

# Mercury

## Toxics *Link* Factsheet

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### Tiny drops that kill

Recent reports of a mercury spill of 25 kg in the East Islands in the Andaman has once again brought the metal, mercury, under the spotlight. The Minamata tragedy is a compelling instance of the harmful effects of exposure to mercury. Mercury is a potent neurotoxin. Even at extremely low levels of exposure, it can cause permanent damage to the human central nervous system. The addition of even 0.9 grams of mercury, that is, one minuscule fraction (1/70<sup>th</sup>) of a teaspoon – is enough to contaminate a 25-acre lake, rendering fish contaminated and unsafe to eat. At higher levels, mercury can damage vital organs such as lungs and kidneys. Common exposures are through food and the diet; with exposure also occurring through air and water.

Mercury levels are extremely high in the

working environments of industrial processes such as chlor-alkali plants, mercury mines, thermometer factories and even medical practices such as dental clinics. Air exposures can be caused through thermal power plant emissions. A typical 100 megawatt thermal power plant can emit over 10 kg of mercury in a single year. About 200 metric tonnes of toxic mercury escapes from industrial chimneys and effluents each year in India.<sup>1</sup>

Mercury's presence in air and water has increased dramatically in the past century owing to human activities. Recent studies suggest that the total global atmospheric mercury burden has increased between 200 and 500 per cent since the beginning of the Industrial Age. Reports also indicate that the levels of mercury in rivers, coastal waters, soil and food items are

### AT A GLANCE

- ❖ Methyl mercury, an organic form of mercury, is one of the six most serious pollution threats to the planet.
- ❖ Human activities, such as burning of mercury-based waste and fossil fuel combustion, have increased the presence of mercury in air and water dramatically.
- ❖ Mercury levels in Indian rivers and in the Arabian Sea were found to be at alarming levels. A study found that mercury content in drinking water in various parts of the country is above permissible limits.
- ❖ It is imperative to limit the use of mercury and use substitutes wherever possible. Dumping of mercury from developed nations should also be curtailed.



PHOTO: P. MADHAVAN

Mercury being sold in highly unsafe conditions in a Delhi market.

### Biomagnification process of mercury

THE PROGRESSIVE bioaccumulation of heavy metals by successive trophic levels is termed as biomagnification. Once in aquatic systems, mercury can exist in dissolved or particulate forms and can undergo a number of chemical transformations.

Inorganic mercury becomes methyl mercury, which is organic, toxic and persistent, travelling from one medium to another in the environment. Methyl mercury is most harmful to humans and wildlife due to its ability to bio-accumulate in the food chain.

This results in its building up as it goes up the aquatic food chain – from plankton to small fish to predator fish, such as sharks, etc. These can have mercury concentrations over a million times higher than their surroundings.

**Methyl mercury can cross the placental barrier and cause foetal brain damage without any symptoms in the expectant mother. The level of methyl mercury in foetal blood is frequently twice as high as the level in the expectant mother's blood**

### Major consumers of mercury in India

Form of mercury	Consumers
Elemental mercury	<b>Chlor-alkali industry</b> (Mercury cell process)
Elemental mercury	<b>Instrument manufacturing</b> <ol style="list-style-type: none"> <li>1. Clinical thermometers</li> <li>2. Laboratory thermometers</li> <li>3. Blood pressure monitors</li> <li>4. Barometers</li> <li>5. Other instruments</li> </ol>
Elemental mercury	<b>Electrical apparatus</b> <ol style="list-style-type: none"> <li>1. Electric switches</li> <li>2. Electric lamps                             <ol style="list-style-type: none"> <li>a) Fluorescent lamps</li> <li>b) Mercury vapour lamps</li> </ol> </li> <li>3. Batteries</li> </ol>
Mercury oxide	
Mercury salts	
Mercury compounds	<b>Fungicides</b> <ol style="list-style-type: none"> <li>1. Phenyl mercury acetate</li> <li>2. Methoxy ethyl mercury chloride</li> <li>3. Others</li> </ol>
Mercury oxide	1. Paints
Mercury compounds	2. Cosmetics
Elemental mercury	<b>Health set-ups</b>
Mercury oxide	1. Drugs, pharmaceuticals
	2. Dental amalgams
	3. Others

way above acceptable levels in India. In fact, mercury usage, in most cases is substitutable – not doing so reflects a lack of concern.

