Dr. Rehmani writes that in Keoladeo National Park, Rajasthan, 96% decline in the population of White-backed Vulture *Gyps bengalensis A* was observed over the last decade. In the case of Long-billed Vulture this goes even further to 97%. The downward trend in population continues in the cases of Indian Griffon *Gyps* and Himalayan Griffon *Gyps himalayensis* and other species of vultures too[iii]. It has been suggested that this was due to bio-accumulation of pesticides..

In this same case of devastating decline of vulture populations, scientist Robert W. Risebrough writes in his report, "On five occasions a white-backed vulture was observed by Dr. Prakash (BNHS) to be either sick or impaired over periods of about 32 days. Typically, they appeared to be drowsy; the neck would fall limp and hang. After appearing to wake up, the bird would raise its head, but then let it fall again. In each case, the bird fell from the tree and died. During the period of illness, however, the birds could fly short distances and even feed their young"[iv].

In this case of vulture decline, toxicologist Reisborough has suggested that an important cause might be in the long term effects of DDT. He suggested that 'Failure of eggs to hatch has largely been, with egg breakage, a result of eggshell structural abnormalities caused by DDE, a derivative of the pesticide DDT'[v].

Imperfect incubation behaviour, however, is also a plausible cause of failure of these eggs to hatch. Death of young in the nest is usually, like a failure to breed, a consequence of food shortage. The most plausible interpretation of these observations is that all of the birds were impaired, even those that showed no symptoms of sickness.

Riesborugh further writes, "Such a pattern of reproductive failure has not been observed in any studies, undertaken on the effects of environmental contaminants on birds, including the many studies of birds of prey"[vi].

In the same case (of widespread decline of vultures), the Centre for Science and Environment in Delhi collected and analysed samples taken from dead cattle from Bharatpur, Rajasthan, and Uttar Pradesh and from areas around Delhi. The analysis was completed at Indian Institute of Technology, Kanpur.

The study revealed high levels of pesticides such as dichlorodiphenyl trichloroethane (DDT), hexachloro cyclohexane (HCH) and dieldrin. The maximum level of DDT in samples from Delhi was 0.632 parts per million (ppm). Maximum levels of HCH were found to be even higher –at 0.839ppm in buffalo carcass and 1.071ppm in pig carcass. Among the various forms of HCH, the most toxic forms, alpha-HCH and beta-HCH, were found to be higher than the other forms[vii].

It is to be kept in mind that samples collected for the above studies were not of dead vultures but only of 'dead cattle' and a direct cause of mortality was also not established, though it was strongly hinted at. It was also sought to be linked with the decline in vulture population, attributable to poisoning.

- **Reproduction**

Birds

A pioneering field study on reproduction, and one of the few studies that is able to so directly link reproductive impairment with pesticides is the one by Rishad Naoroji of BNHS in 1997**.** Rishad Naoroji (1997) has carried out extensive eco-toxicological investigations on the effect of DDT on eggshell thinning in raptors. In his study of the breeding biology of resident raptors, the Himalayan greyheaded fishing eagles, *Ichthyophaga nana plumbea*, of Corbett National Park, he found that 'from 1991-1996 the Greyheaded Fishing Eagles bred unsuccessfully. Eggs from seven nests monitored during this period did not hatch, and while three nests hatched, ones were either found dead in the nest, or disappeared within a week of hatching'. In collected eggs, 'a number of organochlorine compounds were detected. Their ratios provide clues to the local contamination pattern in the area inhabited by the eagles. The parent DDT compound, that is the insecticidal ingredient,p.p-DDT, constituted 36% of the DDTcompounds measured; the amount of o.p-DDT, the minor ingredient in the original DDT mixture was 10% that of the level of p.p-DDT present. The relatively high amounts of these two compounds indicate recent DDT applications in local or nearby areas.

The evident thinning of the shell is most likely an effect of DDE, usually the principal metabolite of DDT in the environment and the compound considered primarily responsible for shell thinning'[viii].

Egg shell thinning is only one of a number of factors that are related to adverse effects of DDE on reproductivity.

Although most of the work in India, as suggested by this review, focuses upon eggshell thinning, there are a large number of foreign studies on the long-term effect of organochlorines on wildlife (i.e., effect of DDE on embryotoxicity, eggshell thinning and related effects that adversely influence avian reproductive success). A glance at the second half of the sixties shows a spurt in scientific studies on the long-term effect of DDT on wildlife population. Shortly after the initial work, a large mass of data accumulated that showed eggshell thinning in 18 families of wild birds in North America[ix] and throughout the world.

Mammals

Reproductive health hazards of Endosulfan have also been demonstrated by Sinha et al,[x] who show how Endosulfan exposure during growing age of rats (during the period of testicular maturation when spermatogenesis is under progress may result in disturbed spermatogenisis during maturity.

Fish

According to studies, highly water soluble pesticides more likely to be distributed in the aquatic system and tend not to be absorbed by the fish.
In fish, the effects are also seen through their impact on reproductive organs.
There are a large number of laboratory studies on the effect of organochlorines on the physiology of aquatic animals. The pesticides reach water bodies through runoff water from fields, and other tracts of land where pesticides are used. They can also reach as wastes and sewage is often disposed off in the river or water body directly.

The dissolved pesticides affect the reproductive potential of fish as revealed by a number of histopathological studies of the ovary of different fish exposed to pesticides. It is therefore crucial to determine the validity of results obtained in laboratory studies (undertaken, in the first place, for different reasons) in landscape level studies undertaken for wild species. Already, unpublished findings are indicating spontaneous sex-change in fish in parts of the Ganga, a phenomenon which will prove to be a disaster for the future of the species.

A study by Hazarika and Das (1998) informs us, "the gonadotoxic impact of BHC induced deleterious changes on ovarian histology of the experimented fish H.fossilis, which destine to effect the fertility and productivity of fish population"[xi].

Given the well documented and large-scale contamination in India of foods, including vegetables and foodgrains, from pesticides, and the bio-accumulative nature of these chemicals, it is reasonable to extrapolate that the results seen in these studies will also be found in an area much wider than merely the locations studied. Hence, organochlorines could be causing widespread damage to species, both local and migratory.

Given the presence of many of these chemicals in India as well, these international studies indicate the existing lacunae in our knowledge and indicate some areas of possible research.

- **Other Results**

The paper found other studies which point to other impacts of pesticides on bio-diversity.

In the case of fish, it has been found that water insoluble or less soluble pesticides are more readily absorbed by the fish. Organophosphates and Carbamates have a higher water solubility than organochlorines and are therefore taken up less and eliminated more than it. In Fish, it is the liver which is the main site of bio-transformation of fish, though this can also occur in plasma and kidney.[xii]

Acetylcholinesterase (AChE) is one of the most studies enzymes in response to the impact of pesticides in fish. This enzyme is crucial for passing impulses across synapses and for neuromuscular junctions. In the case of carbamates and organophosphorus, the action is mainly by inhibiting this enzyme, directly or through their metabolites.[xiii]

ATPaces are also enzymes inhibited by pesticides. In mammals, organochlorines inhibit this enzyme under optimal conditions of the fish. Synthetic pyrethroids are also seen to be important inhibitors of ATPaces

. DDT has also been seen to reduce the ability of the Atlantic Salmon to parr to escape predation..[xiv]

As seen in a lab study, endosulfan induces retardation in oxidative metabolism and consequently, on respiratory aspects in freshwater crab, according to Reddy et al.[xv]

- **Bio-accumulation of Organochlorine Pesticides**

While the studies above were able to link the levels of organochlorine pesticides with a specific health impairment, there are studies which only indicate a high concentration of such chemicals in various species.

The most revealing study in this context is one by migratory birds of South India studied by Tanabe et. al. in 1998. The authors here state that the global comparison of organoclorine concentrations indicated that resident birds in India had the highest residues of HCHs and moderate to high residues of DDTs. It is therefore proposed that migratory birds wintering in India acquire considerable amounts of HCHs and DDTs'[xvi]..

The authors further say, 'Persistent organochlorines such as DDT and its metabolites(DDTs), hexachlorohexane isomers (HCHs), chlorodane compounds(CHLs), hexachlorobenzene (HCB), and polychlorinated biphenyls (PCBs) were determined in whole body homogenates of resident and migratory birds collected from south India by this team[xvii].

Organochlorine contamination pattern in birds varied depending on their migratory behavior. Resident birds contained relatively greater concentrations of HCHs (14—8.800 ng/g wet wt) than DDTs and PCBs concentrations. In contrast , migrants exhibited elevated concentrations of PCBs (20—8.800 ng/g wet wt). The sex differences in concentrations and burdens of organochlorines in birds were pronounced, with females containing lower levels than males. Inland piscivores and scavengers accumulated greater concentrations of HCHs and DDTs while coastal piscivores contained comparable or greater amounts of PCBs. In this study, the authors say 'estimates of hazards associated with organochlorine levels in resident and migratory birds in India suggested that the pond heron, little ringed plover, and terek sandpiper may be at risk from exposure to DDTs'[xviii]. In this manner, toxic contamination from India is spreading well beyond its borders annually and repeatedly.

Put this in the context of another study in the mid-1980s on migratory shorebirds, such as like plovers and sandpipers birds on the South West coast of Chile and Peru, by Dr. Pete Myers. Data showed him how Sanderlings moving along the East Coast of The USA had declined by as much as 80%. After eliminating reasons of habitat decline, he observed the birds feeding in wetlands that were fed by rivers that reeked of pesticides from nearby farming areas. It seemed highly likely that the disappearance of the birds was linked to pesticide intakes. Dr. Theo Colborn, who reports this study in her book, Our Stolen Future, [xix]suggests that it as the birds flew back, the pesticides, accumulated in their fat tissues, would be burned off and enter their blood steams. She writes , "As the stored fat is converted into energy for their flight, the contaminants would be liberated into the blood and most likely move to either the sex organs of the brain, both of which contain major fat deposits. If that was happening, the pesticides might be interfering with migration, disrupting reproduction or even killing the birds."

