CHLORTOX

# A catalogue of gross contamination

## Organochlorine production and exposure in India

*India is one of the few remaining countries still engaged in the large scale manufacture, use and export of some of the most toxic chlorinated pesticides, such as DDT, HCB and pentachlorophenol.* ***David Santillo, Paul Johnston, Ruth Stringer and Bob Edwards*** *analyse the pollution produced by this industry.*

An estimated 70% of the gross tonnage of pesticides used in agricultural applications in India consists of formulations which are banned or severely restricted in the North and West[1]. India is one of only two countries worldwide (along with US) to have applied more than 100,000 tonnes of DDT since its initial formulation[2]. Malarial control programmes have accounted for the majority of the DDT applied since its agricultural use was banned in 1989[3].

India now exports organochlorine and other pesticides to many countries, including US, UK, France, Germany, Netherlands and countries in Latin America, Africa and the Middle East[4]. On the domestic market, BHC (or technical HCH*) has accounted for much of the total sales in India over the last ten years[5,6]. Although a complete ban on the production and sale of BHC came into effect in April 1997[7], the Government of India is encouraging its replacement with lindane (gamma-HCH), an isomer of the same compound which retains many of the hazardous properties of BHC. In addition, the pesticides industry sees the ban on BHC as an opportunity to increase the market share for other pesticides, including the organochlorines endosulfan and fenvalerate[8].

### Sources of exposure

A very high proportion of persistent organic pesticides applied to soils volatilise to the atmosphere (99.6% for HCH in the Vellar River area, South India[9]), and may be carried over long distances before re-depositing. The continued application of these compounds in India therefore adds significantly to the national and, indeed, global burden of persistent organic pollutants (POPs). Intensive application in India accounts for the relatively high levels of lindane, other isomers of HCH, DDT and similar compounds in fauna from the Bay of Bengal[10], in Ganges river dolphins[11], and in the air and rainwater of a number of different provinces[12,13]. Fugitive emissions from pesticide production processes in India are probably also significant on both a local and global basis, but are relatively poorly researched.

There are three principal routes of human exposure to pesticides. The broadest section of the population are exposed through widespread contamination of environmental media (as outlined above) and foodstuffs. Several studies have demonstrated the high incidence of DDT and HCH contamination in both adult and infant food, particularly milk products[14,15]. Singh[16] estimated that, in some regions of India, average daily intake of DDT from mothers' milk was between 13 and 24 times in excess of current WHO guidelines.

Agricultural and household use of pesticides accounts for significant exposure for a smaller sector of the population, particularly when the users are ill-informed of the hazards. To date, there appears to have been no attempt to assess the long term health implications of the continued open application of DDT as a malarial control agent throughout India. Nevertheless, in a classic study of workers in cotton plantations in southern India, Rupa[17] demonstrated a link between chronic exposure to a mixture of DDT, HCH and endosulfan and decreased fertility in males, an increase in birth defects and in neonatal deaths.

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Despite the scale of the chemical manufacturing industry, and future predictions for growth, the significance of direct exposure to pesticides and other chemicals in the workplace or near sites of production has been relatively poorly investigated in the context of practices in India. Very little information is available on working practices, long term worker health and the nature of waste streams and other fugitive emissions generated by individual plant and industrial estates as a whole. This highlights one of the major difficulties in the assessment of occupational chemical exposure in India.