### What is mercury?

Mercury (Hg) is a naturally occurring, highly volatile heavy metal. It is found in trace quantities throughout the environment – rocks, soils and the oceans. Being an element, mercury never breaks down but persists in the environment, cycling through land, air and water.

All forms of mercury are not the same. Mercury can exist in the environment in elemental, organic or inorganic forms. According to the International Chemical Safety Council of United Nations, an organic form of mercury – methyl mercury – is one of the six most serious pollution threats to the planet. Elemental mercury is the familiar mercury metal, which is used in thermometers, barometers, some electrical switches and other applications. It can exist both as a vapour and a solid at room temperature.

### Mercury sources in the environment

The two major sources of mercury in the environment are:

- ❖ Natural mobilisation of mercury from Earth's crust. Mercury becomes airborne in large amounts through volcanic eruptions and forest fires.
- ❖ Anthropogenic emissions from mobilisation of mercury impurities in fossil fuels, incinerators, chlor-alkali industries, mining, processing/refining of mercury ore, gold mining, as well as the manufacturing of pharmaceuticals, lime, cement and batteries. Small amounts are also contributed from paints, landfills, laboratories, crematoriums, and electric bulb breakage.

While most of the mercury released into the environment by human activity is in either elemental or inorganic form, biological processes convert inorganic mercury into highly dangerous forms of organic mercury, such as methyl mercury. This form is the most harmful to people and wildlife because of its ability to take part in biochemical reactions and accumulate in the food chain.

Day-to-day anthropogenic activities such as fossil fuel combustion, mercury disposal and

<sup>1</sup> *Mercury in India: Shimmering.* Unpublished report by Toxics Link.

## Health effects of mercury

Form of mercury	Sources of environmental contamination	Environmental effects	Source of human contamination	Toxicity-related health effects
Methyl mercury	Mercury disposed of in water bodies	Tendency to bio-magnify in the food chain, contaminating fish and marine mammals	Consumption of contaminated fish and marine mammals	Methyl mercury is: classified as a possible human carcinogen; considered a CNS toxin (kidneys are most vulnerable to damage); a risk to the developing foetus since it easily crosses the placental barrier
Mercury	Combustion of coal; incineration of mercury-bearing waste	Deposits in the environment and sometimes travels long distances	Deposits in water bodies and also falls with rain water	Enters body via food
Mercury vapour			Ambient air, dental amalgam	Dangerous if inhaled or ingested

burning of mercury-bearing waste has led to a dramatic presence of this highly toxic metal in air and water.

### Mercury usage

Mercury has over 3,000 industrial uses. The largest consumer of mercury in India is the chlor-alkali industry, which manufactures caustic soda and chlorine as a by-product using the mercury cell process. The second-largest consumption of mercury in India is for the production of measuring instruments such as thermometers, barometers, etc. It is also used in manufacturing electrical apparatus, mercury vapour lamps, electrical switches, fluorescent lamps, etc.

### Mercury poisoning

Methyl mercury intake through fish and other aquatic foods has a considerable effect on human health. Some surveys that provide information on the percentage of mercury originating from fish assume that the percentage of methyl mercury ranges from 60 to 90 per cent. This implies that fish and fish products that we eat can be a major source of methyl mercury.

Unborn foetuses are at a high risk from methyl mercury poisoning. Methyl mercury can

cross the placental barrier and cause foetal brain damage without any symptoms in the expectant mother. The level of methyl mercury in foetal blood is frequently twice as high as the level in the expectant mother's blood. Research shows that the foetal brain is five to 10 times more vulnerable to methyl mercury than an adult's because the chemical interferes with the division and migration of forming cells in the brain. The babies may experience mental and physical disabilities as well as delayed development of motor and verbal skills.