There is no reason why this cannot hold true in the case of India, where birds are shown to be exposed to high levels o pesticides by studies such as the ones mentioned. Furthermore, exposure to pesticides in India in this context would mean that the contamination becomes global in nature.

In a paper " Levels of Organochlorines in select ecological components in Nilgiri District,' authors S. Murlidharan and S.M. Murugavel showed DDT and its metabolites present in water, sediments and fish. In particular, water birds- Little green and Pond Heron and the Little Egret-were examined. This paper is not included in the list of the study as we were unable to procure it or find a reference, but learned about it from a conversation with one of the authors.

However, accumulation of such chemicals can have severe physiological effects, as shown by N. Singh et al, [xx]who demonstrated how exposure to Aldrin reduced the liver and muscle protein content of Freshwater Catfish, *Heteropneustes fossilis.*

- **Pesticides in the Natural Media**

Finally, it is also useful to examine studies showing the accumulation of various pesticides in various media. The case below is that of the River Moorthy, in the Eastern Himalayan region. The areas of doars, through which the river flows, have been converted to forest plantations and tea plantations in the past century. Only limited extent of pristine and natural forest cover is available for conservation in perpetuity. The landscape features comprising different land uses such as tea gardens, human habitations and forests are often interconnected by streams/rivers and the activities in one have an impact on the other. Moorti is an important river system as it is the lifeline for many settlements living in the downstream and the wildlife of Gorumara National Park. The park is one of the hotspots of turtle diversity and habitat for many rare and endangered mammals. The Park also encompasses 12 per cent of the area under grassland ecosystem as a habitat for one-horned rhinoceros.

It was hypothesised by ATREE that the river Moorti and its tributaries (Indong, Garati) are coming from the different tea gardens, agricultural lands and forests and the use of chemicals in these areas may pollute the water and cause adverse effects to the aquatic as well as terrestrial life of the National Park, since there are many protected areas of national and international importance in this area such as the Mahananda Wildlife Sanctuary, Buxa Tiger Reserve, Jaldapara Sanctuary and Gorumara National Park. With the current state of knowledge, the damage being done to wild-bio-diversity can only be speculated about.

Table 7 :Pesticides residues in water and sediments (dry weight) of river Moorti (April 23-25, 2000)

Location of water Bodies	Aldrin	Dieldrin	Total hch	Total Endosulfan	Total DDT
River Moorti u/s Samsung					

Source : Personal Communication, ATREE, Bagdogra

Table 8 : Presence of Pesticides in Various Media

Source : Personal Communication, ATREE, Bagdogra

SnO.	PESTICIDE	Water Ng/l	Sediments Ng/g dry wet	Fish Ng/g of wet wt	Macrophytes Ng/gm of wet wt.	Benthic Macro-invertebrates ng/gm of wet wt.
1	Total BHC Total HCH	- NT	- 65.85	45.32 (16.07) dry wet	362.70(302.25) dry wt	41.53
2	Aldrin	NT	1.77	50.01(17.73) dry wet	7.21(6.01) dry wt.	13.42
3	Total endosulfan	1114.5	12.10	178.24(63.21) dry wt	61.65 (51.38) dry wt.	15.83
4	Dieldrin	NT	4.86	NT	32.47(27.06) dry wt.	5.16
5	Total DDT	NT	41.34	550.23(195.12) dry wt	194.42(162.02) dry wt	29.98

As explained earlier, the far-reaching effects of DDT, which is an organochlorine pesticide, are well known. There are also several studies that show how widespread DDT is in fish, milk, food grains etc. Such studies that indicate its presence in the tissues of animals and birds , as well as the natural media, from where it is able to enter tissue, warns us of the potential danger such populations face. Moreover, since the dangers are not immediately apparent, it is even more difficult to assess the extent and type of dangers posed by them. These are indicators of the possible long term damage that is happening to wild-biodiversity and while further studies to determine the impacts are important, it is even more important to take account of the existing evidence and the ringing alarm bells.

These alarm bells, however, must also go off for other pesticides and insecticides, based on evidence from across the world.

The study from Dodson et al is a good case in point. It has found, in the case of the United States, that the insecticide dieldrin reduces the production of male water fleas, called Daphnia. This is especially troubling because of records showing that Daphnia sex ratios are being affected over time. For example, in the late 1800s daphnia produced 50% males in a particular Wisconsin lake, but now produce less than 5%. Daphnia is considered the base of the food web, serving as a food source for many higher life forms such as fish, so this study has implications for wildlife throughout the food web.[xxi]

It is also important to note what Whitcomb suggests : that a new and growing class of herbicides can affect non-target plant and microorganism species at levels so low that they cannot be detected.[xxii] The 1980s opened the door for a new generation of potent herbicides that could be applied in very low doses compared with the conventional products available at that time. Despite the fact that no technology is available to detect these potent chemicals once they are applied, their use has increased extensively over the years.

Short and Colborn, taking a broad look at herbicides, found that over 60% of the poundage of all agricultural herbicides applied in the U.S. has the potential to disrupt endocrine and/or reproductive systems of humans and wildlife. Despite the fact that new, potent herbicides have come on the market, there has been no significant reduction in reliance on herbicides in the last 10 years.[xxiii]

In sum, therefore, the presence of pesticides in the natural media along with a global understanding that newer pesticides applied in extremely low doses can cause much greater harm than previously believed, should be the basis for understanding gaps in actual studies.

ORGANOPHOSPHATES

Organophosphates are very widely used across the country, as they are easily accessible.

Organophosphates are significant not just because they are widely used but also due to their persistence duration in water bodies. Thus a study of organophosphates is extremely crucial for aquatic toxicological studies.

In two research papers, Morowati (1997, 1998) has investigated the inhalation route of exposure of Thimet, a popular organophosphate[xxiv] , on the Male Swiss Mouse. He has discussed the inhalation route of this popular organpophosphate and how it effects both the liver and nervous systems under laboratory conditions. In another study, Sulekha et al. (1999) have analysed the fate of Monocrotophos on two varieties of fish[xxv], but they only deal with lethal doses.

Dutta et al.(1996) have pointed out the ultrastructural changes in the respiratory system of catfish exposed to sublethal dose of Malathion, an organophosphate[xxvi]. It may be noted here that Malathion is widely used for fogging purposes and can be expected to reach water sources in a number of ways, such as wash offs, run offs etc. This study therefore assumes importance because it indicates an impairment in a particular species lined with Malathion, which is commonly used.

SYNTHETIC PYRETHROIDS

Although our review suggests that there is relatively less work done on synthetic pyrethroids, the few available are important. Zeba et al have undertaken a lab study to demonstrate how the pyrethroid Fenvalerate was found to be toxic to ostracods, a major component of zooplankton fauna, specially in the benthic zone. This was seen in the mass mortality of the organisms, even at very low concentrations. This has serious implications since these ostracods are at the bottom of the food chain and are a major food source to many invertebrates and fishes and disruption to them will casue disrution in the biotic community. A study done by Srivastav et al.(1997) shows, "due to their lipophilicity, pyrethroids have a high rate of gill absorption, which in turn would be a contributing factor in the sensitivity of the fish to aqueous pyrethroid exposures"[xxvii]. The study also suggests that chronic exposure to Deltametherin disturbs the mineral balance in blood freshwater catfish which is ultimately expected to affect reproductive ability.

In another study by Dhawan and Kaur (1996) it has been shown that "synthetic pyrethroids are neither fully metabolised nor quickly detoxicated and therefore create serious problem of residue accumulation"[xxviii].

Cypermetherin, Deltametherin, Fenvalerate , all of which are synthetic pyrethoids , were studied for their effect on the eggs of *Cyprinus carpio* Linn eggs. It was found that the eggs exposed to different concentrations of these pesticides yielded either unhatched eggs, or abnormal or crippled larvae that died within 1-2 days of hatching, reducing the viable hatch significantly.

Hence, even Synthetic Pyrethroids have been seen to impact reproductive capacity at least in one case.

OTHER PESTICIDE RELATED STUDIES

A survey of literature in the field of aquatic ecosystem clearly indicates that the effect of individual pesticides on different physiological and biochemical aspects of aquatics have been extensively studied by a large number of scientists. None of these, however, determine what their findings imply for the health of the affected species or the long term impacts on the species. Besides, this, lower doses, which can lead to long term, irreversible changes, are not taken into account as they are not even measured as part of the study. This reflects the manner in which studies are framed and focused, and in fact, the manner in which the issues of toxic chemicals is itself perceived.

The case of Atrazine, the most commonly used herbicide in the U.S. and possibly the world, is a case in point.[xxix] Atrazine causes an array of sexual abnormalities including hermaphrodism (the development of both male and female sex organs) according to a new study published in the Proceedings of the National Academy of Sciences. The results may provide the key to a global mystery. For the last decade, scientists have documented a worldwide collapse in frog populations, and some believe that as many as 20 species are now extinct. Perhaps most surprising, frog populations have collapsed even in very remote, pristine areas. While the declines are well documented, the cause is a mystery. University of California , Berkeley researcher Tyrone Hayes may have found a key cause that would explain much of the decline : Atrazine.

Atrazine, is used in over 80 countries, and where it is used it is almost invariably found in streams, ponds and lakes. In the U.S., it is found in virtually all waterways. "[It] can be found in rain water, snow runoff, and ground water. There seems to be no atrazine-free environment," says author Hayes. The reason for this is simple: in addition to being widely used, it is also highly mobile and persistent in the environment. The EPA estimates that the average half-life of atrazine in aquatic environments is 167 days, and in the cold waters of Lake Michigan, it is 31 years. Atrazine flows downstream from farms where it is applied and is also picked up by winds and carried to remote areas. The EPA notes that atrazine "was detected in more than 60% of weekly rainfall samples taken in 1995 from agricultural and urban sites in Mississippi, Iowa and Minnesota."

While widespread atrazine pollution in the U.S. is well documented, U.S. pesticide manufacturers have long claimed that it is of little concern because the amounts normally found in the environment produce few obvious effects in laboratory studies. However, traditional toxicological studies use very high concentrations of atrazine and look for gross abnormalities. Hayes's low-dose study, documented subtle sexual abnormalities missed by traditional high-dose atrazine studies. The results of the study, if confirmed, may pave the way to a major rethinking of how toxicological assessments are done in the United States.

