MERCURY IN INDIA

TOXIC PATHWAYS

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Toxics Link

September 2003

Who we are

Toxics Link is an environmental organisation with the goal of disseminating information about toxics to help strengthen campaigns against toxics pollution, provide cleaner alternatives and bring together groups and people concerned with, and affected by, this problem.

"We are a group of people working together for environmental justice and freedom from toxics. We have taken it upon ourselves to collect and share both information about the sources and dangers of poisons in our environment and bodies, and information about clean and sustainable alternatives for India and rest of the world."

This current report was undertaken in light of the UN-based global mercury assessment. The worldwide NGO community participated in this process through the BAN-HG Working Group. The group was initiated by the Basel Action Network (www.ban.org) and the Mercury Policy Group in association with other groups worldwide. Toxics Link acted as the Southern NGO Representative in this process.

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EXECUTIVE SUMMARY

The addition of even 0.9 grams of mercury, that is, one minuscule fraction (1/70th) of a teaspoon – is enough to contaminate a 25-acre lake, and render fish contaminated and unsafe to eat. This is the nature of mer cury, a potent neurotoxin. 'Mercury' brings forth horrific images of the Minamata catastrophe – the devastation which mercury poisoning brought about, claiming thousands of lives in Japan in the decade of the '50s and '60s. Minamata is a small bay in Japan where a chlor-alkali plant had been dumping its mercury-laden waste for years. Mercury, when mixed with water, is methylated and becomes the more dangerous methyl mercury; it accumulates in the tissues of fish, thus contaminating them. The villages on the bay used to eat fish as a staple diet from the contaminated waters of the bay, and were thus poisoned by the mercury. This was the first incident of mercury poisoning at a large scale, and has since been known as the 'Minamata disease' globally.

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

The dispersion of mercury into the environment is a major concern in the world today, especially in developing countries. In India various reports have indicated the levels of mercury in river and coastal water; soil and food items are way above acceptable levels.

Even at extremely low levels of exposure, mercury can cause permanent damage to the human central nervous system. At higher levels, it damages vital organs including lungs and kidneys. The most common exposure routes involve food and diet. Additional exposures may be contributed through air and water, either directly or again through the route of food.

Today 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.

In fact, mercury usages in most cases are substitutable by other methods. For example, the membrane cell process is a sustainable alternative to mercury cell process in the chlor-alkali industry. Similarly all mercury based measurement instruments, such as thermometers, barometers and blood pressure monitors, have an alternative in digital instruments, which are accurate and have longevity.

In terms of import and internal consumption, mercury has always been important to various industries owing to its 3,000 industrial uses. The chlor-alkali, thermometer and other instruments, and fungicide industries are the biggest source of consumption in India. Coal-fired thermal power plants are the biggest source of emission along with the chlor-alkali industry in India.

There is no 'safe disposal' for mercury. Once in the waste stream, it is bound to enter our environment. Thus the only way out is a comprehensive policy both at the national and international levels. Unless there is a change in government policies, mercury would be haphazardly released into the environment.

The UNEP Governing Council felt that there is sufficient evidence of significant global adverse impacts to warrant international action to reduce the risks to human health and the environmental arising from the release of mercury into the environment. This led to the establishment of a Global Mercury Assessment Working Group to assist the UNEP to prepare a *Global Mercury Assessment Report*.

The *Report* was released recently; it 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: "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.

INTRODUCTION

The dispersion of toxic metals in the environment is a major concern in many industrialised coun tries. Although mercury occurs naturally in the environment, human activity causes most mercury releases and has altered the natural cycling of the element. Mercury's presence in our air and water has increased dramatically in the past century due to human activity. 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 levels of mercury in rivers, coastal waters, soil and food items are way above acceptable levels in India. In fact, in most cases, mercury usage is substitutable and not doing so reflects a lack of concern about this extremely toxic heavy metal.

Mercury is a silvery white, poisonous, odourless, metallic element, which is an extremely heavy liquid at room temperature. Its chemical symbol, Hg, is derived from the Greek word ''hydrargyrum', meaning 'liquid silver', or 'quick silver'. Although now obsolete, the word 'quicksilver' was for a long time a synonym for mercury.

The element constitutes only 0.5 parts per million (ppm) of the earth's crust, making it scarcer than uranium but more common than gold or silver. Mercury is principally found as the ore ***cinnabar*** (mercury sulphide) but is also found in an uncombined state. The preparation of mercury from its ores is simple: the ore is ground up and heated to about 580 ^{o}C in the presence of oxygen. Mercury vapour escapes from the ores and sulphur dioxide is removed. The metal is condensed and purified by washing with nitric acid, followed by distillation.

History and Occurrence

Mercury was among the first metals known, and its compounds have been used throughout history. Archaeologists have found mercury in an Egyptian tomb dating from 1500 BC. The Egyptians and the Chinese may have been using cinnabar as a red pigment for centuries before Christ's birth. In many civilisations, mercury was used to placate or chase away evil spirits. Alchemists thought that mercury, which they associated with the planet Mercury, had mystical properties and even used it in their attempts to transmute base metals into gold. The Greeks knew of mercury and used it as a medicine. Mercury and mercury compounds were used from the 15th century to the mid-20th century to cure syphilis. However, since mercury is extremely toxic and its curative effect unproven, other syphilis medicines are now used. These days, its poisonous nature and scarcity limit mercury's uses.

Physical and Chemical Properties

The element shares group II B of the periodic table with zinc and cadmium. Mercury's atomic number is 80; its atomic weight is 200.59. Mercury is very heavy: it has a density of 13.534 at 25 °C, which means that it weighs 13.6 times an equal volume of water. Stone, iron, and even lead can float on its surface. Mercury only occurs in trace amounts in igneous rocks; sedimentary rocks are slightly richer.

It is a rather poor conductor of heat if compared to other metals, but a good conductor of electricity. It alloys easily with metals such as gold, silver and tin, which are called amalgams. Mercury is a fairly unreactive metal and is highly resistant to corrosion. Its boiling point is 356.72 °C and its melting point -38.87 °C, which means that it will be vaporised in furnaces or waste incineration process. Mercury oxidises in air to form mercuric oxide. At 500 °C, mercuric oxide decomposes into mercury and oxygen. The most commonly used compounds are mercuric chloride or $HgCl_2$, mercurous chloride or Hg_2Cl_2, mercury fulminate or $Hg(ONC)_2$ and mercuric sulphide or HgS.

Sources in the Environment

Mercury is probably best known as the silver liquid in thermometers. However, it has 3,000 different industrial uses. Mercury and its compounds are widely distributed in the environment as a result of both natural and man-made activities. The utility, and the toxicity, of mercury have been known for centuries. New toxicological evidence demonstrates that even low levels of mercury exposure may be hazardous. Natural mercury arises from the degassing of the earth's crust through volcanic gases and, probably, by evaporation from the oceans. Local levels in water derived from mercury ores may also be high (up to 80 µg/litre). Atmospheric pollution from industrial production is probably low, but pollution of water by mine tailings is significant.The burning of fossil fuels is another source of mercury. The chlor-alkali industry and, previously, the wood pulping industry, also released significant amounts of mercury.

Although overall use of mercury has been reducing, substantial concentrations of the metal are still present in sediments associated with the industrial applications of mercury. Some mercury compounds have been used in agriculture, principally as fungicides.

Exposure and Distribution

The extent of exposure to mercury depends on its form, with mercury vapour and methyl mercury being the most likely forms since they are completely absorbed into the body. Methyl mercury in fish and fish products is by far the largest source of mercury exposure (94 per cent), followed by breathing mercury vapour from the air (6 per cent). Drinking water makes a negligible contribution. (These figures are averages for people not

The consumption of fish is a common route by which mercury enters the human body; freshwater fish tends to have slightly higher mercury levels than marine species.

exposed at the workplace.)

Above-average exposures to mercury vapour are primarily confined to occupations where it is used. Of special concern are women of child-bearing age who work as dentists or dental assistants and may be exposed to mercury vapour in preparing dental fillings containing mercury metal amalgams. These people/women may be exposed to above-average levels of mercury vapour on a daily basis. Because the developing foetus is especially vulnerable, pregnant dental workers are a greater concern. In addition, those finished fillings in people's teeth release mercury vapour in sufficient quantities to cause adverse health effects. People living with workers who are occupationally exposed (such as dental workers and thermometer manufacturers) may also experience higher than average exposures to mercury vapour because of mercury metal brought home on hands, hair, and clothes worn at the workplace.

People who have been documented as having above-average exposure to methyl mercury are mainly those who eat large amounts of fish. The Environmental Protection Agency, USA, states that those who eat more than 30 pounds of fish per year are in the high-risk group. Freshwater fish tends to have slightly higher mercury levels than marine species. Pike, trout, and bass are the freshwater varieties with the highest concentration rates; shrimp, snapper and halibut are the most frequently consumed marine species with the highest mercury levels. The Great Lakes, in the USA, are a unique example of high levels of concentration of mercury in freshwater fish, because of the presence of mercury above the permissible limits in their waters. The fish-eating communities living in the vicinity of The Great Lakes are the most vulnerable group to mercury poisoning.

Geographically speaking, mercury tends to be distributed in the vicinity of manufacturers using it as well as near mines, smelters, municipal solid waste incinerators, and fossil-fuel burning power plants, since mercury is a trace contaminant of ores and fuels.

Health Effects and Toxicity

Towards the end of 1956, it was established that the "strange Minamata disease" was actually mercury poisoning caused by eating fish and shellfish contaminated with methyl mercury. By the time the facts came into light, hundreds of people had been affected; some had died and children had been born with the disease. Thus the 'Minamata disease' brought to light the case of mercury poisoning.