*With general awareness about the toxicity of mercury being low, handling of the dangerous substance is a commonplace sight.*



PHOTO: P. MADHAVAN

**In India, some of the major rivers tested for heavy metals by the Industrial Toxicological Research Centre (ITRC), Lucknow, were found to contain mercury in alarming levels**

### Estimated average daily intakes and retention of different mercury forms in the general population (WHO, 1991)

Exposure	Elemental Hg vapour	Inorganic Hg compounds	Methyl mercury
Air	0.03 (0.024)*	0.002 (0.001)	0.008 (0.0069)
Dental amalgam	3.8-21 (3-17)	0	0
Food			
Fish	0	0.60 (0.042)	2.4 (2.3)**
Non-fish	0	3.6 (0.25)	0
Drinking water	0	0.050 (0.0035)	0
<b>Total</b>	<b>3.9-21 (3-1-17)</b>	<b>4.3 (0.3)</b>	<b>2.41 (2.31)</b>

The World Health Organisation (WHO) has estimated the daily intake of each form of mercury on the assumption that 75 per cent of mercury is in elemental form, 5 per cent as inorganic and 20 per cent as methyl mercury. By assuming a daily ventilation of 20 m<sup>3</sup>, and the amount absorbed across the pulmonary membranes (80 per cent of elemental mercury, 50 per cent of inorganic mercury, and 80 per cent of methyl mercury), daily intakes were calculated (*see table above*).<sup>2</sup>

Mercury exposure is a common phenomenon in the working environments that use mercury. Occupational exposure may range from the subtlest of health disturbances to serious damages and even death. A number of

cases have been reported from chlor-alkali plants, mercury mines, mercury-based gold extraction, processing and sales, thermometer factories, dental clinics with poor mercury handling practices and production of mercury-based chemicals.

Many studies and hundreds of thousands of clinical tests by medical labs<sup>3</sup> have documented that dental amalgam is the largest source of mercury in most people. Laboratory tests have shown the average person with amalgam gets 10 times as much daily mercury exposure as the average person without.

Elemental and inorganic mercury is also methylated by bacteria, yeasts, etc, in the mouth

#### Is mercury poisoning a new problem?

MERCURY has been mined for more than 2,000 years. It was first used in religious ceremonies. In the Middle Ages, chemists tried to make mercury into gold and silver.

In Japan, mercury poisoning occurred when Chisso Corporation, a fertiliser, petrochemicals and plastics maker dumped at least 27 tonnes of mercury compounds into Minamata Bay and River from 1932 to 1968. It moved through the food chain and was consumed by villagers in fish taken from Minamata Bay. The 'Minamata Disease' affected thousands of people between 1953 and 1973.

One of the worst cases of reported mercury poisoning comes from Iraq. In 1971-1972, hundreds of people died and many more were hospitalised after eating bread made from imported wheat seeds. The bread was made from 90,000 tonnes of seeds that were intended for planting and had been treated with alkyl mercury fungicide. The bags of seeds had a warning not to be eaten, but the warning was in Spanish. The Iraqis used the wheat seed to make bread and ate it. The bread contained on average 7.9 ppm of methyl mercury. Many ingested lethal doses of mercury, but did not experience any symptoms for weeks after they ate the bread. Once the symptoms began to appear, the damage was already done to the brain and the nervous system. Motor functioning and changes in sensation were most often reported. About 6,500 Iraqis were hospitalised and 459 died from mercury poisoning.

<sup>2</sup> UNEP Chemicals, Global Mercury Assessment Report, Draft 1, 25 April 2002, page 37.

<sup>3</sup> A. Kingman et al, National Institute of Dental Research, 'Mercury concentrations in urine and blood associated with amalgam exposure in the US military population', *Dent Resd*, 1998, 77(3):461-71.

<sup>4</sup> UNEP Chemicals, Global Mercury Assessment Report, Draft 1, 25 April 2002.

and intestines to methyl mercury. This also makes dental amalgam the largest source of methyl mercury in most people who have amalgams. This is due to continuous vapourisation in the mouth caused by mercury's high vapour pressure; it is also caused by oral galvanism of mixed metals and the inducement of currents in the metals that are pumped into the body, as confirmed by numerous studies on saliva, oral mucosa and autopsy studies.

The governments of Sweden, Germany, Denmark, Norway, Finland, Austria and Canada have taken steps to limit or phase out mercury use in amalgams, especially among sensitive populations including pregnant women, children and those with impaired kidney functions.<sup>4</sup> A 'Health Canada Position Statement on Dental Amalgam' states that:

"Non-mercury filling materials should be considered for restoring the primary teeth of children; whenever possible, amalgam fillings should not be placed in or removed from the teeth of pregnant women; amalgam should not be placed in patients with impaired kidney functions."