Atrazine is a known endocrine disruptor. Endocrine disruptors cause developmental harm in extremely low doses by interfering with hormonal triggers at key points in the development of an organism. Hayes' study shows significant sexual abnormalities at just 0.1 parts per billion (ppb)--30 times lower than levels allowed by the EPA for drinking water and 120 times lower than the 12 ppb EPA guideline for the protection of aquatic life.

The ubiquity of atrazine in the environment combined with an explanation of how very low concentrations might cause harm to frog populations could provide a key piece of information to unravel the mystery surrounding the decline of frog populations worldwide.

The EPA periodically re-assesses chemicals and is currently finalizing the ecological risk assessment for atrazine. Though this document is supposed to consider all the major ecological impacts, developmental impacts on frogs like those shown by Hayes' paper are not considered in their risk assessment model. In fact, impacts on amphibians are entirely ignored in their model, which only looks at mammals, birds, fish, aquatic invertebrates and plants. The EPA's conclusions, based on this flawed assessment are that "potential effects [are] likely to be greatest where concentrations recurrently or consistently exceed 10 to 20 ppb"--100 to 200 times the concentrations where significant sexual abnormalities were observed in Hayes' study. Though Hayes' results are mentioned elsewhere in the assessment, these risk assessment models are expected to form the basis of any EPA regulatory action.

For the fungicide vinclozilin, Gray found reproductive effects at levels below those previously considered to have no effect. He also goes on to show that for some of the antiandrogen effects, there may be no threshold - in other words, the slightest increase may initiate a response.[xxx] (Administration of Potentially Antiandrogenic Pesticides and Toxic Substances During Sexual Differentiation Produces Diverse Profiles of Reproductive Malformations in the Male Rat: Gray et al.; Environmental Antiandrogens: Low Doses of the Fungicide Vinclozolin Alter Sexual Differentiation of the Male Rat: Gray et al.)

CARBAMATES

A study on the effect of Carbaryl on *Cirrhina mrigala* by Kaur et al showed that it had adverse effect on the protein and lipid concentrations of flesh, liver and gonads and maturation and breeding potential of female *C. mrigala*.[xxxi]

SYNERGETIC STUDIES

While there are examples of studies on the level of pollution in these water bodies, studies on how different polluted land drains cumulatively effect the aquatic life of such water bodies are clearly lacking.

Similarly, a perusal of literature shows that information on the toxic effects of synergistic mixtures of pesticides on fishes is very limited. This could be due to the smaller numbers of field studies, where in fact, it might have been possible to see such synergetic impacts. However, from existing studies, it has been seen that field application of mixtures of two or more pesticides in different proportions, recently adapted by the farmers , makes the synergistic pollution problem more pronounced in the aquatic systems. Comparative studies on the synergistic and individual effects of pesticides is lacking. Ramaswamy et al show how 2 pesticides – Dimercron and Cuman L have a much more severe impact on the oxygen uptake and on blood haemoglobin of Freshwater edible Fish, Sarotherodon mossambicus (Peters) when acting in synergy, than individually [xxxii].

COMPARATIVE STUDIES

A comparative study of the impact of four pesticides on the fresh water snail, Bellamya dissimilis Mueller, shows us the irreversible physiological damage, whereby all 4 pesticides impact the digestive gland, mantle and foot of the animal. The lobules, inter-connective lobular tissue, muscle fibres surrounding the lobules were also damaged, but these varied with the pesticide. The table below indicates specific problems encountered with each pesticide.[xxxiii]

S.No	**Pesticide**	**Results**
1.	Endosulfan 35%	Shrunken lumen of digestive tube.
2.	Methyl-parathion 50%	Broken inter-lobular tissue, vacuoles in hepatic cells and connective tissues.
3.	Quinalphos 25%	Increased vacuoles in inter-lobular connective tissue, secretory cells become irregular.
4.	Nuvan 36%	Extensive damage to digestive gland tubules, deformity of hepatic cells, or complete destruction of tubules, hypertrophy of muscles, and hepatic necrosis.

In another study, N.Kaushik et al have shown how Aldrin, monocrotophos and Carbayl casue serious deleterious effects in the midgut (digestive system) , including lesions and even possible carcinogenic growth, of freshwater crab.[xxxiv]

Both these studies show how pesticides result in a deadly dysfunctionalism of various species.

A study on the impact of Furadan SP 50 on the Blue Rock pigeon, *Columbia livia* Gmelin shows that is causes significant alternations in haematological parameters, such as fall in Haemoglobin content and erythorocyte number, indicating anemia.[xxxv]

Chatterjee et al have shown how Carbofuran Technical 75DB was detrimental to survival and egg development of catfish, in a lab study.[xxxvi]

Pesticide poisoning has also been a cause for concern, particularly in the last 5 years. The most recent cases have been related to the use of an organophosphate pesticide (Demecron) to poison elephants at Nameri, Assam. [xxxvii] This case, like several others, is instructive because it opens out other possibilities ; As such animals are poisoned, poisons often banned or restricted are introduced into the eco-system, from where there is no further control upon them and they are able to contaminate the soil, other animals who may feed on the carcass, water etc. As wildlife-animal conflicts are reported more often, it has been seen that cases of poisoning by pesticides are more frequently reported. Hence, Cranes have been seen to be poisoned in Bharatpur, Rajasthan, peacocks in Morena, etc, typically wilfully and in order to rid the area of crop-raiders. This not only reflects the desperation at these levels, but also, the accessibility to highly toxic materials at affordable prices and unrestricted quantities. It also brings into focus the issue of the pesticide policy and its easy availability into question.

Heavy Metals

Heavy metals include Lead, Cadmium and Mercury, all of which are known to cause severe disorders in human beings. In the case of their impact on bio-diversity, a few important studies involving heavy metals have been carried out in India.

Studies have mostly been carried out on Fish, but three studies on Crustaceans and a single study on reptiles were also found.

Fish

Bioaccumulation pattern of metals in fish tissue can be utilised as effective indicators of environmental metal contamination. In a field study, Sultana and Rao (1998) have shown the bioaccumulation of Zinc, Copper, Lead and Cadmium in different organ systems of grey mullet, *Mugil cephalus*, a detritus feeder living in contaminated waters of the Visakhapatanam harbour[xxxviii].

In the case of Cadmium, a know nephrotoxic in the case of human beings, it was seen by Singhal et al that exposure to cadmium chloride damaged the histology, or cell structure of the kidneys of Common Carp, *Cyprinus carpio,* thus impairing it severely.

Meanwhile, a laboratory study by Chaurasia et al on the effect of lead on the thyroid dysfunction and lipid Peroxidation in the fish *Clarias batrachus* shows that is toxic to thyroid functioning in catfish even at low concentrations. Hepatotoxic functions of lead were also found in this study.

While the source of the contamination has not been specified, it is also difficult to source these. For example, lead and cadmium is present in several plastic colouring agents and can leach out in various media. Further, lead is widely used in paints and as an anti-rusting agency, which can also be found on ships in the harbour, old debris, etc. and in other uses. Various informal and formal industrial activities could also be the sources of these.

This study shows that not only does the liver but also the kidney accumulates heavy metals in a significant manner. Further, the metal content in the liver and kidney of *M.Cephalus* can be used as indicator in the rapid assessment of the metal contaminated waters. A useful conclusion of the study is that metal concentrations in the organs of fish rather than the metal concentrations in the water are suitable for environmental monitoring, especially when trying to relate the toxicity of metal to the biological function of specific organs[xxxix]. Unfortunately, the study does not tell us about how the species itself is impacted by heavy metals.
The impact of copper, which is also known to be toxic to animal life, except in micro-quantities, has been studied as well in a laboratory

study by James et al in VO Chidambaram College, Tutucorin, Tamil Nadu. Here, it was seen that freshwater fish, *Oreochromis mossambicus*, was severely impacted by exposure to copper. The physiological changes seen were a decrease in red blood corpuscles, Haemoglobin content, Haematocrit value, and Oxygen carrying capacity of the blood. White Blood cells, however, showed an increase under these circumstances, although the authors have not attempted to explain this as a defence mechanism of the fish. The study also found that the addition of a chelating agent, EDTA , to the copper media, reduced the copper level in water and the uptake in tissue. In field conditions, however, the factors becomes much more complex and a similar outcome cannot be predicted. What is possible is to invoke the Precautionary Principal to presume that discharges containing copper, could impact this species of fish in a manner similar to the laboratory study.

In another aquatic study, metal concentration has been analysed in fishes from Thane and Bassein creeks of Bombay by Asha Jyothi Krishnamurti and Vijaylakshami. However, this is a bioaccumulation study and does not give further information on the effects of this metal concentration on the physiology of fish or health impacts on it[xl].

REPTILES

Another significant study is that by Sahoo et al (1998), regarding the distribution of heavy metals in the eggs and hatchlings of Olive Ridley sea turtle *Lepidochelys olivacea,* in Gahirmatha, Orissa. Sahoo et. al. have reported that "Shell and yolk albumen of fresh eggs, hatched egg shells and newly emerged hatchlings of Olive Ridley sea turtle, *Lepidochelys olivacea,* along with eight nesting beach sand samples showed higher iron, zinc and lead concentrations than cobalt, chromium, copper and nickel. Beach sand samples recorded higher values of all metals than the egg components. Newly emerged hatchlings also recorded higher values than the fresh eggs. Embryos might have accumulated these metals from the nesting beach during incubation"[xli].

The study is an example of accumulation of heavy metals on the eggshell.[xlii] This is also a very important study because its results suggest that the heavy metals would clearly have impacted the embryo and effected its neurological and even renal systems. It is not easy to ascertain where these heavy metals have come from into the eco-system, but even poor disposal of municipal or household solid waste can introduce these into the environment. Given the poor or even nonexistent systems of waste handling in most parts of India, this is a scenario that should not be ruled out.

However, further studies linking the high levels of these elements with the sources of pollution have not been done. The existing studies offer important data but do not manage themselves to view the linkage as being important to biodiversity preservation.