Exposure to mercury can occur through inhalation, ingestion or dermal absorption. The amount of mercury absorbed by the body – and thus the degree of toxicity – is dependent upon the chemical form of mercury. For instance, ingested elemental mercury is only 0.01 per cent absorbed, but methyl mercury is nearly 100 per cent absorbed from the gastrointestinal tract. The biological half-life of mercury is 60 days. Thus, even after exposure is reduced, the body burden will remain for at least a few months.

Elemental mercury is most hazardous when inhaled. Only about 25 per cent of an inhaled dose is exhaled. Skin absorption of mercury vapour occurs, but at low levels (for example, 2.2 per cent of the total dose). Dermal contact with liquid mercury can significantly increase biological levels. In the human body, mercury that accumulates in the liver, kidney, brain and blood, may cause acute or chronic health effects. Acute exposure (that is, short term, high dose) is not as common today due to greater precautions and decreased handling. However, effects may include severe gastrointestinal damage, cardiovascular collapse or kidney failure, all of which could be fatal. Inhalation of 1-3 mg/m^3 for two to five hours may cause headaches, salivation, metallic taste in the mouth, chills, cough, fever, tremors, abdominal cramps, diarrhoea, nausea, vomiting, tightness in the chest, difficulty in breathing, fatigue, or lung irritation. The onset of such symptoms may be delayed for a number of hours.

Chronic effects include central nervous system effects, kidney damage and birth defects; genetic damage is also suspected. These are the most critical effects of chronic mercury exposure as they are consistent and pronounced. Some elemental mercury is dissolved in the blood and may be transported across the blood/brain barrier, oxidised and retained in brain tissue. Elimination from the brain is slow, resulting in nerve tissue accumulation.

Symptoms of chronic mercury exposure on the nervous system include high excitability, mental instability, tendency to weep, fine tremors of the hands and feet, and personality changes. The term 'mad as a hatter' derives from these symptoms, which were a result of mercury exposure of workers manufacturing felt hats.

Kidney effects: Kidney damage includes increased protein in the urine and may result in kidney failure at high doses of mercury exposure.

Birth defects: Neurological damage results from exposure to methyl mercury. The manifestations of mild exposure include delayed developmental milestones, altered muscle tone and tendon reflexes, and depressed intelligence.

Mercury exposure in children can cause a severe form of poisoning called acrodynia. The symptoms of acrodynia are pain in the extremities, pinkness and peeling of the hands, feet and nose, irritability, sweating, rapid heartbeat and loss of mobility.

The present study is aimed at presenting the status of mercury in India, with an overview of various problems of environmental pollution by mercury and its various compounds. The study also looks into the trade pattern, that is, the import and export of mercury with reference to India. The various laws, legislations and standards on mercury in the Indian context are also looked at. The study finally provides an outline of the various research works done so far on mercury in India.

Report Structure

Chapter 1. Mercury Usage and Releases: The first chapter looks into the total usage of mercury and mercury compounds in various industries. Analyses of the releases from these industries have also been done. The chapter also highlights the amount of air emissions from various sources and health effects of mercury.

Chapter 2. Environmental and Health Aspects: The second chapter analyses the environmental and health aspects of mercury in the Indian scenario. It details how mercury enters our environment and bodies.

Chapter 3. Trade in Mercury: The third chapter attempts to understand the economics of mercury trade. A data analysis of import and export figures of mercury and mercury-based compounds has been carried out in order to understand the dynamics of mercury trade in India.

Chapter 4. Standards and Legislations: In the last chapter, an attempt is made to look into the laws, standards and policies pertaining to mercury in India. A brief review has also been carried out to understand them.

MERCURY IN INDIA

USAGE AND RELEASES

MERCURY IN INDIA

- Mercury's ability to alloy with most metals, liquidity at room temperature, ease of vaporising and freezing and electrical conductivity make mercury an important and very popular industrial metal.
- It has 3,000 industrial uses, primarily in the caustic soda-chlorine production, the manufacturing of thermometers and other instruments and of electrical apparatus, as well as the formulation of various compounds. Paints and industrial instruments are also among the major uses of mercury.
- While developed countries have stopped using the mercury cell process in the chlor-alkali industry because of environmental and health hazards, mercury use in chlor-alkali industry is still very prevalent in India.
- The loss of mercury is 100 per cent in the production of caustic soda, that is, 394 gm/tonne of caustic soda produced. Thus with an annual capacity of 475.6 thousand tonnes in 1999-2000, on an average nearly 150-200 tonnes of mercury is lost in production of caustic soda by the mercury cell process annually.
- The Government of India has banned the commissioning of new mercury cell based chlor-alkali plants since 1991. Thus it has become mandatory for new chlor-alkali plants to instal the modern membrane cell technology
- On an average India produces 10 to 12 million instruments a year including clinical and laboratory thermometers as well as blood pressure monitors (sphygmomanometers), consuming about 15 tonnes of mercury annually.
- Additionally, mercury exists in medical waste and emitted through medical waste incinerators. Even if very expensive cleaners are installed in the stacks, there are still mercury emissions into the nearby ecosystem because mercury, which exists as a contaminant in medical waste, is combusted at high temperatures, vaporises and exits the combusting gas exhaust stack.

CHAPTER 1
USAGE AND RELEASES

Mercury and its compounds have found various usages through the ages. Properties such as the ability to alloy with most metals, liquidity at room temperature, ease of vaporising and freezing and electrical conductivity make mercury an important and very popular industrial metal. Among its current 3,000 industrial uses, its primary uses are caustic soda-chlorine production, the manufacturing of thermometers and other instruments and of electrical apparatus, as well as the formulation of various compounds. Paints and industrial instruments are also among the major uses of mercury.

Mercury is used in electrical switches; it is highly suitable for use in thermometers. Mercury dissolves numerous metals to form amalgams. Mercury is used to make vapour lamps, which are widely used because they are powerful sources of ultraviolet and visible light.

Mercuric oxide is a constituent of mercury batteries.

Mercurous chloride, or **calomel**, is a white, relatively insoluble salt. It is used in calomel electrodes, which are commonly used in electrochemistry, and in medicine as a cathartic and diuretic. Sometimes, calomel is also used as a teething powder for young children.

Mercuric chloride, or corrosive sublimate, is highly poisonous because it is very soluble. It was used for deliberate poisonings as early as the 14th century. It is now used as a disinfectant, in preparation of other mercury compounds, and in anti-fungal skin ointments.

Mercuric sulphide occurs in a red form and an amorphous black form. The red form (vermilion) is used as a colouring material. It is sometimes used to colour tattoos red, but it causes significant skin irritations and obstructions of the lymphatic system.

Mercuric fulminate is an explosive that is sensitive to impact and is used in percussion caps for ammunition and detonators.

Mercurochrome is an organic mercury compound that is used on wounds as an anti-bacterial agent.

Environmental and toxicity concerns have reduced the use and consumption of mercury metal in the industry. Over the years, there has been a phase-out of mercury by various consumers. Several European countries, especially Scandinavian countries, have completely phased out the use of mercury in day-to-day life.

However, concerns about the detrimental effects of mercury are yet to be taken on board in India.

Mercury Usage and Releases in India

Mercury finds a wide variety of applications in India. It is, however, impossible to examine all its applications as part of this study. Therefore, only a few major users are mentioned and discussed here.

The largest consumer of mercury is the chlor-alkali industry, which manufactures caustic soda and chlorine as a by-product using electrolytic process with mercury electrodes. The second-largest consumption of mercury is for the production of electrical apparatus, mercury vapour lamps, electrical switches, fluorescent lamps, etc. Mercury is also used in the manufacturing of instruments, such as thermometres, barometers, etc. Mercury finds application in metallurgy and mirror coating and as a coolant and neutron absorber in nuclear power plants as well. In addition, mercury is used in the health care sector for blood pressure monitoring instruments, feeding tubes, dilators and batteries, dental amalgams and also used in laboratory chemicals like zenkers solution and histological fixatives. The third-largest consumption of mercury in India takes place during the production of mercury-based compounds used as fungicides.

Chlor-alkali Industry

Chlor-alkali production is the manufacturing of caustic soda and chlorine. India's chlor-alkali industry is small in comparison with the rest of the world's production, and it still uses the outdated mercury cell technology extensively. Chlorine and caustic soda, the outputs of this industry, are used as the raw material for industries like paper and pulp, textiles, metal processing, planting, soap, organic solvents, PVC plastics, etc.

It is important to note that chlorine from the caustic soda industry finds a major application in PVC plas-

MAJOR CONSUMERS OF MERCURY IN INDIA

Mercury	Consumers	Amount (estimated)
Elemental mercury	Chlor-alkali industry (Mercury cell process)	100-150 tonnes annually
Elemental mercury	Instrument manufacturing 1. Clinical thermometer 2. Laboratory thermometer 3. Blood pressure monitors 4. Barometers 5. Other instruments	20 tonnes annually
Elemental mercury Mercury oxide Mercury salts	Electrical apparatus manufacturing 1. Electric switches 2. Electric lamps a) Fluorescent lamps b) Mercury vapour lamps 3. Batteries	Data not available
Mercury compounds	Fungicides a) Phenyl mercury acetate b) Methoxy ethyl mercury chloride	Data not available
Mercury oxide Mercury compounds	Other products a) Paints b) Cosmetics	Data not available
Elemental mercury Mercury oxide	Health set-ups a) Drugs and pharmaceuticals b) Dental amalgams c) Others	Data not available

Caustic Soda Usage Pattern ('000 tonnes)

End Use	1990	1995	2000
Paper/paper board	160	235	300
Miscellaneous	113	133	160
Soaps and detergents	110	115	130
Chemicals	90	105	120
Aluminium	86	110	110
Exports	15	35	93
Rayon grade wood pulp/viscose yarn/VSF	89	89	89
Cotton textiles	77	77	77
Fertilisers	40	50	72
Dyes and intermediates	35	42	50
Pharmaceuticals	31	34	38
Petrochemicals	13	22	35
Demineralisation	16	20	26
Power	16	20	26
Oil drilling	8	10	12
Vegetable oils	8	9	10
Rayon tyre cord	9	9	9
Mineral and metals	4	5	6
Total	**920**	**1,120**	**1,363**

(Source: The Hindu Survey of Indian Industry, 1995.)

tic. Almost 60 per cent of PVC is chlorine compound by weight.[1] Here the growth of PVC, a highly toxic plastic, has been synonymous with the growth of the chlor-alkali industry.