### Industrial estates of the 'Golden Corridor'

Some of the largest agglomerations of chemical manufacturers are located in the North Western coastal state of Gujarat, including the industrial estates at Nandesari, Ankleshwar and Vapi situated along the 'Golden Corridor' between Mumbai (Bombay) and Ahmedabad. These estates encompass a wide range of chemical manufacturing industries, producing pesticides, dyes, textiles, plastics, paints, pharmaceuticals and chemical intermediates. Larger units, generally well organised on site and often screened by high walls and trees, operate alongside numerous smaller units, many of which utilise plants in an appalling state of repair and give little, if any, regard to worker safety. Beyond the boundary fences of most plants, effluents are simply discharged into open roadside ditches. These serve to collect liquid wastes from a particular area of the estate, irrespective of composition, and deliver them, at best, to the settling ponds of a common effluent treatment plant and, at worst, to a number of larger collection ponds which in turn discharge to a nearby water course. Ankleshwar alone generates 60,000 tonnes per year of solid wastes;[18] no estimates are available for liquid wastes. Solid wastes from many plants, including sludges from treatment plants, are commonly dumped directly on to soil on the periphery of the estates. In simple terms, the quality of the air, water and soil surrounding and downstream from these estates has been sacrificed to the manufacture of chemicals on a massive scale.

Ankleshwar is probably the largest chemical industrial zone in Asia[19] and, in common with the smaller estates, has the characteristics of development with little planning control and practically no consideration for waste management. There are more than 1,200 industries on the estate, employing approximately 70,000 people, primarily a migrant, casual labour force. Security on some plants is tight, on others non-existent, but there is a universal unwillingness to discuss working conditions for fear of losing jobs.

### Waste identification survey

In April 1996 a scientist from the Greenpeace Research Laboratories visited some of the main industrial complexes in Gujarat, and other regions of India, in order to conduct a preliminary survey of waste management practices in the chemical industry sector. Samples were obtained from a limited range of liquid and solid wastes, representative of the many waste streams present, at the point of release to the environment. Samples were prepared using simple solvent extraction and subjected to qualitative analysis by GC/MS (gas chromatography/mass spectrometry) in order to identify, as far as possible, the organic contaminants present. The intention was to obtain a broad overview of the quality of typical wastes, the efficacy of treatment systems where operational and the nature and scale of hazards resulting from current prac-

** BHC (benzene hexachloride) is an acronym for technical-HCH, a mixture of up to six stable isomers of hexachlorocyclohexane (predominantly alpha-HCH, but with varying proportions of the beta, gamma, delta and epsilon isomers). Lindane is defined as a preparation of the gamma-isomer of HCH which is not less than 99% pure[20].*



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tices. Some of the key findings related to pesticides are outlined below (for a more detailed discussion, see[20]).

As expected, wastes were generally characterised by the presence of a large number and range of chlorinated and non-chlorinated organic contaminants (more than 200 compounds isolated in some cases), relatively few of which could be reliably identified. For those which were identified, the degree to which they could be traced back to source was severely limited by uncontrolled mixing of effluent streams in common discharge canals and the impossibility of identifying the majority of inputs.

For example, an effluent discharging to an open ditch on the Nandeseri estate (see photo above) contained more than 100 individual compounds; only 23 could be reliably identified, but among these the most abundant were o,p'-DDT, p,p'-DDD, and a range of related derivatives. Although the screen analysis employed was non-quantitative, comparison with detector response for the internal standard suggested DDT was present in the high parts per million range, strongly indicative of manufacture of this pesticide upstream from the discharge point. Despite efforts to identify the source, we were able to establish only that the discharge comprised combined effluents from three small to medium scale units nearby, namely Bahulal, Farmson and Parul Industries. None of these industries appears to be licensed to manufacture DDT. Indeed, according to the Indian Government, manufacture is restricted solely to Hindustan Pesticides, located in Delhi.

Similar problems exist on the Ankleshwar estate. A sample of mixed industrial effluent from a shallow and overflowing collection pond serving the Kisari Pumping Station (see photo below) contained o,p'-DDT and p,p'-DDD, along with a complex mixture of chlorinated benzenes and other organic compounds. The labourer employed to maintain the pump, situated in a small block building which also served as his home, informed us that the building frequently flooded with effluent as a result of pump failure.