CRUSTACEANS

Three studies examined the impact of heavy metals on Crustaceans.

In their study, Reddy at al found that lead and napthalene induced hyperglycemia in a Fiddler Crab Species, *Uca pugilator.* [xliii]

The study on freshwater crabs by Venugopal et al on the impact of Cadmium of crabs idemonstrates susceptibility of tissues to oxidative stress following exposure to Cadmium. However, given the nephrotoxic aspects of Cadmium, it is important to further link oxidative stress with larger impacts. The example of the Common Carp, cited above, shows how these effects have been observed in other animals.

In another study, Vijayan et al showed that freshwater prawns *Macrobrachium malcomsonii* was not able to regulate tissue concentrations of copper and chromium and thus accumulated these when exposed to them chronically. It is able to regulate zinc levels in its body below a threshold level, after which it also accumulates zinc. The study, however, does not examine the impact upon the animal of such accumulation.

Nevertheless, it is clear that crustaceans accumulate heavy metals and that it is likely that through them, species higher up in the food chain are impacted by this bio-magnification. How exactly these species are impacted is uncertain in the absence of field studies, but the presence and uptake of known toxins poses a problem of ecological health in any case.

OTHERS SPECIES

Another study by M. Gupta and P. Chandra on the bio-accumulation and Physiologica changes in Hydrilla verticillata Royale in response to Mercury shows that plants of Hydrilla, a profusely occurring submergent species found to thrive in polluted environments, is able to accumulate

Mercury effectively and show a high level of tolerance to it. However, at higher concentrations, the toxic effects of Mercury were seen through reduction in chlorophyll content , protein, nitrogen, phosphorus and potassium of the plant.[xliv] It is possible therefore to extrapolate form this study that Mercury at high concentrations reduces the ability of the plant to synthesize its own food, thereby posing a severe threat. However, it is still difficult to assess how such plants, that act as Mercury sinks, further release Mercury back into the environment to act as a further risk during their life cycles and later. Since this was a laboratory study, many of these answers can be got only by shifting the study base to the field.

INDICATORS IN OTHER MEDIA

While studies in this area might be limited, it is possible to gauge the problem through other kinds of available data : pollution in other media.. The study of Dr. Nitish Priyadarshi , "Damodar Pollution : Blame it on Coal" is a good case in point . According to Dr. Priyadarshi, who has studied the Damodar in Jharkhand , the river today is like a sewage canal with a high heavy metal load. The Damodar river basin is a repository of approximately 46% of the Indian coal reserves and this impacts the water resources in the region.

Due to easy availability of coal and prime coking coal, several thermal power plants and steel plants have grown up. Discharge of uncontrolled and untreated industrial wastewater, often containing highly toxic metals is the major source of pollution of Damodar River. Mine water and runoff through overburden material of open cast mines also contribute towards pollution of nearby water resources of the area.

Heavy metals like manganese, chromium, lead, arsenic, mercury, fluoride, cadmium, and copper are also found in the sediments and water of Damodar River and its tributary like Safi River. The presence of lead is high- over 300 ppm (parts per million) in the coals of North Karanpura coal field. Arsenic in the water ranges from 0.001 to 0.006 mg/l, mercury ranges from 0.0002 to 0.0004 mg/l, fluoride ranges from 1 to 3 mg/l.

With such high levels of heavy metals in the water, it is plausible that various fish and other species in the water will absorb these heavy metals and exhibit signs of being impacted.

Kaur and Kaur have studied the effect of Nickel chrome electroplating on different life stages of fishes (*Channa punctatus and Cyprus Carpio*)[xlv]. Although theirs is a laboratory study, they have used effluent from Hero Cycles to carry out their study, which reveals that at t a certain concentration, the fish , fry and fingerlings die due to respiratory disorders from blockage of gills from mucous. However, since the effluent contained chromium, cadmium, nickel, cupper, zinc, iron and mercury, it is difficult to determine the exact chemical that caused the death.

In the case of heavy metals, it is seen that the studies are poorly linked with sources, an omission that is surprising as it is not difficult to source many of these pollutants. It is also noteworthy that none of the studies, barring the one by Kaur and Kaur on nickel chrome electroplating , links an industrial activity with the discharge and consequent pollution. Nevertheless, it is possible to glean some information about the impact of heavy metals on wild-biodiversity.

OTHER CHEMICALS

There are very few relevant studies that have been carried out in India regarding other chemicals, or a mix of them. However, it is still important to take note of the complex cocktail of pollutants that are found in the natural environment and elsewhere, and the high possibility that these impact the bio-diversity in many ways. Often, despite the lack of data, anecdotal evidence or observations of the communities in the area serve as useful pointers. Although studies regarding the impact of toxics on bio-diversity are lacking in India, evidence from other parts of the world renders it likely that they are causing a deal of harm, given the irrefutable quantities in which they are present.

NON-PESTICIDE ORGANOCHLORINES

There are other organochlorines that are not pesticides, but are found commonly in various media. These include dioxins and furans, which are a by product of incineration of municipal, medical and hazardous wastes which contain the highly common chlorine, as well as open burning of wastes. Dioxins are also formed in industrial processes and are often found to contaminate the final product. They are also seen to be made during the life cycle of PVC plastics and the bleaching of paper using a chlorinated process. Often effluents from paper mills are used to irrigate fields. In other words, they are very much a part of our everyday living. Dioxins and furans are amongst the most toxic chemicals known to mankind. The discussion about dioxins has shifted from its cancer causing nature , as it was viewed in the early 1990s, to its properties as a reproductive and developmental toxins, as more and more was understood about it. It is now known to be a disruptor of the hormone system and cause severe reproductive effects in wildlife.

Another organochlorine is Poly Chlorinated bi-phenols, or PCBs. They are mostly used in transformers and capacitators. Although they are no longer supposed to be used or manufactured in India, they nevertheless remain in our surroundings from previous and current uses carried over from earlier uses and threaten the environment. The World Bank estimates that there are appx. 2000-4000 tons of PCBs in India currently. Internationally, PCBs have been banned much earlier. The USA, for example, banned it in 1976.

It has been seen that PCBs can travel very large distances, and impact human beings and animals in areas where there is almost no trace of PCBs locally. The case of the Polar Bears in Svalbard, for example, were found to contain high contents of PCBs in their fat, even though there was no clear use of PCBs in the area. Finally, it was widely hypothcized that the PCBs had traveled from the USA, where they had been produced or used.

PCBs are seen to severely impact the reproductive system through its hormone disrupting attributes, displayed even in small doses. In the case of the Svalbard bears, studied in the early 1990s, it was found that they had 20 times higher PCBs in their bodies than other Arctic bears. In this case, not only were there bear cubs being born with the reproductive organs of both sexes, but often, the female bears were even failing to reproduce at all. It has also been noticed that in general, the chemicals impact the young ones more than adults. Theo Colborn notes that researches studying seals in the Wadden Zee, off the Netherlands, which received industrial waste via the Rhine Muese estuary, find that even small doses – as low as 70 parts per million of PCBs is enough to cause severe problems in female seals. These include suppressed immune systems, deformities of the uterus and fallopian tube.

In their study of concentration of various organochlorines in the tissues of wildlife, domesticated animals and human beings, Senthil Kumar et al [xlvi] found dioxins and furans in most of the samples analyzed with the liver of spotted owlet containing the highest concentration of 3300 pg/g. Among fishes, meat, and wildlife samples analyzed, concentrations of dioxins were found in the following order: country chicken < goat/lamb fat < fishes < river dolphins < predatory birds. The authors suggest , "To our knowledge, this is the first report of PCDDs and PCDFs in human tissues, fishes, meat, and wildlife collected from India." This study also therefore serves as an indicator of two things. Firstly, the possible havoc being caused to both species like the Spotted Owlet and River Dolphins, as the data indicates. Secondly, that there are probably several other species which, as a result of bio-accumulation, are probably highly impacted. This becomes clear as they are seen in terms of the food chain.

Table 9 : The all-pervasive nature of organochlorines.

Table 8 : Industry and types of POPs

Types of Industry	Capacity	Inputs	Process	Types of POPs formed	Estimate of POPs production
Paper and Pulp	3.022x10x10 x10x10x10x10	Chlorine	C-E-H-H	di and tri cholor ophenols (Precursors to dioxins, furans) dioxins, furans)	Release to land (not by incineration) 24gms/86,000MT/ day Release in waste water 20 gms/ 86,000Mt/day Release in products- 25gms/86,000MT/dayx -3.
Dyes and intermediates	55,000 tonnes (only in organi sed units)	Chlorine	No Data	No Data	Currently no data available
Polyvinyl Chlo ride	7,80,000MT	Chlorine	Direct Chlo rination & Oxychlorin ation	Dioxins and Furans	An EDC/ PVC plant could produce up to 400 grams TEQ (toxic equi valents to the most toxic dioxins) per 100,0 00 tons of EDC produced
Incineration (municipal and hospital)		Chlorinated plastics and other materials	Combustion of Chlorina ted materials	Dioxins, furans and PCBs	**For municipal waste incinerator only** No calculation of emission to air. But in ash TEQ lev els range from 106ng/kg to 466 ng / kg with a mean value of 258 ng / kg. The fly ash has higher contamination levels 13000ng TEQ / kgx -5.

MISCELLANEOUS

Industrial Estates

There is no doubt that there is a severe problem of pollution in industrial estates. Often, the effluents that are released are a mixture of a number of chemicals. Hence, their effect on bio-diversity cannot be easily commented upon, in the absence of studies. The case of the seals at Wadden Zee, just mentioned above, gives an idea of just one type of problem. Other problems can be gauged from local understanding and observations.