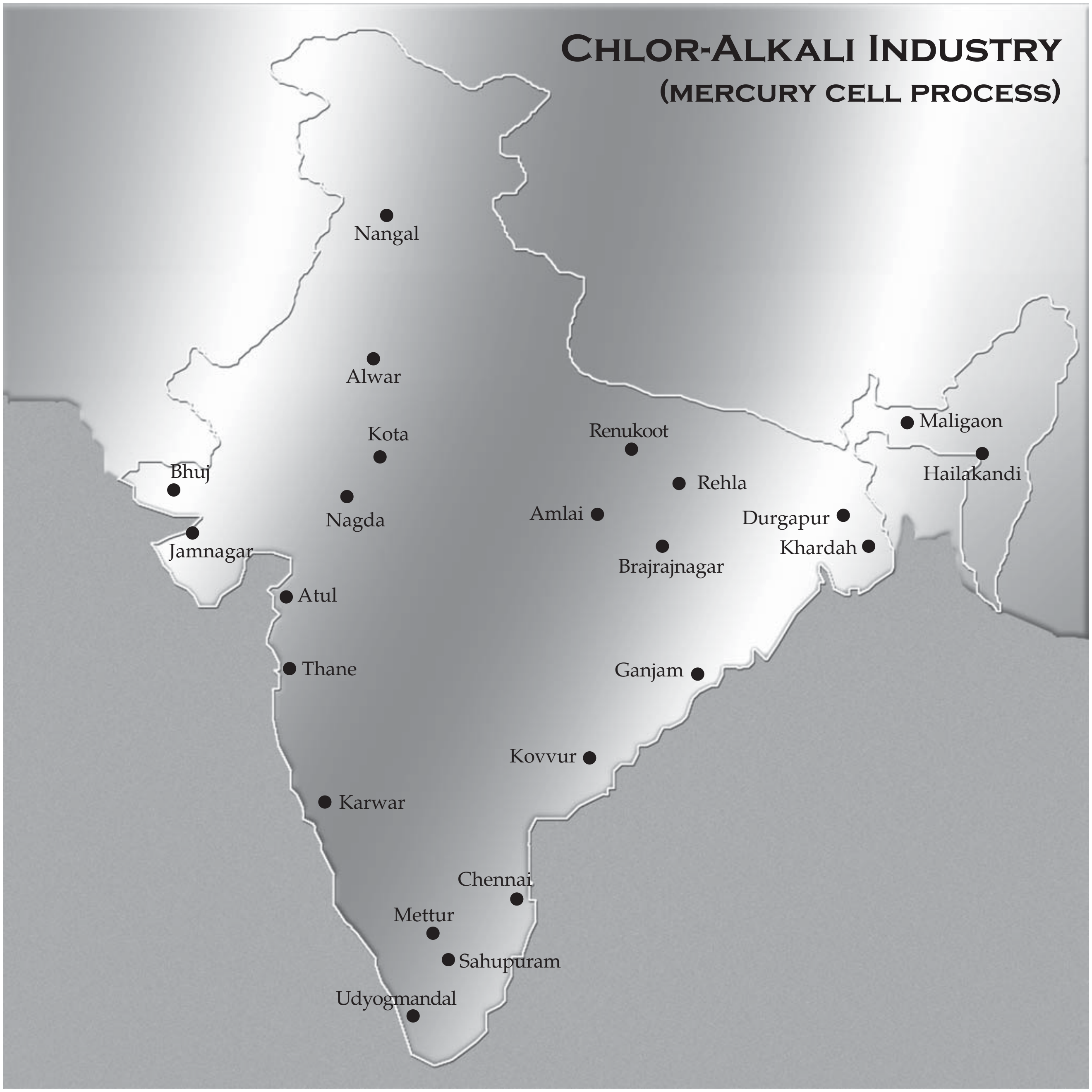
Chlor-alkali is one of the 10 most energy-intensive industry sectors in India. Historically, the caustic soda industry had always been plagued by the problem of high-energy consumption and mercury pollution. The high-energy consumption has a direct bearing not only on a country's most essential resource but also on the cost of production.

As mentioned earlier, caustic soda and chlorine are two basic chemicals being used in various products. The usage pattern of caustic soda is depicted in the table above.

An increase in the production of paper, aluminium, soaps and detergents, chemicals and other miscellaneous items, has naturally led to an increased requirement of caustic soda and chlorine. It should, however, be noted that the caustic soda and chlorine market has been a cyclical one. It is expected that the present trend will continue for a few more years.

On the other hand, chlorine has also shown a tremendous growth pattern over the years. There has been increased production of paper and pulp, PVC, paraffin wax and inorganic chemicals. The present trend of growth will continue, as in the case of, for instance, caustic soda.

Since the first 5-tonnes-a-day plant was opened in



Mettur in Tamil Nadu in 1936, the chlor-alkali industry has grown in India to produce almost 1.51 million metric tonnes in 2000. There are two processes currently used by the chlor-alkali industry, the older mercury cell and the more modern membrane cell. The production of caustic soda by mercury cell started in the 1950s and now accounts for 32 per cent of total caustic soda production.

In the mercury cell process, mercury is used in the basic electrolysis process of splitting sodium chloride (common salt) into chlorine gas and caustic soda, and hydrogen is released.

According to the Alkali Manufacturers Association of India, there are at present 42 caustic soda units functioning in the country with a total installed capacity of 2.23 million metric tonnes as on March 2000, which is about 5 per cent of the world's annual production. Membrane cell process accounts for 66 per cent of the total production while mercury cell accounts for nearly 34 per cent. Of the 42 manufacturing units, 11 units are completely based on the mercury cell processes, 12 units have both mercury and membrane cell processes, 18 units have the membrane cell process alone and there is only one unit using diaphragm cell process.

In other words, there are still 23 units, which wholly or partly use the mercury cell process for caustic-chlorine production. The list of these 23 units along with their respective production processes is given in

The Mercury Cell Process: A typical mercury cell has positively charged electrodes (anodes) made of either high quality graphite or specially coated titanium metal. The anodes are fixed to the vessel of the cell. Mercury, which is liquid at ordinary temperatures, is the negatively charged electrode (cathode). Its place is at the bottom of the cell. However, it is not stationary. The vessel is installed at a slight inclination so that mercury can flow down and be re-circulated with the help of a pump. In between the cathode and the anodes is the brine solution (electrolyte), which is also in constant circulation. The vessel is long and has a rectangular cross section. It is made of steel and has arrangements for chlorine outlet, electricity input and for brine and mercury re-circulation. Each cell has a secondary cell where mercury flows from the primary cell.

In a mercury cell, the following reaction takes place during the passing of electric current under 3 to 4.5 volts:

2 NaCl + electrical energy =	2 Na	+	Cl_2
sodium chloride (electrolyte)	sodium (at cathode)		chlorine gas (at anode)

Chlorine gas moves up and is taken out through pipes. The highly reactive sodium liberated at the cathode, which is mercury, immediately forms sodium mercury amalgam. It flows out to the secondary cell also known as denuder which is a small circular chamber packed with loose inert material, through which de-mineralised water flows. No electricity is used. The following reaction takes place:

2 Na-Hg	+	2 H_2O	=	NaOH	+	H_2	+	Hg
sodium - mercury		water		sodium hydroxide		hydrogen		mercury

Water reacts with sodium and forms sodium hydroxide (caustic soda liberating mercury for re-circulation to the primary cell to act as cathode again and again. Hydrogen is simultaneously liberated.