The prominence of DDT in the combined wastewater again suggests its continued manufacture by one or more unidentified units on the Ankleshwar estate. This was supported by finding p,p'-DDD, among other persistent organochlorines, in a sample of unidentified solid residues from an area of open land within the estate which labourers and children on foot frequently crossed. Sludge wastes sampled from open channels on the Vapi estate yielded, among other compounds, several PCBs and HCH isomers.

## Threats to health

Pandya's[21] survey of worker health and safety standards in a range of chemical production units on both the Vapi and Ankleshwar estates revealed that almost 80% of workers wore no protective equipment, supervision was inadequate in 45% of units and warning alarm systems were absent from 82%. Workers in 75-85% of the units investigated suffered some degree of skin, eye or respiratory irritation. While this study did not focus on any one sector of the chemical industry, it is likely that such poor standards are typical within small to medium scale units.

Medical records for labourers are generally poor, particularly where much of the workforce is migrant. Where records do exist, doctors may be reluctant to draw links between ailments and occupational exposure to chemicals. Few of the workers have any specific information regarding the hazards to which they are exposed, either through direct handling of chemicals at work or exposure resulting from poor management of waste streams. Nevertheless, casual discussions with labourers revealed a general acceptance that their work and working environment was in some way damaging their health. Such discussions uncovered what were often stark assessments of risks. For example, the worker responsible for maintenance of the Kisari pump, also a qualified HGV driver, said he would rather lose 20 years of his life through chemical exposure than risk his life daily on the roads.

Clearly the health hazards are by no means restricted to pesticides, but their widespread presence as contaminants in wastes on site and released to the open environment serves to illustrate the nature and scale of the wider problem. In addition, recent studies have linked a wide range of industrial chemicals, including a number of chlorinated pesticides, with the ability to interfere with hormone systems and, consequently, development and reproductive health, in animals. The oestrogenic activity of DDT has been recognised for many years[22] and the devastating impact of DDD on reproductive development in Lake Apopka alligators was highlighted by Guillette's group[23] in 1994. More recently, Kelce *et al*[24] have reported that p,p'-DDE is a potent inhibitor of the androgen receptor in male rats. Similarity of hormonal systems between animals and humans suggests that similar impacts may be possible in exposed human populations.

## Inadequate proposals

Regulation of pesticide production processes is currently extremely limited and appears to be inadequately enforced. Laboratories with the responsibility to monitor effluent quality generally do not have the capability even to identify organic contaminants. As a result, effluents may be considered acceptable for discharge to receiving waters despite containing high residual concentrations of POPs. More effective collection of waste and the construction of common effluent treatment plants (CETPs) are presented as solutions to the problems of environmental contamination resulting from pesticide and other chemical manufacture. It is widely recognised, however, that CETPs cannot effectively address persistent organic pollutants, including residues of many of the more problematic organochlorine pesticides[25,26].

Despite restrictions on the use of chlorinated pesticides, many are still readily available on the market. During a tour of numerous small hardware stores in Mumbai in November 1996, we were offered a range of products for the control of household pests, primarily formulations of HCH (labelled as BHC) packaged in simple card containers with few, if any, warnings or instructions. In most cases these products were offered 'under the counter'. Whether the ban has been effective in preventing such sales is not yet known.

DDT has also been targeted for phase out by the Indian Government over the next few years. In the meantime, Hindustan Pesticides, the only officially recognised producer of DDT, will be relocated away from centres of population in Delhi to a more rural location, following a Supreme Court decision. Quite apart from the fact that this will simply transfer the problems of fugitive emissions elsewhere, there appear to be no plans to assess levels of contamination, or remove, contain or treat contaminated soils and sediments at the former site. Our analysis of sediments from an open canal adjacent to Hindustan Pesticides indicated high levels of contami-

nation with DDT and derivatives[27].