In Gujarat, for example, the local communities now record the disappearance of mud skippers from the Daman Ganga river. Fish kills due to sudden discharge of effluents are often reported in many rivers along the golden industrial corridor of Gujarat. Already, 72 out of 184 Talukas of Gujarat are affected by ground water pollution. Organizations such as Paryavaran Suraksha Samiti (PSS) and Indian People's Tribunal, as well as Centre for Science and Environment (CSE), Greenpeace and Gujarat Ecology Commission have carried out studies that show the presence of many toxics. CSE has found mercury, lead, zinc and iron at alarming levels in all the chemical industrial areas they investigated. Greenpeace found over a hundred organic pollutants in the rivers, many of which are known to be carcinogenic, mutagenic, teratogenic. [xlvii]

Furthermore, according to PSS, rivers like Par, Kolak, Mini, Sabarmati, Mahi, Narmada, Daman Ganga[xlviii]are dying or already dead, due to the effluents they have been either carrying or receiving from industrial discharges.

In Purushan, Kerala, local communities have seen the disappearance of butterflies, damsel flies and honey bees from the area. Additionally, several plants, including medicinal plants (local names Mukkuty, Muthanga, Kurunatholi) [xlix]have also disappeared. Amongst fishes, Kolan and Poolai are also no longer seen.[l]

Near the NALCO plant Orissa, local communities observed a disappearance of crocodiles, fish, crabs and reptiles from the delta after the ash pond overflowed and almost 250 kilometers was contaminated on December 31st, 1999. [li]Ash is not only an immediate cause of contamination due to the particulate matter, but since it contains heavy metals like mercury and lead, it is also likely to effect species health in this manner as well, as studies by Sahu et al have shown in the case of the Olive Ridley Turtle.

However, mortality or morbidity of species could occur even due to other reasons. A study on the physiology of the Mole Crab *Emerita asiatica* at The Madras Atomic Power Station showed that 100% mortality of the species was seen at the Condenser Cooling Water

Pumps (CCWP) compared to no mortality at all at the Processed Sea Water Pumps, although the levels of residual chlorine and water velocity were similar. It was therefore concluded that the mortality in the CCWP was due to the higher temperature there.

While no toxics were examined in the study, it became significant even as it showed how industrial activity can impact bio-diversity before toxics are able to.

'Inert' Substances

Another area, which is only slightly understood, but important for the Indian context, is that of the myth of the inert. Inert substances include plastics, including those that are typically considered to be safe. However, it is now understood that additives in plastics can be toxic and often leach out. Gray et al , in 4 studies, [lii]describe the antiandrogen effects of some commonly used pesticides, toxic substances like phthalates (commonly found in plastics such as infant toys and floor tiles), and one of the PCBs. In the womb these chemicals produce diverse reproductive malformations in the male rat, such as undescended testes, hypospadias, vaginal pouches where penises should occur, permanent nipples in the male, and other reproductive malformations. In 1989, after two years of hard work, Ana Soto and Carlos Sonnenschien researches at Tufts University discovered what made breast cancer cells in the new plastic test-tubes behave as if estrogen was added to them. It was p-nonylphenol, which is part of a family of chemicals called alkylphenols, and is added to PVC and Polystyrene, to make them both less breakable and more stable.[liii] In 1993, another study was put into the public domain : A research team at Stanford leaned about another estrogen mimic – bisphenol-A, which was found in polycarbonates. It also became known that the bisphenol will leach if the plastic is cleaned using caustic cleaners or if it is kept at high temperatures. In the same case, it was also discovered that leaching of small amounts was not detected, because the company's detection limit was ten parts per billion. However, the amounts leaching, as low as two to five parts per billion, untdetectable, but "enough to cause an estrogenic response in cells in the lab."[liv]

Many of these plastics are now entering everyday Indian living, both as replacements for earlier materials and as new products themselves. Polycarbonates, for example, are commonly used as large water dispensing containers and the PVC market is expanding rapidly. There is also no policy to curb this growth : rather, as policy making for a and committees remain under the control of the plastics and petrochemicals industries, it seems unlikely that such scientific data will be admitted or reflected in decision making.

Recommendations and Conclusions

This review-study leads us to the following broad conclusions:

1. There is a very small body of literature available on the impacts of various toxics on bio-diversity.
2. The little information available indicates that many chemicals have been seen to adversely impact bio-diversity health. However, these have been studied only in the context of larger doses.
3. The impacts of these chemicals are possibly much wider than indicated by these studies.
4. Most studies do not indicate an understanding of the possible impact of toxics on a species. Hence, their own aim is to demonstrate effects rather than address the broader issue of species health or its possible endangerment. There are large gaps in the scientific data on levels of toxic chemicals in wildlife and aquatics and their impact on wildlife of the country in general. As this survey has pointed out, of the available data, most are restricted to investigating the levels of only a few individual organochlorines and organophosphates.
5. The studies usually do not examine the source of the toxin. They also do not place the results they find in the wider context of impacts on bio-diversity and bio-diversity conservation.
6. However, both lab studies and filed studies are able to provide us with a fair picture of the possible hazards that various toxins are likely to be creating for bio-diversity. The use of studies done abroad is also useful here.

In this context, the following recommendations have been made :

Recommendations for Research

a. There is a need for increased field studies taking into consideration a wide variety of known toxics.

Laboratory studies are unable to take into account the exposure to realistic environmental regimens, movement and quantum of toxics. Another important aspect of field studies is the toxicity drift pattern. Studies in USA have made us aware of how pesticides travel from one eco-zone to another. Pollutants such as PCBs from distant industrial centres have been blamed for an alarming incidence of hermaphroditic polar bears in the Arctic Svalbard islands. Recent studies have shown that 1.2% of Svalbard's polar bear population now have the reproductive organs of both sexes, but that ten years ago the phenomenon was unknown in this Norwegian territory where the bear's population equals that of humans[lv].

In India, to follow this example, there are about 2000-4000 tons of PCBs, used in transformers and capacitors. Though their use is restricted, their continued presence makes it likely that they are released into the environment through poor disposal by scrap dealers and fires in electrical installations. The impact of these can, from the above example, be expected to be severe. Studies on this and other chemicals, which have been found to have impacts in other parts of the world, should be undertaken as field studies at the landscape level. Hence, a co-ordinated effort between known toxic chemicals widely used in India and their impacts on bio-diversity must be undertaken.

b. Species specific studies, including top of food chain species must be undertaken.
Studies on species-specific chronic effects of environmental exposures to individual toxic chemicals are limited and should be further explored. In this context, it is useful to determine the impacts of toxics, including through bioaccumulation, on species on top of the food chain. This includes the tiger, elephant, rhino and other big mammals.

c. Links between disappearing or endangered species and toxics, if any, must be determined.

d. There is an absence of cross-basin indicator studies in India. Cross-basin indicator studies are needed to understand the toxic path and toxic effect-route of different pesticides/insecticides/heavy metals on non-target species[lvi]. Hence, identification of key indicator species and studies on top-level indicators are essential to carry out cross-basin indicator studies. Similarly, it is important to identify key indicator species across various zones , possibly those zones already identified by the NBSAP process, and where there is already an existing network, in order to monitor changes and the reasons for these.

e. There is a need to identify and **study the impact of toxics on biodiversity in highly polluted zones.** For this, collaboration with people's organizations, which are able to identify polluting establishments or estates, is essential. These toxic hotspots could include

- Tea Gardens
- Areas with a rich bio-diversity where there is agricultural run-off

- Factories generating organochlorines, such as pulp and paper mills (through their effluents) or chlor alkali plants, pesticide manufacturing units
- Other cash crop cultivating areas with intensive use of pesticides, such as Kasargod, in Kerala, where Endosulphan has proved to be the cause of gross human health damage. As an organochlorine, it is likely to have severe bio-diversity impacts too, based upon existing evidence within India and outside .
- Specific Highly Polluted Spots, such as the Gulf of Mannar and Tuticorin;
  Vapi-Ankaleshwar chemical belt in Gujarat; Mahim Creek; Mining Areas; such as Bauxite Mines etc; dumps of fly ash, which is known to contain heavy metals such as lead; Protected Areas which are near areas where toxics are manufactured or used and may enter through run-offs; such as Khaziranga, which is near the Tea Gardens.

f. **Investigations must be conducted where cases of drop in the number of species or other abnormalities are reported,** verbally, anecdotally or otherwise. Examples include Damanganga, near Vapi, Gujarat, where there is a dramatic drop in fish-biodiversity reported and abnormalities in mudskippers. In Kannur, there are reports of weird nesting patterns that must be followed up. In order to do this effectively, a network with local groups and those working on toxics will need to be established. (*See other recommendations in networks)*.

g. Our studies have shown the accumulation of pesticides in migratory birds, which later return to their summer homes. Hence, persistent chemicals, in the environment and the body of the animal travel across borders and can have an impact on them in both regions. Hence, more **trans-national collaborative work** should be undertaken as a follow up on existing data on sensitive species.

h. It is important to improve **monitoring facilities** to monitor the effect of toxics on wildlife population. This can be located within various networks, suggested in the next section, and can take the form of data collection and observation feedback systems. The capacity of existing monitoring stations should also be built up to this end.

i. Bio-Monitoring is also an important tool in this context, because it assists communities to assess the health of their own eco-systems. It is also indicative of synergetic effects that are only poorly understood in laboratory studies. It is important to introduce bio-monitoring either at the village/local urban levels through capacity building and with a mind and an emphasis on local understandings of the environment. *However, this will have to be only a preliminary, indicative action, because most of the chemicals discussed require complex analysis.* Nevertheless, it will serve to help create the basis for adopting a Precautionary understanding.

i. Many cases of disappearance of various species or their poor health is based upon observations of local communities and activists. It is crucial to build upon this by finding means of dialoguing with such communities and helping them to both observe and report such observations. For example, this could include training in the kinds of problems that are seen elsewhere, in discussing problems so that they are easier to identify, in identifying toxins that impact both the bio-diversity and human health.

j. In recent years, a lot of scientific emphasis has been on the sub lethal dose effect of toxic agents on wildlife species. These studies are time consuming in nature. In fact, timing of exposure relative to the organism's life cycle is also a critical determinant of outcome. There may be a considerable delay between toxic exposure and onset of effects. In addition, toxic effects are often not manifested in the environmentally exposed adult organism, rather, abnormalities may occur in the second or third generation offspring, and even then perhaps not evident until the offspring reaches physical or sexual maturity. In order to understand how any particular toxic agent effects one single species, we need to have regular and prolong monitoring of toxic agents over that particular species at different growth levels[lvii].