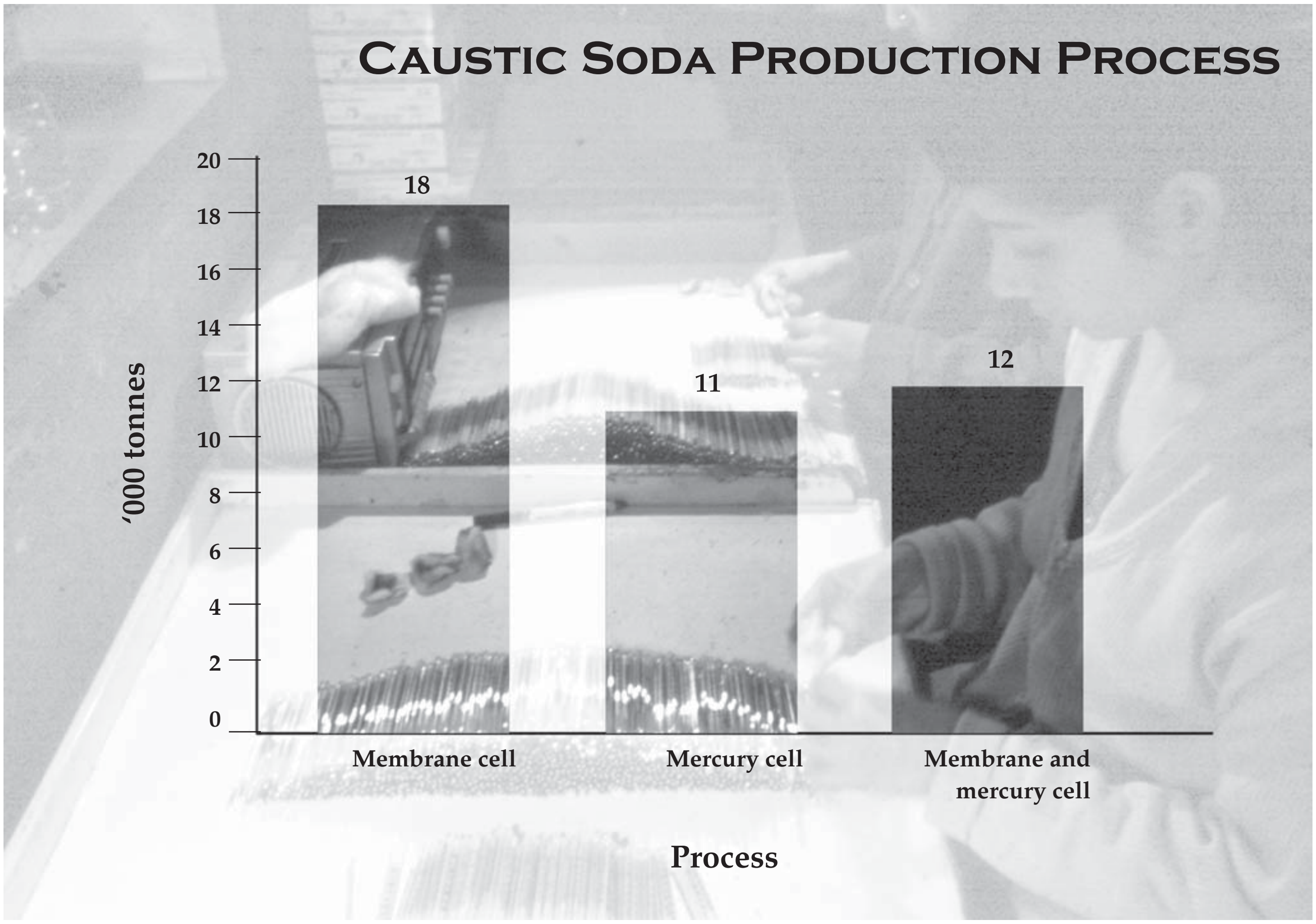
Thus the net reaction of chlor-alkali production can be rewritten as:

2 NaCl + 2 H_2O + electrical energy = 2 NaOH + Cl_2 + H_2

CHLORINE USAGE PATTERN ('000 TONNES)

End Use	1990	1995	2000
Pulp and paper	140	170	210
PVC	115	150	200
Chlorinated paraffin wax	72	80	100
Inorganic chemicals	65	70	75
Organic chemicals	40	45	55
Pesticides and insecticides	38	45	50
Miscellaneous	30	40	50
Water treatment	16	25	42
Pharmaceuticals	15	18	20
Rayon grade wood pulp	10	10	10
Total	**541**	**653**	**812**

(Source: The Hindu Survey of Indian Industry, 1995.)



the Annexure.

The chlor-alkali industry is the largest user of mercury in India; however, the amount of caustic soda-chlorine produced using mercury cells has declined over the years. Though India's chlor-alkali industry is small in comparison to the rest of the world, it still largely uses the outdated mercury cell technology extensively. While developed countries have stopped using the mercury cell process in the chlor-alkali industry, because of environmental and health hazards, mercury use in chlor-alkali industry is still very prevalent in developing countries like India. Mercury consumption by the chlor-alkali sector is at least 50 times (1.5-2 gm/tonne to 150 gm/tonne)[2] higher than the average European consumption.

Alternatives to Mercury Cell

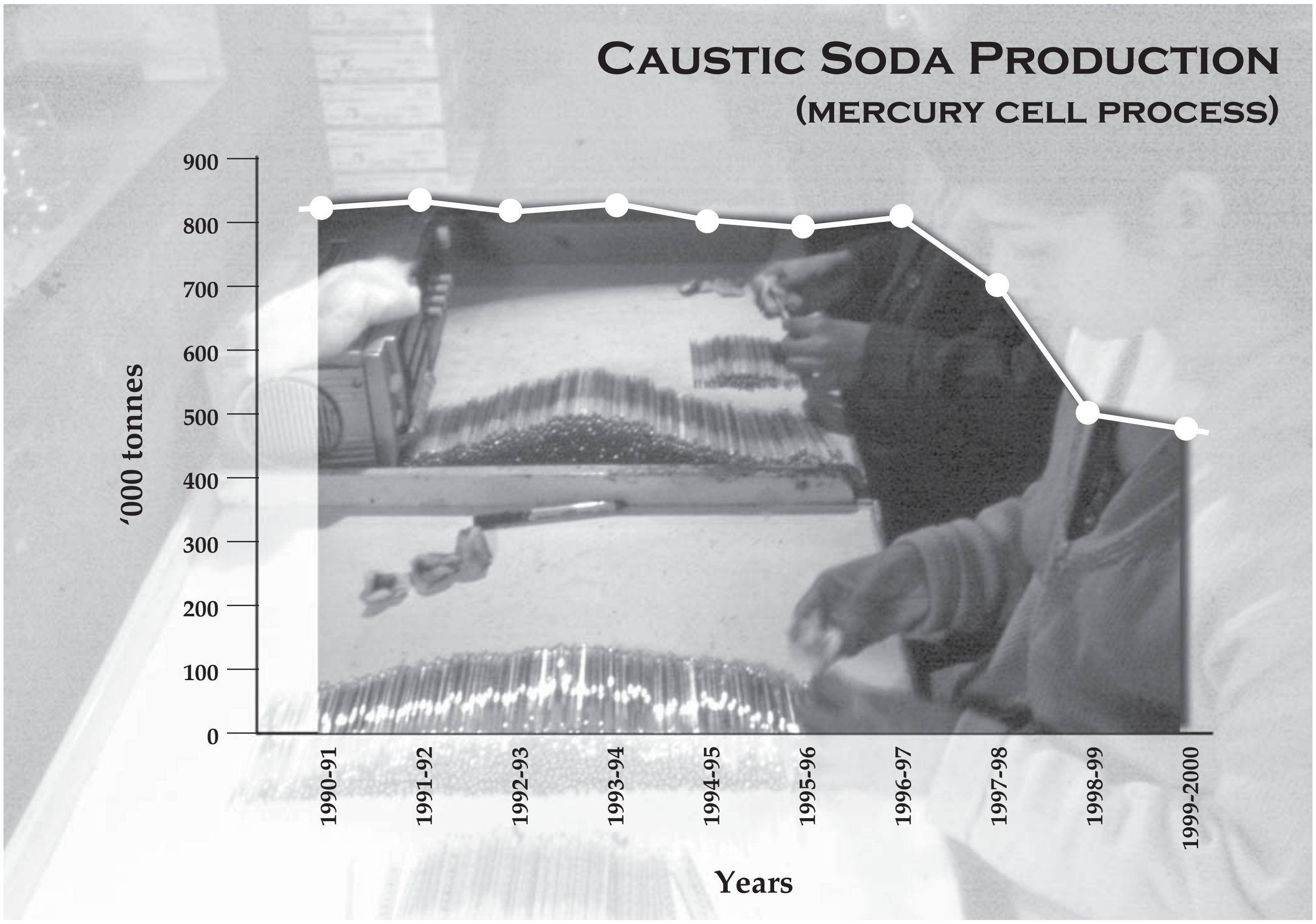
The membrane cell process is an efficient alternative, as there is no usage of mercury and it consumes less energy as well. The only problem highlighted by the industry in the conversion of mercury cell based caustic-chlorine plants to membrane cell process is the involvement of high costs of conversion. The cost of conversion of a 100 tonnes per day mercury cell to a membrane cell plant is Rs 650 million, that is, US$ 13 million. As the industry excuses itself by saying that servicing of this capital will nullify the savings made in energy consumption.

Legislation

The Government of India has banned the commissioning of new mercury cell based chlor-alkali plants since 1991. Thus it has become mandatory that new chlor-alkali plants should be installed with the modern membrane cell technology, which is more energy efficient and less polluting. However, there has been a lack of initiative on the part of the government and industry to do away with the existing mercury cell-based caustic soda-chlorine producing units. The industry, on its part, is demanding soft loans from government institutions to convert these plants. Cuts in the import duty on membrane cells have also been demanded as they have high duty charges.

The trend in the graph also suggests that mercury cell technology is being phased out. The production of caustic soda has reduced from 835 thousand tonnes in 1990-91 to 475.6 thousand tonnes in 1999-2000, thus showing the phasing out of the mercury cell technology by the industry.

The Central Pollution Control Board (CPCB) has published a number of documents between 1981 and 1985 as 'Comprehensive Industry Document Series and



Programme Objective Series' on various aspects of the chlor-alkali industry (*see page 17*). The documents try to review the status of this industry with special reference to the mercury cell process. There have also been case studies on some chlor-alkali units using the mercury cell technology.

The figures in the graph above suggest that consumption of mercury in the mercury cell technology depends on the age and maintenance of the cathodes of mercury in the plants: the old cell house will consume more mercury as compared with the new cell house. Thus, consumption of mercury varies from one unit to another. Mercury consumption in the mercury cell process varies from 75-80 gm to 394 gm per tonne of caustic soda produced.

There is also variation in the mercury consumption in the mercury cell process, depending on the mercury cells, their type and maintenance in the unit. If the cell is new or maintained properly, mercury consumption will be less, and vice versa.

On the basis of the figures given above, we can say that, on an average, around 150 gm of mercury is consumed per tonne of caustic soda produced in India. The total production of caustic soda by mercury cell processes in 1999-2000 was 475.6 thousand tonnes. Thus the consumption of mercury in the mercury cell process in the production of caustic soda was 71 tonnes in 1999-2000.