Meanwhile manufacture of other chlorinated pesticides continues. An estimated 45,000 tonnes of elemental chlorine were employed in pesticide production in India in 1995[28]. While the production of BHC has now been banned, its replacement with lindane (gamma-HCH), coupled with continued manufacture of other chlorinated formulations and increased access to global markets, seems unlikely to lead to a significant reduction in the total quantity of organochlorine pesticides manufactured in India in the short to medium term.

Even if working practices are substantially improved in years to come, which seems unlikely in many of the small to medium scale plants, the fundamental problems associated with the release of POPs to the environment will remain unchanged. The clean up of existing manufacturing and waste disposal practices, although an essential first step, will not be sufficient to address the wider problems. Nor is it acceptable simply to replace one hazardous formulation with another. If the release of POPs is to be addressed on a global scale, then action must be taken at both global and national levels. The Government of India must recognise its responsibility and initiate a phase-out of the manufacture and use of POPs, especially the chlorinated pesticides.

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# Organochlorines in African ecosystems

A number of highly persistent organochlorine (OC) pesticides, widely banned in other countries, are still used in African countries, including DDT, lindane, heptachlor, chlordane and toxaphene. Endosulfan, a less persistent OC, is also widely used. The lower cost of these older pesticides means farmers in poorer areas find them attractive and affordable. The dangers resulting from their accumulation through food chains, interference with reproduction of mammals and birds, and toxicity to aquatic life, are little known among farmers.

Most data on the environmental impact of pesticides are based on studies in temperate climates. African countries have less information than other tropical regions because the pesticide market is smaller and the infrastructure poor. A Swedish-funded study initiated in the 1980s set out to redress the problem and supported studies in Algeria, Egypt, Ghana, Nigeria, Tanzania, Uganda, Zambia and Zimbabwe. The programme, which was coordinated through the International Atomic Energy Agency (IAEA) joint division with the Food and Agriculture Organisation (FAO) in Austria, also helped build skills and standardised experimental procedures in participating countries, increasing the capacity for residue analysis and developing validated methods for ecotoxicological studies.

The studies focused on maize production systems and the major maize pest, stem borer, but other crops were included. It investigated the effect of OCs on beneficial insects and the agroecosystem, environmental persistence, and the effects on higher fauna. The exercise presented the multi-disciplinary teams with numerous practical challenges as they combated drought, electricity failures, and in one case a closure of the University system, but it contributed significantly to knowledge of pesticide impacts in Africa and provided useful comparative material.

Looking at environmental persistence, results confirmed that lindane and endosulfan persist for a shorter period in areas of high temperature and heavy rainfall. Most studies showed that lindane reduced the incidence of pest attack on maize although there was not always a corresponding increase in crop yield. On the other hand lindane was not recommended for use on maize in some of the countries studied. The population of non-target organisms and beneficial insects were reduced, but in most cases recovered within 6-8 weeks and the adverse impact did not appear to last from one season to the next. Of concern also were findings of OC residues in fish which were of higher concentration than in the water, and a scarcity of fish in rivers which suggested a toxic agent was present. Surveyed birds in Tanzania, notably African Fish Eagles from Lake Victoria, showed residues of DDT and the Egyptian study showed degenerative changes in liver, kidney and nerve tissue of birds sampled.

While the studies provide useful scientific knowledge and testing protocols, they also raise questions. Some comparisons showed no impact on economic return from use of the OC compounds. Others which showed higher yields from sprayed crops compared to unsprayed crops did not provide any data on whether the unsprayed crops were simply left, or whether a more benign pest management regime was used. The research on environmental persistence did not examine evidence that OCs move from tropical to temperate regions on water and air currents, where they are now accumulating. We can also assume that under experimental conditions, recommended doses of the OCs were used with well maintained equipment, a situation which does not equate with field conditions. ***(BD)***

*Organochlorine insecticides in African Ecosystems, Report on a Final Research Co-ordination Meeting, Food and Agriculture Organisation/International Atomic Energy Agency, Wagramerstasse 5, PO Box 100, A-1400 Vienna, Austria, March 1997, 250pp.*