This is possible through simulated field studies or through simulated lab studies. We have examples of simulated field studies on rats and some varieties of fishes and crabs. However, we need to extend the scope of such exercises and varieties of species for simulated eco-toxicological studies.

j. Apart from simulated exercises there should be **intense dialogue between laboratory researchers and field researchers** on the subject under discussion. Here, we have noted that the focus of lab studies in India is more on understanding the impact of toxic agents on human beings rather than on wildlife. This can be inferred from the number of studies on rats and from the objectives of these studies. However, results from lab studies must be conveyed to those undertaking field studies.

k. While field studies are based upon specific toxics, **the sources of many of these are not ascertained. It is important to begin to discuss the limitations of such studies and the need to expand the scope of studies in order to overcome such limitations.** This must be done for important and significant studies in order to work towards a phase out advocacy. For example, while heavy metals have been found accumulated in various species, it is not known from where, and due to which activities and facilities the heavy metals originated. If this is known, then it is possible to consider more wide-impacting changes and protect bio-diversity. The study then also becomes more relevant to other areas with similar sources of contamination.

Building Networks

In order to be able to work more effectively, it is critical to build up networks of various kinds, which can receive and send information as well as be a part of the monitoring and surveillance exercise. This may be done as follows:

a. **A small clearinghouse of information must be immediately set up in this context**. The clearinghouse must be able to both facilitate information sharing and connect interested persons, as well as create an interest in the issue. It must also build up a network of such persons who are interested in the issue from various perspectives.

Its work could include housing all the papers on the issue, contacts of the scientists and others, be able to make these available to researchers, access newer work internationally and circulate it to interested groups, gather complaints and make the information available to any interested group. This will act as the core which will be able to help researchers and other interested organizations in both research and advocacy measures by compiling information and improving its accessibility to lay persons and researchers.

A body outside the government will be an appropriate agency to house such a clearinghouse.

b. **An exercise to make linkages between toxics and bio-diversity clearer to faculty and researchers** in various university departments etc. must be undertaken, through discussions etc.. This should aim at promoting research in the area.

c. Many of the physiological defects discussed are internal and have been reported by laboratories. It therefore is useful to **set up a reporting mechanism in responsive laboratories, based upon a profoma** (which could be handled by the clearinghouse), in order to learn if series of abnormalities are being observed in specific species at a given site and time and over a specific period of time.

d.**Links with local groups, whether or not working on toxics, particularly in highly polluted areas** are important, as mentioned earlier. This must be done by allying with them through both a dialogue process as well as part of the clearinghouse.

e. A simple proforma must be made and circulated to various types of organizations and officials: forest officers, district officials, research bodies, bird-watchers clubs etc. This would **enable a reporting and feed back mechanism for physiological or other changes in species.** The above-mentioned clearinghouse can also handle this.

f.**All information gathered about a specific species in an area must be transmitted back to the local population and to the officials and discussed with them** in a number of relevant ways.

h.A better dialogue created within those working on toxics and those working on bio-diversity is absolutely critical. The sectors working on wildlife protection and more broadly, bio-diversity conservation, as well as those working on toxics must **set up a mechanism to support, dialogue and interact with one another and build up an alliance.** Hence, the means for doing so must be laid out. The NBSAP mechanism, for the time being, and later, the clearinghouse described above can be central to this effort. An annual workshop to take stock of the situation and new information and a bi-monthly newsletter will be some of the means by which this process can be built up.

Education-related Recommendations

1. **It is critical to educate the public** and build up public understanding, through schools and otherwise, about the impact of toxic chemicals on their natural systems. This will also help them to make informed choices. This can be included as part of environmental education or mainstreamed in the science curriculum, as well as in higher education. It should also be taught to foresters, wildlifers etc. institutionally. Specific campaigns should be funded and undertaken to target adults.

2. Products used by consumers must be better labelled through a more suitable labelling scheme which also indicates if the product has components that can be acutely toxic, under what circumstances and to whom. A wide-spread campaign to familiarize the public must be undertaken.

3. All plastics must be labelled with a code, so as to enable the consumer to determine its polymer type as well as additives. This will also put such materials into public scrutiny.

Policy Recommendations

India at present follows toxics related policies that have neither forward linkages nor backward linkages. In the case of pesticides, there is only no policy being followed at all, but only the Insecticides Act, 1968. There are three clear areas where policy may be discussed : organochlorines, pesticides and heavy metals.

While India is a signatory to the POPs convention, which requires it to phase out 12 of the most deadly POPs, the means by which this can be done is not in place[lviii]. Many of the pesticides listed here as well those being reviewed are easily available across the counter, despite being banned. There is also no inventory on stockpiles, which accumulate and add to the environmental burden. There is also no move to encourage any biological means of controlling maleria, integrated pest management or improving sanitation and water channelling. DDT continues to be used for maleria control, despite its ineffectual results. Meanwhile, several more pesticides are available for use in household applications, making them even more readily dispersed in the air, water and soil. A s there is no extended producer responsibility, their containers, often with residual amounts of pesticide, are left to further contaminate.

Similarly, dioxins and furans, listed under the POPs Treaty, are created through processes like incineration and open burning of wastes. Yet, there has been a spurt in the number of burn technologies (those using incineration, gassification and other thermal means of waste handling, including waste to energy projects.) being approved all over the country. The Ministry of Non-Conventional Energy Sources has a scheme that greatly encourages such technologies and offers both subsidies and loans to entrepreneurs setting them up. No comparable encouragement is given to waste reduction, composting or improved packaging.

It is crucial that zero waste creation, waste minimization and better materials use is also incentivized through institutional support.

The danger of open burning, an important source of dioxins, has not hit home at any level of governance. While citizens are commonly seen to be burning uncollected waste, municipal authorities often do the same, to reduce the volumes as well as to compensate for their inefficient service delivery.

A much wider understanding of the problem needs to be built up, through workshop formats at the local levels across the country, for various kinds of persons working in the field of sanitation and conservancy as well as citizens. Such work needs to be carried out in collaboration with both civil society organizations that have worked on the ground level on these issues as well as the medical and scientific community.

Dioxins are also created during various industrial processes, such as PVC manufacturing and recycling, bleaching of paper production, making household cleaners, cement kilns, copper smelting and medical waste incineration. Increasingly, leaching from landfills is also posing a big threat for this reason. While PVC can be phased out in India, as it is being in several uses in other parts of the world, other operations will require cleaner production or substitute technologies. In the case of medical waste incineration, these are already in place in the Bio-Medical Waste (Handling and Management) Rules, 1998. For paper, peroxide bleaching is also underway, with the initiative having been undertaken by the Central Pollution Control Board.

PCBs are still around in vast quantities. However, there is a need to inventorize these, contain them, completely ban the further use of these and enforce regulations.

The situation is much more complex in the case of heavy metals as they are widely used. However, three heavy metals need special attention, because of their deadly effects : Lead, Cadmium and Mercury. **Here, while there is no policy framework to phase out toxics, including heavy metals., it is possible to create a framework for their phase out in various applications and create incentives to promote alternatives. In some cases, such as the Lead Acid Batteries, there are regulations in place, but these are not widely understood even by administrators. This needs to be changed through building a greater understanding of existing rules and their applications, as well as facilitating better networks within implementing agencies so as to support each other through experiences and information**. While Mercury is used in several applications, it is useful to take note of the new laws in the United States, which are phasing out Mercury Thermometers in favour of alternatives. **Such progressive policy frameworks must be built up through public pressure and advocacy.**

However, in the case of toxics, these policy issues, as yet unexplored, remain critical

1. **Transparency and Mandatory Sharing of Information** : It must be mandatory to make available a detailed database of the components all materials and formulations , as well as their known effects on animals or human beings, entering the market. These can be coded with the details available in the public domain, on the net and as published and updated versions. This is critical because it enables interested persons to learn about the possible harm from various materials and chemicals. It is also different from Right to Information, which presumes that citizens are aware enough about toxicity to ask the appropriate questions in order to learn about the possible impacts on their own health and the environment.

2. **Toxics Release Inventories and the Community Right to Know :** While it is mandatory for industrial units in many parts of the world to inform the community of the chemicals being manufactured and wastes and by-products being released, as well as the possible dangers associated with this, it is not so in India. This must be implemented and linked up with the permissions to operate.

3. **Re-visit Exports :**India manufacturers both toxic chemicals, like various pesticides, as well as using hazardous processes to manufacture products, like Mercury Thermometers, for the purpose of export. In this

way then, the importing countries are able to use India as a dumping site in advance of receiving the goods, which is similar in principal to exporting toxic wastes. A list of such export-only commercial ventures must be re-visited and discussed in the light of their environmental impacts. Similarly, the Export Promotion Zones must also be re-examined.

4. **Extended Producer Responsibility :** Some of the existing contamination problems are also due to poor disposal of various goods, such as Ni-cad batteries and computers, after their active use. It must be mandatory for the manufacturer to take them back for proper disposal, failing which manufacturing itself cannot take place.

5. **Globally, a more transparent waste handling regime must be advocated for**, in order to stop the trans-boundary movement of hazardous waste . This can be done through strong alliance building.