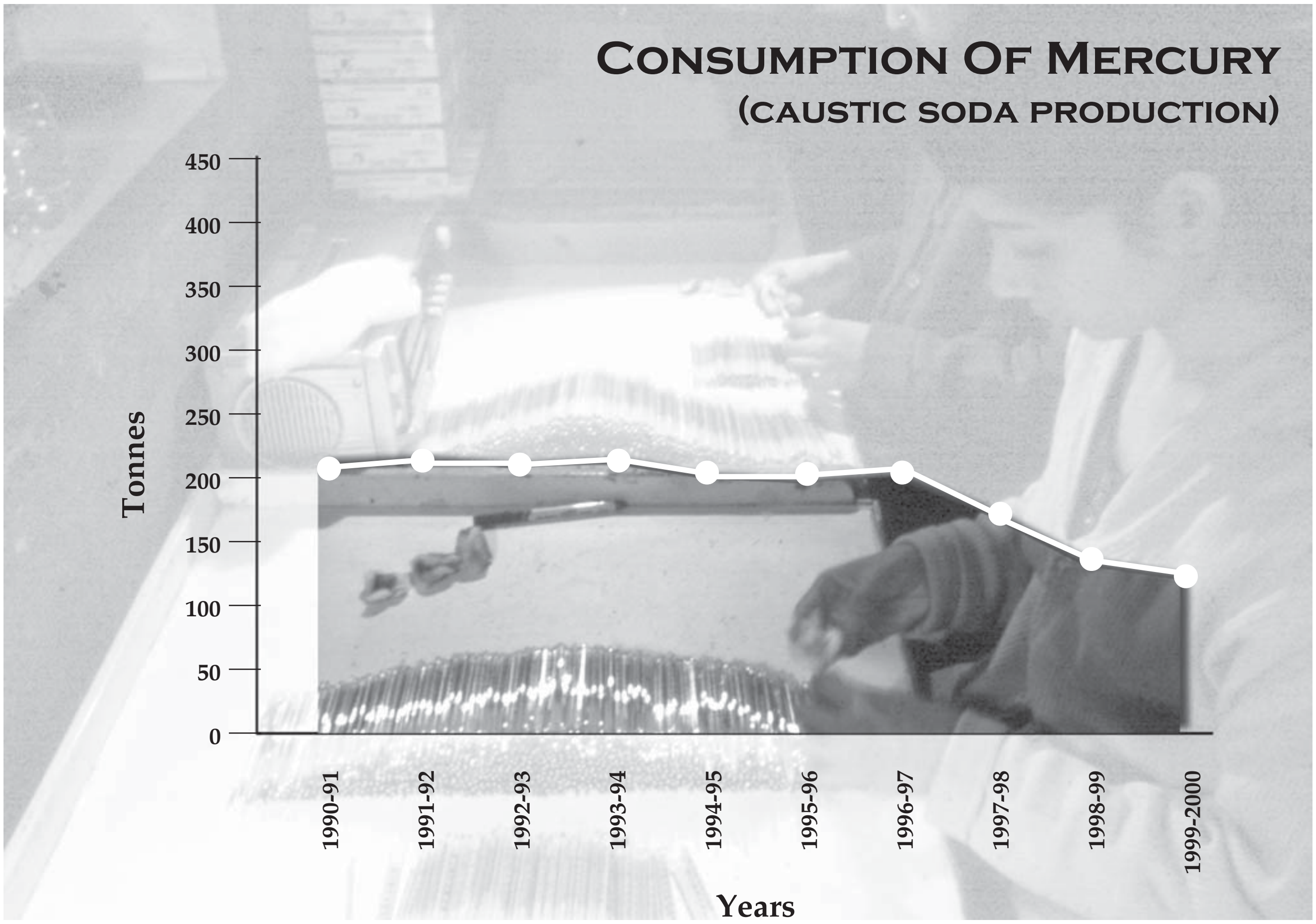
Though it is very difficult to estimate accurate figures, on an average we can say that around 70 to 80 tonnes of mercury is consumed by the mercury cell technology of chlor-alkali production.

The graph on the next page shows reducing mercury consumption in the mercury cell process of chlor-alkali production over time because of mercury's toxicity concerns for the environment and the Government of India's mandate (as mentioned earlier).

Releases from Chlor-alkali Industry

There is an immediate environmental impact from the use of mercury in the mercury cell process. Although mercury does not take part in the reaction, it is always lost to the environment during the process, often as a contaminant in brine sludge. Thus caustic-chlorine production by mercury cell process is declining and production by the membrane cell process is on the rise.

Mercury discharges to land, water and air mostly come from the mercury cell process of the chlor-alkali industry. The quantity of mercury that is consumed in the production of one tonne of caustic soda is nearly the same as the amount lost in the same production process!



Thus it can be said that 90 to100 per cent of the consumed mercury is lost during the production process.

A study released by the CPCB in 1977 suggests that the average mercury consumption of the chlor-alkali industry be targeted as 394 gm/tonne of caustic soda produced.[3]

The loss of mercury is 100 per cent in the production of caustic soda, that is, 394 gm/tonne of caustic soda produced.

Mercury Loss from Chlor-alkali Plants

Source	Gm Hg/tonne NaOH	Percentage
Water	1	0.3
Hydrogen	5	1.3
Products	22	5.6
Handling loss	50	12.7
Unknown*	62	15.6
Brine mud	254	64.5
Total	**394**	**100**

Thus with an annual capacity of 475.6 thousand tonnes in 1999-2000, on an average nearly 150-200 tonnes of mercury is lost in production of caustic soda by the mercury cell process annually.

Another study suggests that about 0.23 kg of mercury is lost per tonne of caustic soda produced.[4]

Thus, on the basis of this study, we can say that on an average 110 tonnes of mercury are lost in the production of caustic soda by the mercury cell process annually.

It is also very important to note that mercury loss from the mercury cell process varies from one plant to another, as it also depends on the age and maintenance of the plant. If the mercury cells are old then the loss will be greater.

Hence, in light of the above discussion, it can be estimated that around 100-150 tonnes of mercury are emitted annually by the chlor-alkali industry.

Process-wise Caustic Soda Production ('000 tonnes)

Year	Membrane	Mercury	Diaphragm	Chemical	Total
1990-91	115.8	835.0	66.2	1.1	1,018.0
1991-92	155.4	845.9	52.1	0.9	1,054.4
1992-93	220.0	825.8	50.6	5.3	1,101.7
1993-94	232.2	831.9	44.5	6.7	1,115.3
1994-95	356.0	796.0	50.3	5.0	1,207.4
1995-96	491.2	772.6	41.7	3.2	1,308.7
1996-97	527.7	789.6	3.3	-	1,320.7
1997-98	740.0	676.5	3.0	-	1,419.5
1998-99	975.4	514.9	-	-	1,494.8
1999-2000	1,035.4	475.6	-	-	1,514.0

CPCB Documents

Name	Industry	Mercury Consumption
Comprehensive Industry Document Series: 1981-82: 'Minimal National Standards Caustic Soda (Mercury cell) Industry'	Basis of mercury supplied to industry	394 gm/tonne caustic soda produced
Programme Objective Series: 1985: 'An Assessment of Mercury Pollution Problem at Kothari Industries Ltd, Chennai'	Kothari Industries Ltd, Chennai	75-80 gm/tonne caustic soda produced
Programme Objective Series: 1982-83: 'Mercury Transfer to Environment from Chlor-alkali Industry: A Case Study'	Hindustan Heavy Chemicals, Khardah, West Bengal	150 gm/tonne caustic soda produced

Instrument Manufacturing Industry

Mercury is used in many medical and industrial instruments for measurement and control functions. These instruments include all types of thermometers such as clinical, laboratory and meteorological ones, as well as blood pressure monitors (sphygmomanometers) and barometers.

Mercury has been used in the instrument manufacturing industry because of its unique physical and chemical properties. Mercury's linear expansion is uniform, between -39 to 359 degrees and, if mixed with 8 per cent of thallium, its coefficient of expansion expands to -55 to 600^{o}C. Beside these usages, mercury is used in barometers to measure atmospheric pressure. These instruments are found in major research laboratories, hospitals and clinics, school and college laboratories, meteorological observatories, clinical thermometers and in some common household items.

Thermometer Industry

The thermometer industry in India is essentially a small sector industry with a capacity of 40,000 to 50,000 pieces per month.

Clinical Thermometers

Mercury was found to be highly suitable for use in clinical as well as other types of thermometers because it does not moisten glass and has a uniform thermal expansion, though there are very serious concerns about the impact of its disposal practices (water pollution and occupational health). Clinical thermometers are largely manufactured in the small-scale sector in India. The industry is localised in north India and is based in Delhi and in the nearby towns of Aligarh, Ambala, Sonepat, etc (*see box below*)

On an average, around 425 thousand clinical thermometers are produced in India in a month, which means 5 million annually. A clinical thermometer contains approximately 0.61 grams of mercury. Thus with an annual capacity of 5 million clinical thermometers, about 3.1 tonnes of mercury are required annually for their manufacture.

Laboratory Thermometers

Laboratory thermometers are bigger in size than clinical thermometers and are used in various laboratories of educational and research institutions for research purposes. The laboratory thermometer industry is based in Delhi, Ambala, and few other places in India, mostly in the unorganised sector.