Though it is evident that there is acute mercury poisoning among workers, no comprehensive study has been carried out in India. A small study was conducted by the Community Health Cell, Bangalore, in Kodaikanal amongst former workers of the Hindustan Lever mercury thermometer plant.

Acute mercury poisoning in India is rare, but it still occurs because of mercury's unique appearance and behaviour. Unwary children can be drawn to it (even play with it!) in school laboratories or with broken thermometers and suffer acute exposure.

Unlike some western countries, India does not have fish consumption advisories. A fish advisory informs the population about the effects of mercury on the human body. It tells people to avoid varieties of fish through which the probability of mercury poisoning is high. Due to this lack, people fishing for subsistence, low-income or poor fishermen and children remain at risk of mercury poisoning.

There is consumer legislation in place – the Prevention of Food Adulteration Act, 1955, – which aims to protect consumers from adulterated food and ensure food safety. The Rules declare mercury as a poisonous metal and



PHOTO: GREENPEACE INTERNATIONAL

limit its concentration in fish to 0.5 ppm and in other food items to 1.0 ppm. Methyl mercury concentration in fish is limited to 0.25 ppm.<sup>5</sup>

The WHO and the Food and Agriculture Organisation (FAO), in their codex alimentarius guidelines, have also limited the concentration of methyl mercury to 0.5 mg/kg for all fishes except predatory fishes, and 1 mg/kg for predatory fishes such as shark, swordfish, tuna, pike, etc.<sup>6</sup>

On the basis of the risk assessments, a number of countries have stipulated levels of daily or weekly mercury intakes. However, in a country like India where a large percentage of the population eat fish as a staple food, no provisions for daily or weekly mercury intake levels have been set down.

### Drinking water standards for mercury

The Bureau of Indian Standards (BIS) has laid down safety limits for drinking water at 0.001 mg of mercury per litre. A number of samples of groundwater in some industrial belts have shown concentrations of mercury higher than safe standards. A study shows levels of mercury to be very high as compared to the permissible limit. The table above shows the critical geographical areas.<sup>7</sup>

### Increase in mercury pollution in India

In India, some of the major rivers tested for heavy metals by the Industrial Toxicological Research Centre (ITRC), Lucknow, were found to contain mercury in alarming levels.<sup>8</sup> Testing

*Obsolete thermometers containing mercury are often disposed of in an unsafe manner.*

<sup>5</sup> The Prevention of Food Adulteration Act and Rules, 1955.

<sup>6</sup> UNEP Chemicals, Global Mercury Assessment Report, Draft 1, 25 April 2002, page 30.

<sup>7</sup> *Down to Earth*, August 31, 1999.

<sup>8</sup> Heavy metals in Indian environment, ITRC, 1998, in Report of the High Powered Committee on Management of Hazardous Wastes, Vol 3.

### Levels of mercury (mg/l)

Permissible limit ..... 0.001

Industrial Area, Panipat (Haryana) .....	0.268
Barsai Road, Panipat (Haryana) .....	0.074
Machua Village, Vatva (Gujarat) .....	0.115
Lali Village, Vatva (Gujarat) .....	0.211
Chiri Village, Vapi (Gujarat) .....	0.096
Sarangpur Village, Ankleshwar (Gujarat) .....	0.118
Bapunagar, Ankleshwar (Gujarat) .....	0.176
Pocharam Village, Patancheru (Andhra Pradesh) .....	0.058

(Source: Down to Earth, Aug 31, 1999)

**The five super thermal power plants in the Singrauli area, which supply 10 per cent of India's power, are responsible for 16.85 per cent or 10 tonnes per annum of total mercury pollution through power generation**

of seawater by the National Institute of Oceanography, Goa, found increased mercury concentrations in the Arabian Sea.<sup>9</sup> Several studies on fish and prawns in Mumbai, Kolkata, Orissa, etc, have reported alarming rates of mercury concentrations.<sup>10</sup>

Recent studies have shown that the total mercury pollution potential from coal in India is estimated to be 77.91 tonnes per annum, if average concentration of mercury in coal is assumed to be 0.272 ppm. About 59.29 tonnes of mercury per annum is mobilised from coal-fired thermal power plants alone.<sup>11</sup> The five super thermal power plants in the Singrauli area, which supply 10 per cent of India's power,

are responsible for 16.85 per cent or 10 tonnes per annum of total mercury pollution through power generation.