The following recommendations are based upon the understanding that it is imperative that the issue of toxics/chemicals be included in the bio-diversity protection agenda. The movement against a toxics regime will also find ammunition for its own advocacy in this and its own objectives will be served as well. . Knowledge about the impact of toxic chemicals on wildlife needs to be incorporated both into the policy framework for wildlife protection as well as regulation and control of hazardous chemicals.

a. Since pesticides and other toxics travel far and wide, regardless of their point of use, **a toxics regime must be established around and within buffer zones around Protected Areas and other bio-diversity hot spots.** This should examine the use of the organic farming and alternative/less harmful ways of maleria control, as well as best practices for waste handling as all these activities cause toxicity in the environment. Where required, specific incentives, determined through a dialogue process with the communities, can be offered for making such shifts in practice For example, in highly popular PA s, some of the costs paid by tourists can go towards incentivizing alternative practices to pesticides and growing organic foods, which can be brought back for local consumption and even as a tourist attraction. Similarly, improved liquid and solid waste handling is also critical and communities may be trained to handle these better through simple practices, such as not burning waste etc. Another area of concern is the use of household toxins by various guest houses and even homes. Here, a list of the most toxic solvents and other chemicals used must be created along with their alternatives for both awareness as well as strict implementation. *However, it is important to note that this is no substitute for actually phasing out toxics* in toto, on a global scale.

b. Industrial processes that can be potentially hazardous through their emissions or products, situated near or in a Protected Area, must be considered in the light of their impact on bio-diversity and manufacturers should be encouraged to shift to cleaner production. It is exactly for such small shifts that policies with incentives at their core are required. Where this is difficult, a case to case decision must be taken by a small core group, aimed at minimizing pollution, without creating unemployment. Such steps could include other types of work , cleaner production, producing cleaner alternatives etc.

c.The Union Ministry of Agriculture is currently considering a policy of encouraging organic farming. However, it is imperative to **advocate for greater incentives for organic farming, especially during the crossing over period. It is also advisable to enforce higher pricing and stricter availability of many pesticide formulations**.(ak: Phasing out subsidies on chemicals and putting them into organic inputs) The list of these can be drawn up based upon their impact on human health and the environment. Are there any changes needed in the distribution system which presently advocates pesticides/fertilizers.

d.The presence of old stockpiles of expired pesticides is posing a tremendous problem. While it is difficult to handle this without adding pollution, it is imperative that production capacity is reduced to meet only essential demands till the phasing out of these chemicals is complete. As the phase out progresses, the capacity of these factories must be reduced, in order for them to close down finally without huge stockpiles. Although the current disposal mechanism for old stockpiles is still contentious, inventorization can be begun without any delay.

e.There can never be any other way to protect the environment, bio-diversity or human health from the impact of toxics except by phasing out the toxics regime. This can be achieved through both a re-examination of the goods produced through these proceses as well as the notions of clean production and extended producer responsibility. Some of the important steps to be taken in these areas are as below:

- Phase out of the 12 compounds mentioned under the POPs Treaty

- Phase out all incineration unless very specific, centralized facilities for certain categories of bio-medical waste meeting the prescribed standards are set up.
- No more incentives for any burn technologies) in India and a total ban on these.
- Incentivized move towards cleaner production in chlorine based industries, such as paper and other bleaching (replaced by peroxide bleaching) and dry cleaning (non-perc based cleaning, including wet cleaning).

- Phase out of Mercury from various applications. Initially, some of the phase out steps could include phasing out mercury thermometers.
- Phase out of Lead and Cadmium (the latter is also listed as an endocrine disruptor) based upon a priority list. Lead is slated to be phased out of paints, but alternatives must be sought out for batteries and dyes, apart from other uses. Cadmium is relatively unacknowledged for the purpose of phasing out.
- Common Effluent Treatment Plants are being propounded as the means of handling mixed toxic effluents from industrial areas. These however are ineffectual in dealing with the problem and the policy trend must be reversed.
- A phase out and total ban on chlorinated plastics like Poly Vinyl Chloride (PVC) and polyurethane.
- Pesticide availability must be made much tighter and restricted.
- All these can be back-stopped by either alternatives products or processes, or even a shift to service delivery. This needs to be done through a well synchronized mechanism which involves both creation of a list of priorities based on human health and environmental damage and a medium term plan to incentivize production of alternatives and create a phase out mechanism. The working group can follow the systems of the NBSAP process in the sense of creating linkages till the grass roots in each working sector. The process must be steered not only by government agencies, but representatives of civil society, the medical community, scientists and research organizations. The participation of industry and dialogue with it is important but its participation in steering the process may be questioned.

In initiatives linked to these, which impact both human health and bio-diversity, there must be joint campaigning and support extended by one sector to another.

g.The issue must be placed for **discussion and action at the level of Panchayats**, which now enjoy more decision-making powers and autonomy after the 73rd Amendment. In this case, it must be linked up clearly with the impact toxics have on human health, including reproductive health.

h. It is critical to build up a strong voice to advocate against the promotion of a toxics regime through misguided policy in India, through impacting political decision making. Being a part of the anti-toxics movement must appear to be an attractive proposition to political leaders and must be made a part of their agenda. A broader coalition of civil society is essential to deal with the problem

EndNotes

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[i] Endocrine disruptors are synthetic chemicals that block, mimic or otherwise interfere with naturally produced hormones, the body's chemical messengers, that control how an organism develops and functions. Wildlife and humans are exposed daily to these pervasive chemicals that have already caused numerous adverse effects in wildlife and are most likely affecting humans as well. Hormones play a crucial role in the proper development of the growing fetus. The fetus is vulnerable even to the most minute concentrations of introduced toxic substances. Chemicals are passed from mother to offspring, via the womb and breastmilk in mammals and via the egg in reptiles, amphibians, fish and chickens, leading to "trans-generational" effects.

[ii] wwf : global toxic., for more cases of endocrinal disruption see, Nagler JJ, J Bouma, GH Thorgaard, and DD Dauble. 2001. High Incidence of a Male-Specific Genetic Marker in Phenotypic Female Chinook Salmon from the Columbia River. Environmental Health Perspectives 109:67-69. For more recent studies on endocrinal disruption please see, http://worlwildlife.org/toxics/progareas/ed/sci_2.htm

[iii] Ibid.,

[iv] WORLDTWITCH-India-ReportbyRobertW.Risebrough
worldtwitch.virtualave.net/vultures_india.htm

[v] WORLDTWITCH-India-ReportbyRobertW.Risebrough
worldtwitch.virtualave.net/vultures_india.htm

[vi] Ibid.

[vii] "Killers at large" Press Release of 4th January 1999, **CSE,**

[viii] Naoroji Rishad, "Contamination In Egg Shells of Himalayan Greyheaded Fishing Eagle Ichthyophaga Nana Plumbea In Corbet National Park, India", ***Journal of Bombay Natural History Society,*** vol. 94**,** 1997, pp. 398-400.

[ix] Hickey J.J. and Anderson D.W., "Chlorinatede Hydrocarbon and Eggshell Changes in Raptorial andFissh Eating Birds", ***Science***, vol.162, 1968., Risebrough R.W., "Pesticides and Bird Populations", ***Current Ornithology***, vol.3, 1986., Anderson D.W. and Hickey J.J., " Eggshell Changes in certain North American Birds", ***Proceedings of International Ornithology Congress., 1972.***

[x] Sinha N, Narayan R, Saxena D.K, "Effects of Endosulfan on the Testis of Growing Rats," *Bulletin of Environmental Contamination*, vol.58, 1997, pp.79-86

[xi] Hazarika R. and Das M., "Toxicological Impact of BHC on the Ovary of the Air-Breathing Catfish *Heteropneustes fosilis* (Bloch)", ***Bulletin of Environmental Contamination***, vol.60, 1998, pp.16-21.

[xii] Singh T.P, Lal Bechan, Yadav Atulya Kumar, "Pesticides and fish," Fish Endochronology Laboratory,Centre for advanced study in Zooology, Benaras Hindu University.

[xiii] Ibid

[xiv] Ibid

[xv] Reddy A.N, Venugopal N.B.R.K, Reddy, S.L.N, " Effect of Endosulfan 35 EC on some Biochemical Changes in the tissues and Haemolymph of a Freshwater Field

Crab, barytelphusa guerini. "***Bulletin of Environmental Contamination***, vol.55, 1995 pp. 116-121.

[xvi] Tanabe S, Senthilkumar K., Kannan K. and Subhramanian A.N., " Accumulation Features of Polychlorinated Biphenyls and Organochlorine Pesticides in Resident and Migratory Birds from South India", ***Archieves of Environmental Contamination and Toxicology,*** vol.34, 1998, pp.387-397.

[xvii]Ibid

[xviii] Tanabe S, Senthilkumar K., Kannan K. and Subhramanian A.N., " Accumulation Features of Polychlorinated Biphenyls and Organochlorine Pesticides in Resident and Migratory Birds from South India", ***Archieves of Environmental Contamination and Toxicology,*** vol.34, 1998, pp.387-397.

[xix] Colborn Theo, Myers John Peterson, Dumanoski, Dianne " Our Stolen Future" ***Little, Brown and Company,*** 1996.

[xx] Singh, N.N, Das, V.K,Singh, S, " Effect of Aldrin on Carbohydrate, Protein, and Ionic Metabolism of a Freshwater Catfish, *Heteropneustes fossilis.*" ***Bulletin of Environmental Contamination***, vol.57, 1996, pp.204-210.

[xxi] Dodson et al, " Dieldrin Reduces Male Production and Sex Ratio in Daphnia *Galeata mendotae*.", **from**://www.worldwildlife.org/toxics/progareas/ed/scs.htm

[xxii] www.worldwildlife.org/toxics/progareas/ed/scs.htm

[xxiii] ibid

[xxiv] Morowati Mohssen, "Inhalation Toxicity Studies of Thimet (Phorate) in Male Swiss Albino Mouse, *Mus Mussculus* :I.Hepaatotoxicity", ***Environmental Pollution***, vol.96, no.3,1997, pp.283-288.

------"Inhalation Toxicity Studies of Thimet (Phorate) in Male Swiss Albino Mouse, *Mus Mussculus* :II. Lung Histopaathology, Pseudocholinesterase Level and Haematological Studies", ***Environmental Pollution***, vol.103, no.3,1998, pp.309-315.

[xxv] Sulekhaa B.T., Mercy T.V.A and Nair J.R., "Lethal Toxicity of Monocrotophos on the Juveniles of Rohu and Mrigal", ***Indian Jounaal of Fissh,*** vol. 46, no.2, 1999, pp.319-321.

Dutta H.M., Munshi J.S.D., Roy P.K., Singh N.K., Adhikari S. and Killius J., "Ultrastructural Changes in the Respiratory Lamellae of the Catfish, *Heteropneustes Fossilis* after Sublithal Exposure to Malathion", ***Environmental Pollution***, vol.. 92, no.3, 1996, pp. 329-341.