Clinical Thermometer Manufacturers

Company	Production (pieces per month approx)
Unitech Thermometers (Delhi)	40,000-50,000
Hanimax Thermometers (Delhi)	50,000-60,000
Hindustan Thermometers (Delhi)	50,000-60,000
Wilkho Thermometers (Delhi)	30,000-35,000
MCP (Medical Products) (Delhi)	40,000-45,000
Locally made (unorganised sector) (Delhi)	25,000-30,000
Hick Thermometers (Aligarh)	60,000-70,000
Maharana Thermometers (Sonepat)	50,000-55,000
Locally made (unorganised sector) (Ambala)	50,000-60,000
Total	**395,000-465,000**

(Source: Personal communication)

Laboratory Thermometer Industry

Place	Production (pieces per year approx)
Delhi	100,000
Ambala	100,000
Other parts of India (unorganised sector)	100,000
Total	**300,000**

(Source: Personal communication)

On an average, about 300,000 laboratory thermometers are manufactured annually in India. A laboratory thermometer contains approximately 3 gm of mercury. Thus, about 900 kg of mercury is consumed to produce 300,000 laboratory thermometers in one year.

Blood Pressure Monitors (Sphygmomanometers)

Although many liquids could be used in pressure measuring devices, mercury is used in sphygmomanometers because its high density requires less space. Blood pressure monitors, one of the important instruments used in the health care sector, are found in all hospitals and clinics. They are used to measure and monitor the blood pressure of the patients, especially heart patients. These instruments are also being used in households and gaining importance day-by-day. Like the other thermometer companies, blood pressure monitor making companies are mostly localised in and around Delhi.

In all, about 200,000 blood pressure monitoring instruments are manufactured annually in India. A blood pressure monitor contains approximately 60 gm of mercury. Thus about 12,000 kg of mercury is consumed to produce 200,000 blood pressure monitoring instruments annually.

Barometers

Barometers are one of the important instruments used in meteorological departments, and can also be found in weather stations and educational and research institutions. Barometers are used to measure atmospheric pressure and are helpful in analysing and forecasting weather. The barometer manufacturing industry is based in Kolkata where the company National Instruments produces them.

Generally all the barometers manufactured are of one standard size and contain approximately 5 kg of

Sphygmomanometer Industry	
Place	**Production (pieces per year approx)**
Delhi	100,000
Other parts of India	100,000
Total	**200,000**

(Source: Personal communication)

mercury. On an average, around 25 pieces a year are manufactured in India, generally on the basis of orders given by various institutions. Thus, about 125 kg of mercury is annually required in the manufacturing of barometers.

Thus, the instruments manufacturing industry is a major consumer of mercury in India. It will take time to replace mercury by a viable alternative in this industry. On an average, the instrument manufacturing industry consumes around 16 tonnes of mercury per year.

Alternatives

There is a trend to shift towards safer mercury-free alternatives to these measuring instruments as these instruments have a short life span and their disposal means the release of toxic mercury in the environment. Digital measuring instruments are the best available al-

Glass Thermometer Manufacturing Process

The production of glass thermometers begins by cutting glass tubes to the required length and size. Next, either a glass or metal bulb, used to hold the mercury, is attached to the base of the tube. The tubes are filled with mercury in an isolated room. A typical mercury filling process is conducted inside a bell jar. Each batch of tubes is set with open ends down into a pan, and the pan set under the bell jar, which is lowered and sealed. The tubes are heated to about 200ºC, and a vacuum is drawn inside the bell jar. Mercury is allowed to flow into the pan from either an enclosed mercury addition system or a manually filled reservoir.

When the vacuum in the jar is released, the resultant air pressure forces the mercury into the bulbs and capillaries. After filling, the pan containing the tubes is manually removed from the bell jar. Excess mercury in the bottom of the pan is re-filtered and reused in the process.

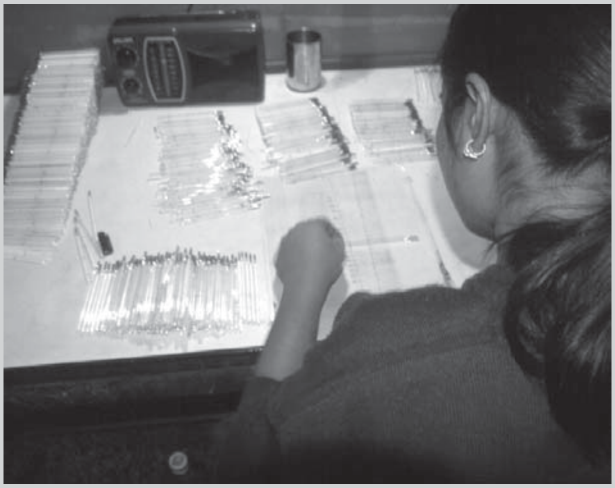
Excess mercury in the tube stems is forced out the open ends by heating the bulb ends of the tubes in a hot water or oil bath. The mercury column is shortened to a specific height by flame heating the open ends. The tubes are cut to a finished length just above the mercury column, and the ends of the tubes are sealed. All this is done manually. Lastly, the temperature scale is etched on to the tube, completing the assembly.

Visit to a typical thermometer factory, Delhi

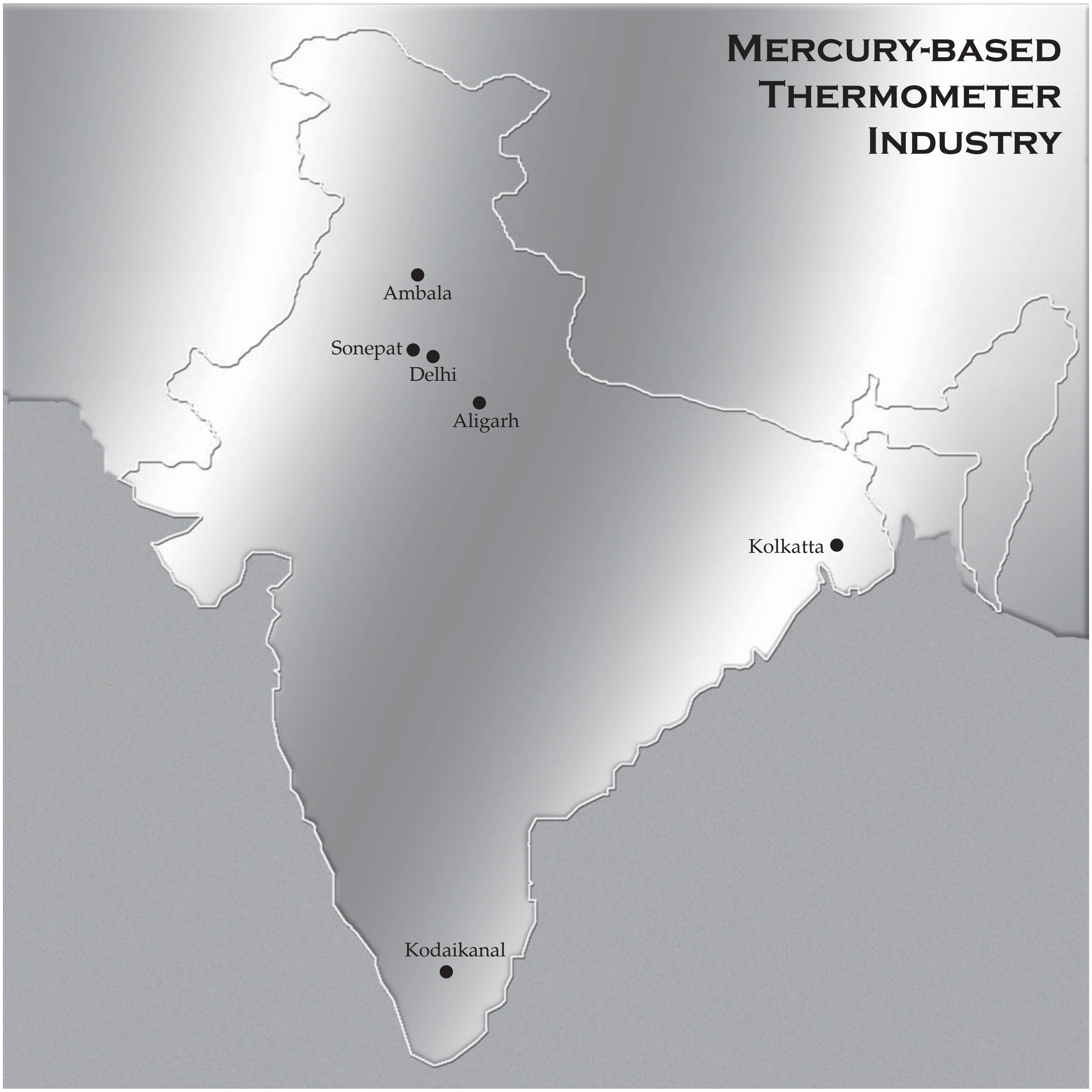
The thermometer factories in Delhi are generally located in residential areas. At first sight, the factory that we went to visit looked like a residential house. The factory is on the ground floor and the proprietor lives upstairs.

The location of this thermometer factory clearly highlights the problem of mushrooming of small-scale industries in residential areas. Both liquid and solid wastes find their way into the municipal waste facilities.

There has been a tremendous decline in the growth of these industries because, since the early 1990s, China has been dumping its mercury-based clinical thermometers in the Indian market. Chinese thermometers are said to look attractive, be accurate and, above all, be cheaper than Indian thermometers. The production cost of these Chinese thermometers is said to be Rs 6 as compared to the Indian price of Rs 10-15. This is because they do not have to import raw materials such as mercury and fine glass, like India has to do. Part of India's such imports come from China!



There is now a trend among producers to import these cheap Chinese thermometers and to market them under their own brand names rather than manufacturing them on their own, because importing remains cheaper than producing.



ternative to mercury-based instruments and have been used widely in the developed countries. They are very costly as compared to the mercury-based instruments but prove their cost-effectiveness in the long run, as they are very accurate and have longevity. Thus, the cost factor would even out in the long run.

Releases from Instrument Manufacturing Industry

The weight of mercury in each of these instruments is dependent on the type and grading. Average mercury content is 1 gm per thermometer, a range of +/- 0.0012 per cent. There is a breakage rate of 30 to 40 per cent in the manufacturing of these instruments, especially thermometers.