The Paryavaran Suraksha Samiti (PSS) collected samples from over 20 villages affected by industrial pollution in the Golden Corridor of Gujarat to investigate the water situation there. The samples were analysed for Mercury and Chemical Oxygen Demand (COD). In Haria village and Atul Complex, mercury was shockingly high at 12 ppm – 1200 per cent more than the permissible limit of 1 ppm. Another sample in Ankleshwar showed mercury at a high level of 2 ppm which is 200 per cent above the standard. Samples in Vadodara-Nandesari ECP Area also showed high mercury levels at 6 ppm and 1.3 ppm, which are 600 per cent and 30 per cent more than the prescribed standards, respectively.

The People's Science Institute (PSI) in Dehradun has recently found high levels of mercury in the groundwater sources of Bhopal, especially near the Union Carbide factory. The water is dangerous for human consumption as the area of groundwater contamination is increasing. Water samples from various localities taken for testing showed that contamination levels in some places were as high as 2 ppm.

A recent study conducted by the Environmental Science Department of the Guru

### Major emitters of mercury in India

Mercury	Consumers	Amount (approximate)
Mercury in effluent (mercury cell process)	Chlor alkali industry	100-150 tonnes per annum
Mercury in effluents and soil	Instrument manufacturing industries	Data not available
Mercury in air and fly ash power plants	Coal-based thermal	60 tonnes per annum
Mercury in air and dust	Cement manufacturing plants	Data not available
Mercury in air	Burning of mineral oil	Data not available
Mercury in air and effluents	Disposal of municipal solid waste	Data not available
Mercury in air	Disposal of medical wastes	Data not available

<sup>9</sup> Kaladharan, P. et al, 'Mercury in seawater along the West Coast of India', *Indian Journal of Marine Sciences*, Vol 28, 1999, pp 338-340.

<sup>10</sup> Tejam, B.M. and B.C. Haldar, 'A preliminary survey of mercury in fish from Bombay and Thana environment', *Indian Journal of Environmental Health*, Vol 17 (1), 1975, pp 9-16.

<sup>11</sup> CPCB, 'Mercury balance in thermal power plants', Annual Report, 2001 (under preparation).

Gobind Singh Indraprastha University, Delhi, reveals that the concentration of contaminants like arsenic, mercury, nitrates, etc, in the groundwater of Delhi exceeds the permissible limits. The study entailed 50 samples of groundwater being lifted from random spots along a 22-km stretch between Palla and Okhla. The mercury concentration in some samples was as high as 4.6 ppm, 460 per cent above the permissible limit. This alarming presence of mercury in groundwater can be traced to the continuous discharge of sewage and industrial effluents into the Yamuna and, subsequently, into the groundwater aquifer which, being sandy in nature, allows mercury pollution to spread at a rapid rate.

### Visible symptoms of mercury poisoning

The symptoms of methyl mercury poisoning are varied and can mimic other illnesses. Many of the symptoms take a number of weeks, or even months, to appear. The symptoms include:

- ❖ tingling and numbness of extremities;
- ❖ depression, emotional instability, memory reduction, irritability;
- ❖ defects in hearing, vision and speech;
- ❖ difficulty in writing, delays in motor and language development, inability to walk properly, tremors, and
- ❖ in extreme cases, death.

Mercury levels are measured through either the blood or hair. The half-life period of mercury is about 70 days in the human body.

Just walk into Tilak Bazaar, a market in Delhi, and you can easily find mercury. All the traders in this market buy the required amount of mercury from importers in Delhi and later supply it to all the major consumers in India.

This market is situated in Khari Baoli, in the Chandni Chowk area of Delhi. The workers and people working here are unaware of the hazards of mercury. The concept of chemical safety is an academic issue, which is studied but never put in practice.