[xxvii] Srivastav A.K., Srivastava S.K. and Srivastav S.K., "Impact of Deltamethrin on Serum Calcium and Inorganic Phosphate of Freshwater Catfish, *Heteropenustes fossilis*", ***Bulletin of Environmental Contamination***, vol.59, 1997, pp.841-846.

[xxviii] Dhawan A. and Kaur K., " Effect of Carbaryl on Tissue Composition, Maturation, and Breeding Potential of *Cirrhina mrigala* (Ham.), ***Bulletin of Environmental Contamination***, vol.57, 1996, pp.480-486.

-----------, " Toxic Effects of Synthetic Pyrthroids on *Cyprinus Carpio* Linn. Eggs", ***Bulletin of Environmental Contamination***, vol.57, 1996, pp. 999-1002.

[xxix] Feminized Frogs: Herbicide disrupts sexual groups," Science News Online, April 20, 2002, Vol. 161, No. 16, http://www.sciencenews.org/20020420/fob1.asp. Also see www.panna.org

[xxx] Administration of Potentially Antiandrogenic Pesticides and Toxic Substances During Sexual Differentiation Produces Diverse Profiles of Reproductive Malformations in the Male Rat: Gray et al.; Environmental Antiandrogens: Low Doses of the Fungicide Vinclozolin Alter Sexual Differentiation of the Male Rat: Gray et al

[xxxi] Kaur, K and Dhawan A, " Effect of Carbyl on Tissue Composition, Maturation and Breeding Potential of *Cirrhina mrigala* (Ham.) " ***Bulletin of Environmental Contamination***, vol.57, 1996, pp. 480-486.

[xxxii] For such kinds of studies see, Ramaswami M., Thangavel P., Dhanalakshami S., Govindraj P. and Karuppaih D., "Comparative study on the Synergistic and Individual Effects of Dimecron and Cuman L on Oxygen Uptake and

Haematological Parameters of a Freshwater Edible Fish, Sarotheroddon mossambicus (Peters)", ***Bulletin of Environmental Contamination***, vol.56, 1996, pp.796-802.

[xxxiii] Jonnalagadda, P.R and Rao, M, B, P " Histopathological Changes Induced by Specific Pesticides on Some Tissues of Fresh Water Snail, Bellamya dissimilis Muller." ", ***Bulletin of Environmental Contamination***, vol.57, 1996, pp.648-654

[xxxiv] Kaushik, N and Kumar, S, " Midgut Pathology of Aldrin, Monocrotophos and Carbyl in the Freshwater Crab *Paratelphusa masoniana,* "***Bulletin of Environmental Contamination***, vol.60, 1998, pp. 480-486.

[xxxv] Sharma, L.L and Saxena, P.N, " Furadan SP50 Induced Haematological Responses of Blue Rock Pigeon, *Columba Livia,* Gmelin. ***Bulletin of Environmental Contamination***, vol.61, 1998, pp.297-302

[xxxvi] Chatterjee S, Ghosh, R, " Toxicity of Carbofuran Technical 75DB to the fertilization of Eggs of Catfish, Heteropneustes fossilis (Bloch)", ***Bulletin of Environmental Contamination***, vol.55, 1995, pp.111-115.

[xxxvii] Surajit Khaund , " Pesticide poisoning responsible for pachyderm deaths at Nameri,"
Assam Tribune , Guwahati, 15th September 2001.

[xxxviii] Sultana R. and Rao D.P., "Bioaccumulation Patterns of Zinc, Copper, Lead, aand Cadmium in Grey Mullet, Mugil Cephalus (L.), from Harbour Waters of Visakhapatnam, India", ***Bulletin of Environmental Contamination***, vol.6o, 1998, pp.949-955.

[xxxix] ibid., p.954

[xl] Krishnamurti Asha Jyothi and Nair R. Vijayalakshami, "Concentration of Metals in Fishes from Thane and Bassein Creeks of Bombay, India", ***Indian Journal of Marine Sciences***, vol. 28, 1999, pp.39-44.

[xli] Sahoo G., Sahoo R.K., Mohanty P. and Hejmadi, " Distribution of Heavy Metals in the Eggs and Hatchings of Olive Ridley Sea Turtle, *Lepidochelys Olivacea,* From Gahirmatha, Orissa", ***Indian Journal of Marine Sciences***, vol. 25, 1996, pp. 371-372

[xlii] Sahoo G., Sahoo R.K., Mohanty P. and Hejmadi, " Distribution of Heavy Metals in the Eggs and Hatchings of Olive Ridley Sea Turtle, *Lepidochelys Olivacea,* From Gahirmatha, Orissa", ***Indian Journal of Marine Sciences***, vol. 25, 1996, pp. 371-372.

[xliii] Reddy, P.S, Katyanai, R.V, Fingerman, M " Cadmium and Napthlene induced Hyperglycemia in the Fiddler Crab, *Uca Pugilator* : Differential Modes of Action on the Neuroendocrine system." ***Bulletin of Environmental Contamination***, vol.56, 1996, pp.425-431.

[xliv] Gupta, M and Chndra, P " Bio-Accumulation and Physiological changes in *Hydrilla verticillata* Royale in Response to Mercury." ***Bulletin of Environmental Contamination***, vol.56, 1996, pp.319-326.

[xlv] Kaur A. and Kaur K.,"Relative Susceptibility of Different Life Stages of *Channa punctatus* and *Cyprus Carpio* to Nickel- Chrome Electroplating Effluent", ***Bulletin of Environmental Contamination***, vol.57, 1996, pp.836-84

[xlvi] K u r u n t h a c h a l a m s e n t h i l k u m a r ,* ,† k u r u n t h a c h a l a m k a n n a n , ‡ o d a t h u r a i n . p a r a m a s i v a n , § v e l l a k o v i l p . s h a n m u g a s u n d a r a m , | j u n k o n a k a n i s h i , † a n d s h i g e k i m a s u n a g a, " Polychlorinated Dibenzo-p-Dioxins, Dibenzofurans, and Polychlorinated Biphenyls in Human Tissues, Meat, Fish, and Wildlife Samples from

India, " Institute of Environmental Science and Technology, Yokohama National University, 79-7 Tokiwadai, Hodogaya-ku, Yokohama 240-8501 Japan,
National Food Safety and Toxicology Center, Michigan State University, East Lansing, Michigan 48824,
Kovai Medical Center and Hospitals, P.O. Box 3209, Avinashi Road, Coimbatore 641014,
Tamil Nadu, India, and K. G. Hospital and Post Graduate Medical Institute, Arts College Road, Coimbatore 641018,
Tamil Nadu, India
Environmental Science & Technology / Vol. 35, no. 17, 2001

[xlvii] Paryavaran Suraksha Samiti, " Affluent in Effluent : Investigating Contamination of Ground Water in Golden Corridor of Gujarat". Report. Gujarat. June 2002.

[xlviii] Ibid

[xlix] Personal discussion with activists and communities from the area, July, 2002, Bangalore.

[l] Ibid

[li] Discussions with communities working on health issues from the site, Bangalore, July 2002

[lii] www. worldwildlife.org

[liii] Colborn Theo, Myers John Peterson, Dumanoski, Dianne " Our Stolen Future" ***Little, Brown and Company,*** 1996.

[liv] ibid

[lv] Researchers from the Norwegian Polar Institute believe that it may be no coincidence that levels of Pychlorinated biphenyls (PCBs) in Svalbard polar bears are up to 20 times higher than Alaskan ones. Effects of pollutants such as PCBs on polar bears could be tracked because of the short and simple food chain. Plankton contaminated by the chemicals is eaten by fish, which are subsequently eaten by ringed seals, the staple diet of polar bears. Polar bears are thought to be the animals most visibly affected by PCBs because they primarily consume seal fat, and such pollutants gather in fat tissue. PCBs are known to affect the endocrine system, which may explain conditions such as hermaphroditism taking place among the female bears. Svalbard is particularly prone to pollution because toxic materials are dumped by the prevailing southerly winds from

industrial Europe and also by large Russian rivers carrying pollutants into the Norwegian Sea through the Fram Strait, west of the islands"Pollutants blamed for huge increase in hermaphrodite polar bears", http://www.arctic.noaa.gov/, http://www.edie.net/ http://www.lby.npolar.no

[lvi] Generally the studies have been very focused in terms of geographic regions. From the studies of polar bears and Slamon fishes we know that toxics know no boundry. Notably high levels of organochlorines are evident in some countries of tropical Southeast Asia where some of the compounds are still used. In addition, high levels of organochlorines also persist in the environment of Southeast Asia and Oceania as a result of past uses of these compounds. Marine pollution by organotins was high across the region but exceptionally high around Japan. POPs which are released in tropical Southeast Asia not only cause local contamination problems but may also contribute to pollution in areas of the world far away from their source. Studies on rivers and sediments indicate that because of high temperatures in the tropics, the residence time of POPs is shorter in water bodies and transfer to the atmosphere is greater. Shorter residence times in tropical waters may be favorable for this aquatic environment but transfer to air has wider implications for the global environment. Semivolatile and persistent POPs such as HCB and HCH appear to be gradually redistributed from tropical point sources to colder regions on a global scale. In the marine environment, it has been suggested that chlordanes and PCBs are likely to disperse to remote oceans through the ocean atmosphere whereas HCHs and DDTs are less transportable through the ocean atmosphere and are rapidly absorbed in the water bodies close to the emission source. Levels of POPs are still high enough to be of concern, and moreover, levels of other POPs which are still widely produced, such as the brominated flame retardants and organotins, add to the already heavy burden of POPs. Because the release of POPs into the environment is continuing, there is a potential for further severe impacts on the health of wildlife and humans.

[lvii] An example of life cylce effect of toxic chemical is, Cote Steeve D., Bianchet Marco Festa and Fournier Francois, " Life- History Effects of Chemical Immobilization and Radiocollars on Mountain Goats", ***Journal Of Wildlife Management,*** vol. 62, no.2, 1998, pp. 745-752

[lviii] For a list of the dirty dozen, please see Table 8, Pg