On an average India produces 10 to 12 million instruments a year including clinical and laboratory thermometers as well as blood pressure monitors (sphygmomanometers), consuming about 15 tonnes of mercury annually. Due to breakage during the manufacturing process of these instruments, broken glasses with trace amounts of mercury are also accumulated in tonnes. Manufacturing units use all the traditional and modern methods to recover mercury from these broken glass pieces. If not properly recovered, however, there is a grave danger of mercury entering our environment and bodies, as the broken glass pieces can land up in municipal waste dumps and in drains, causing

Mercury Thermometer Factory, Kodaikanal

In 1977, a second-hand mercury thermometer factory owned by Cheseborough Ponds was exported from the USA and bought by Ponds India Ltd. It was located in the southern Indian town of Kodaikanal, Tamil Nadu. The town is a famous hill resort and host to a few dozen boarding schools.

The thermometer factory changed hands in 1997, when Hindustan Lever Ltd bought it from Ponds India Ltd. Hindustan Lever is 51 per cent owned by Anglo-Dutch multinational Unilever. According to Hindustan Lever Ltd, mercury for the thermometers was imported primarily from the United States; the finished thermometers were exported back to the United States and then further distributed to markets in Germany, the UK, Australia, Spain and Canada.

The factory, now closed, was situated at an altitude of 2,000 metres amidst the flourishing tropical montane forest of the Western Ghats, one of the world's biodiversity hotspots. To the east of the factory wall, the land slopes steeply to the Pambar Shola forest, which was recently designated as a sanctuary by the Tamil Nadu government. The company secured a special exemption from the Tamil Nadu government to establish its factory on the ridge of the Pambar Shola slope, on the grounds that the factory was non-polluting.

It was one of the largest thermometer manufacturing plants in the world, producing 100,000 to 150,000 pieces a month, thus consuming nearly 75 kg of mercury per month (or 900 kg of mercury annually). Till its closure it manufactured around 165 million thermometers. The plant's operations were stopped because it was carrying illegal dumping of its mercury-bearing waste in the surroundings. The slopes where the wastes are dumped are part of the Pambar Shola watershed, draining water through the Pambar River, which eventually ends up in the plains leading up to the temple city of Madurai.

Over the years, the factory used these slopes as a dumping ground for all kinds of wastes, including broken mercury-containing thermometers and other potentially mercury-contaminated wastes.

A few years ago, production fell owing to declining demand in Western markets where environmental and public health concerns over mercury have led to the replacement of mercury thermometers by non-mercury thermometers.

At the factory, the highly hazardous mercury-bearing wastes were stored haphazardly in open and torn sacks, with the contents spilling onto the workspace, frequented by barefooted and unprotected workers. Reports gathered from several workers indicate serious health effects including a variety of neural disorders, tremors, infertility and loss of appetite.

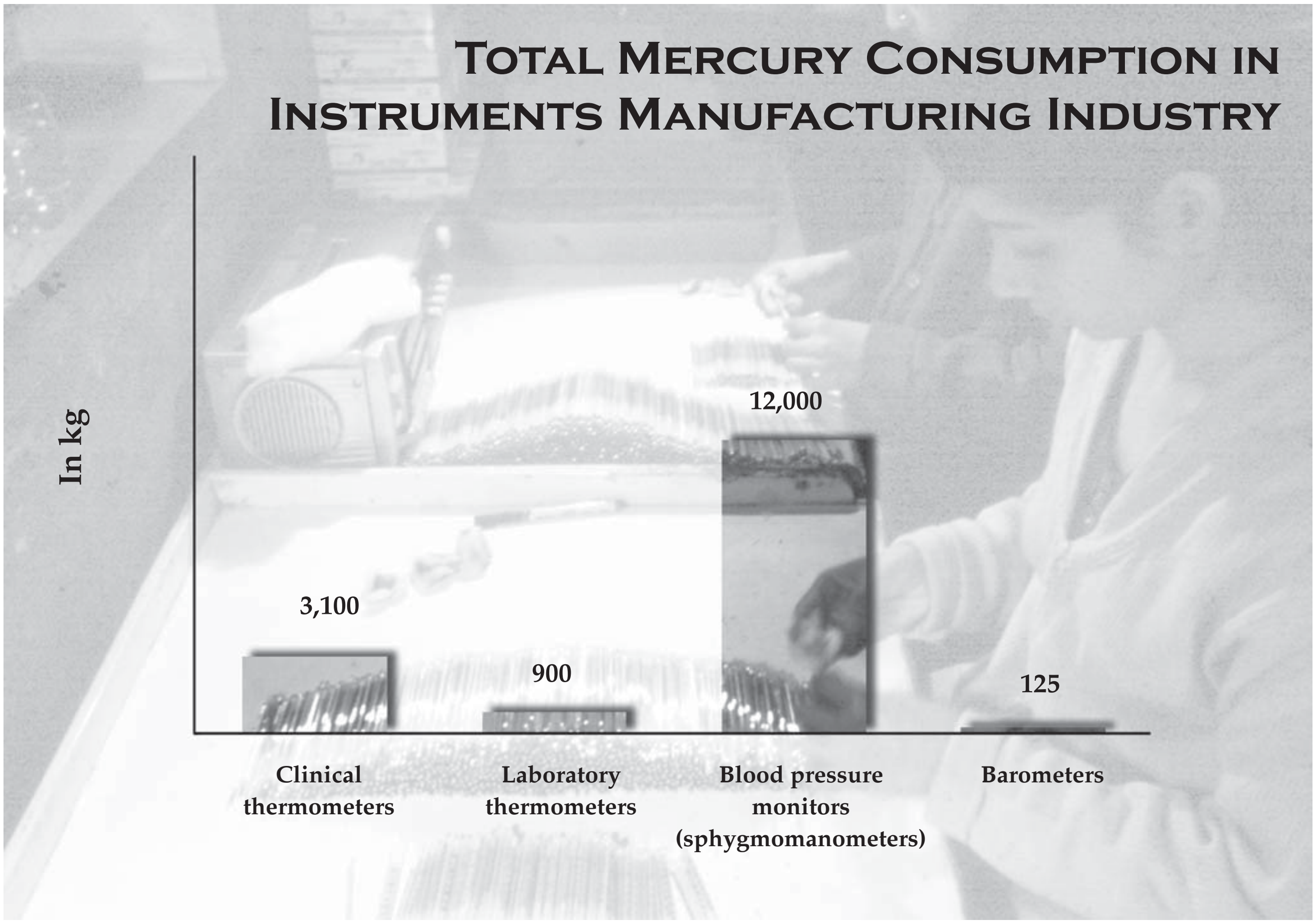
According to the waste merchant at the dumpsite, children with bare feet and hands used to recover half a litre of mercury, while a local merchant purchased broken thermometers containing hazardous waste for less than five cents per kilo. Many of the broken thermometers were stamped with Baxter or Medline, two US medical product suppliers.

serious threat to both surface and ground water sources.

The Kodaikanal thermometer factory has highlighted the harm a mercury-based thermometer plant can do to the environment. The Hindustan Lever Ltd thermometer plant has been guilty of dumping tonnes of broken glass waste (with traces of mercury in it) in the local forest and of selling some of it to the local waste dealers. Broken glass with traces of mercury was not stored properly; it was kept in the open, resulting in washing of mercury during the rains and draining into nearby streams and rivers. The company, in its report to the Tamil Nadu Pollution Control Board, assesses the amount of mercury released into the environment from its factory site in Kodaikanal at 539 kg (stating a statistical variance of 'between 43 kg minimum to 1,075 kg maximum').[5]

Electrical Apparatus Manufacturing Industry

Mercury is widely used and consumed in the electrical apparatus industry. Though the actual quantity used is not very large, usage-wise mercury plays a major role. Mercury is one of the best electrical conductors among metals and is used in many areas of electrical apparatus manufacturing. In India, the main manufactured apparatuses are electric switches and lamps.



Total Mercury Consumption in Instruments Manufacturing Industry

Name	Unit (in kg)	Used/unit
Clinical thermometers	3,100	0.61 gm
Laboratory thermometers	900	3 gm
Blood pressure monitors (Sphygmomanometers)	12,000	60 gm
Barometers	125	5 kg
Total	**16,125**	

Electric Switches

Mercury switches are used in thermostats and some alarm type clocks. Electric switches containing mercury have been manufactured since the 1960s with approximately 1 lakh produced annually. No information on locations of manufacturers, of electric switches that specifically contain mercury, is available. The electric switch is an important household item; its presence is necessary in every building and house where electricity is available. Mercury switches are also used in automobiles, thus playing an important part in the automobile industry.

Electric Lamps

Electric lamps containing mercury include fluorescent, mercury vapour, metal halide and high-pressure sodium vapour lamps. These lamps are used for both indoor and outdoor applications including heat lamps, lights of high-ceiling rooms, film projection, photography, dental examinations, photochemistry and street lighting. These lamps are both manufactured in India as well as imported. The main mercury-containing electric lamps manufactured in India are:

Fluorescent lamps: All fluorescent lamps (both tubes and bulbs) contain elemental mercury in the form of mercury vapour, put inside the glass tube. Mercury has a unique combination that makes it the most efficient material for use in fluorescent lamps. In fluorescent lamp production, pre-cut glass bulbs are washed, dried and coated with liquid phosphorus emulsion that deposits a film on the inside of the lamp bulb. The glass bulb is then exhausted on exhaust machines and approximately 15 to 250 mg of mercury is added. Some of

Production of Fluorescent Lamps

Years	Number (in millions)
1980-81	2.36
1985-86	3.55
1990-91	5.07
1993-94	6.36
1994-95	7.71
1995-96	9.77
1996-97	11.36
1997-98	14.50
1998-99	13.23
1999-2000	12.49

(Source: Monthly Abstract of Statistics, Central Statistical Organisation, Govt of India.)

the mercury combines with the emulsion on the interior of the bulb and remains there over the life of the bulb. The glass bulb is filled with an inert gas and sealed. After the lamps are sealed, metal bases are attached to the ends and are cemented in place by heating.