There is a lack of awareness about mercury and its ill effects on human health among workers and labourers (like any other chemical). At the shops one can see boys pouring mercury from one flask to other with their bare hands and uncovered face, as if they are pouring water from one jar to another! The boys and the

trader there seem unaware of the toxicity of mercury. This is a gross violation of Indian Standard: 7812 (1975) 'Code of Safety of Mercury'.

Tilak Bazaar caters mostly to the demand of mercury in North India. All the major thermometer companies, especially those industries using mercury on a small-scale basis, buy the required amount of mercury from this market. Besides industries, many schools, colleges and laboratories do the same.

### How much mercury is too much?

Years ago, technology was not able to detect low levels of mercury. With improvements in technology, low levels can now be measured. However, the standards and rules to regulate contamination have not changed. With mercury's bio-accumulative qualities, even tiny amounts of the metal could be harmful in some cases. All the standards should be stringent, based on health effects, and be in consonance with global standards.

**A study estimates that the present global mercury emission into the atmosphere is 5,000 tonnes per year, of which 80 per cent is of anthropogenic origin**

## Mercury applications and alternatives

### Mercury applications

Chlor-alkali production (chlorine and caustic soda)

Dental amalgam

Medical thermometers

Pressure measuring and control equipment

Electric and electronic switches

Pesticides (seed dressing)

### Alternatives available

Membrane cell technology is the best available technology for production of chlor-alkali.

A number of new alternatives, such as gold, silver, gallium, ceramic and porcelain are available.

Electrical and electronic thermometers, glass thermometers containing a Ga/Sn alloy, etc.

Three main technologies that could be used to replace mercury in pressure gauges are: flexible and membranes; piezoelectric crystals and other sensors; and fibre-optic pressure sensors, based on light transmission.

Manual/mechanical micro switches, solid-state switches, optical switches, etc.

Use of processes not requiring chemical pesticides/biocides and easily degradable, narrow-targeted substances with minimal environmental impact.

## FACT FILE

- ❖ A study estimates that the present total global mercury emissions into the atmosphere are 5,000 tonnes per year, of which 80 per cent are of anthropogenic origin.
- ❖ There are indications showing an increase in the anthropogenic emissions of mercury from 0.5-3 times since pre-industrial times.
- ❖ The areas surrounding the industries also show increased deposition rates of mercury by a factor of 2-10 during the last 200 years.<sup>12</sup>

### People's movement makes headway

In 2001, an active campaign led by several environment groups both from India and the USA turned back a Mumbai-bound cargo ship carrying close to 20 tonnes of mercury reclaimed from a Maine factory in the USA. The campaign was successful in highlighting the harmful effects of mercury and put pressure on the government to stop the USA from dumping its mercury in India.

Hindustan Lever Ltd, an Indian subsidiary of Unilever (an Anglo-Dutch multinational) with a thermometer plant at Kodaikanal, has been found guilty of dumping its mercury waste. These multinationals employ double standards in dealing with mercury waste in developed and developing countries.

It's high time urgent policy intervention, both at the national and state levels, corrects our mercury consumption pattern. Meanwhile, a nationwide awareness drive with similar people's movements needs to be launched to reduce the mercury in emissions in municipal and industrial waste streams. The ultimate goal is to eliminate mercury use. Several international pressure groups are also working to ban the use of mercury.

### International initiation

The UNEP Governing Council concluded that there is sufficient evidence of significant global adverse impacts to warrant international action aimed at reducing the risks to human health and the environment, which arise from the release of mercury into the environment. A new UN Report has named Asia as the biggest villain in polluting the atmosphere with new mercury emissions, which is impacting the health of people and wildlife.

The first global study on mercury says that "India could be one of the dozen hot spots after the rise in mercury emissions over 30 years". Launching the Global Mercury Assessment Report in Nairobi, UNEP executive director Klaus Toepfer said action is essential. The report says that coal-fired power stations and waste incinerators account for about 1,500 tonnes, or 70 per cent of new quantified man-made mercury emissions annually. The biggest share of 860 tonnes is from Asia.

<sup>12</sup> UNEP Chemicals, Global Mercury Assessment Report, Draft 1, 25 April 2002, page 30.

**If you have any suggestions or require some information, please contact Ravi Agarwal/Kishore Wankhade**

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