All fluorescent lamps operate by discharging an electric arc through mercury plasma enclosed in a glass tube. The ultraviolet (UV) photons emitted by the de-excitation of mercury atoms are converted to visible light by a phosphor coating on the inside of the glass tube.

Fluorescent lamps save a lot of energy and last 10 to 20 times longer than incandescent light bulbs. They provide the same high-quality light with less than one-quarter the electricity consumption.

The major companies manufacturing fluorescent lamps in India are Philips, Laxman Sylvania, Osram, Surya, Crompton Greaves, GE Lightings and some local companies including ABBA Lightings, etc.

Mercury vapour lamps: Mercury and metal halide lamps consist of an inner quartz arc tube enclosed in an outer envelope of heat resistant glass. The quartz arc tube contains a small amount of mercury ranging from 20 mg in a 75-watt lamp to 250 mg in a 1000-watt lamp. According to the manufacturers, no other substance has been found to replace mercury. However, this needs to be re-examined. High-pressure sodium vapour lamps consist of an inner, high purity alumina ceramic tube enclosed in an outer envelope of heat-resistant glass. The ceramic tube contains a small amount of sodium-mercury amalgam, ranging from 8.3 mg of mercury in a 50-watt lamp to 25 mg in a 1000-watt lamp.

The major companies manufacturing mercury vapour lamps are Philips, Laxman Sylvania, Osram, Surya, GE Lightings, Crompton Greaves; local companies include ABBA Lightings, etc.

Battery Production

A battery is a device that converts chemical energy into electrical energy. The battery is made up of an anode (positive electrode), a cathode (negative electrode) and an electrolyte. Different materials may be used to make the anodes and cathodes, such as zinc, mercury oxide and silver oxide, lead acid, carbon and nickel and cadmium.

Mercury has been used in batteries for two purposes. The first use is as a component in the zinc-mercury amalgam used as the anode in mercury oxide and alkaline batteries and as a component in the cathode of mercury oxide batteries. Its second use is to inhibit side reactions and corrosion of the battery casing material in carbon-zinc and alkaline batteries. Most primary batteries and some storage batteries contain mercury in the form of mercury oxide (HgO), zinc amalgam (Zn-Hg), mercuric chloride ($HgCl_2$), or mercurous chloride (Hg_2Cl_2).

Mercury batteries have a zinc anode, mercuric oxide cathode, and an electrolyte of an aqueous solution of potassium hydroxide or sodium hydroxide. The cell has a solid cathode of mercuric oxide and contains 33 to 50 per cent mercury or mercuric oxide. This cannot be reduced without proportionally reducing the energy content of these batteries. The battery cell contains a caustic electrolyte and can have the same adverse health effects as alkaline batteries.

Mercuric oxide batteries fall into two categories: button cell and larger sizes. Most mercuric batteries sold for personal use are button cells. Button cells are small, circular, relatively flat batteries that are used in transistorised equipment, walkie-talkies, hearing aids, electronic watches and other items requiring small batteries.

Mercuric oxide batteries are widely used for applications including medical, industrial and military applications and other non-household devices.

The major companies manufacturing dry cell and other types of batteries are: Eveready, BPL, Novino, Nippo, Panasonic, Energiser, etc, though multinational companies have started producing mercury-free batteries. In India, there are companies that make batteries on a very small scale, and the use of mercury in their operations is unaccounted.

Releases from Electrical Apparatus Manufacturing Industry

There has been no documented case of mercury release from the production process of these industries, though there could be breakage rate in production of fluorescent and mercury vapour lamps. The process of mercury recovery from broken glasses, as also their way of disposal, can release mercury in the environment.

Fungicide Industry

A pesticide that kills fungi is called a fungicide. Fungicides are based on the broadly toxic elements; copper, mercury and sulphur were among the earliest agrochemicals. Copper sulphate and mercury chlorides have been used since the 18th century. Though synthetic systemic compounds have largely superseded them, mercury-based compounds are still an integral part of the pesticide industry. Diseases such as rusts, mildew and blights spread rapidly once established. Fungicides are thus routinely applied to growing and stored crops as a preventive measure, generally as foliar sprays or seed dressings.

Organo-mercurial compounds are used as fungicides. In India, mercury is used to produce organo-mercurial compounds and their production constitutes the third-largest consumption of mercury in the country. Farmers use fungicides for seed dressing.

In India various organo-mercurial compounds are sold in the market under different brand names, for instance Ceresan, Aretan, Agallol, to be used as fungicides. Though these are very effective in seed treatment, various studies have proved that mercury in the fungicide enters seeds when treated, further persists in the plant tissues, translocates in the food crop in trace amounts and finally finds its way into the human food chain. The impact of seed dressing is enormous since it is applied to a large volume of seeds, which are subsequently sowed over millions of acres, thereby causing widespread dispersal of mercury.

Some typical compounds of this category are methyl mercury nitrite, methyl mercury dicyandiamide, methyl mercury acetate, phenyl mercury acetate (PMA), ethyl mercury chloride, methoxy ethyl mercury chloride (MEMC), etc.

India has banned the use of some organo-mercurials like phenyl mercury acetate (PMA), ethyl mercury chloride, and restricted the use of methoxy ethyl mercury chloride (MEMC) as fungicides, because they get accumulated into the plants through treated seeds. The mercury poisoning incident in Iraq, in 1956, is well known worldwide, where people consumed bread made of wheat, treated with methyl mercury acetate. The wheat was treated to sow and by mistake it came to Iraq through relief.

In India all the fungicides in use have to be registered under the Insecticides Act, 1968. The mercury-based compounds used as fungicides registered on a regular basis under section 9(3) of the Insecticides Act, 1968, are:

- Ethyl mercury phosphate
- Ethyl mercury chloride*
- Ethoxy ethyl mercury chloride
- Mercuric chloride
- Methoxy ethyl mercury chloride (MEMC)*
- Methyl mercury chloride
- Phenyl mercury acetate (PMA)*
- Phenyl mercury chloride
- Phenyl mercury urea
- Tolyl mercury acetate

(*Only these three are manufactured in India.)

The use of phenyl mercury acetate (PMA) has been banned in India since 1973, with effect from 1.1.73, but it was still produced for export. In 1999, its manufacturing was also banned in India with effect from 26.3.1999.

The use of methoxy ethyl mercury chloride (MEMC) has been banned since 2001 with effect from 17.7.2001, by the Ministry of Agriculture, except for seed treatment of potatoes and sugarcane in the country.

The data provided by the Directorate of Plant Protection, Ministry of Agriculture, (*in the table below*) shows that in the last five years no organo-mercurial compounds have been produced, imported or exported to India, though consumption is on a slight increase. It leads to the conclusion that there is a large stockpile of these compounds in India. The Directorate of Plant Protection states that "as per the FAO inventory of stockpiles of obsolete pesticides in India, 3,346 tonnes of stock are present". There is a possibility that a large quantity of these would be organo-mercurials.

The data given by the Ministry of Environment and Forests shows that India has a stockpile of 44 tonnes

Organo-mercurial Compounds

	1995-96	1996-97	1997-98	1998-99	1999-2000
Production (in MT)	0	0	0	0	0
Import (in MT)	0	0	0	0	0
Export (in MT)	0	0	0	0	0
Consumption (MEMC) (in MT)	81	73	82	87	85

(Source: Dr P.S. Chandurkar, Plant Protection Adviser, Directorate of Plant Protection, Ministry of Agriculture, Govt of India) of organo-mercurial compounds and there is restricted use of these stocks in agriculture. How is this possible when the annual consumption figures given by the Directorate of Plant Protection are of 80 tonnes on average?[7] There seems to be a huge data gap in production and consumption figures between the various governmental agencies responsible for handling organo-mercurial compounds.

Mercury in Health Set-ups

Mercury is widely used in the health care sector. Mercury and mercury-containing products are used in patients' areas and pathology laboratories, in clinical procedures and in medicines. At least 20 different medical products contain mercury and many mercury-containing solvents and degreasers are found in laboratories, housekeeping departments, and kitchen and maintenance areas. Mercury is an ingredient in some proprietary formulas used to manufacture medical and industrial supplies.

This section tries to view the role of mercury in the health care sector in India.

Source of Mercury in Hospitals

1. Thermometers and thermostats
2. Blood pressure monitors (sphygmomanometers)
3. Dilators and batteries
4. Dental amalgams
5. Laboratory chemicals like zenkers solution and histological fixatives

Hospitals and clinics, big or small, are the largest consumers of these instruments.

The industrial and chemical uses of mercury are manifold in the medical community: besides the instruments, hospitals have mercury in fluorescent and high-intensity lamps, in thermostats and switches and in a variety of generators, manometers and batteries. Non-medical uses of mercury include cleaning solutions, preservatives, paints and anti-fouling agents for wood and other surfaces. Beside these instruments and non-medical uses, other health care sectors that use mercury or mercury-based products are:

Dental amalgams: Mercury is used in dentistry, primarily in amalgam fillings for teeth. The dentist drills out the cavity and then fills the cavity with amalgams. Dental amalgams are typically 40-50 per cent elemental mercury by weight. Mercury has the unique property of mixing well with various metals. In dental amalgams, mercury is mixed with copper, gold and silver to form an amalgam. Dental amalgams represent a significant source of overall mercury exposure and are probably the population's major source of elemental mercury vapour.

Medicines: Mercury and mercury-compounds have been used in the manufacturing of medicines but the details are not known. Ayurveda in India uses mercury for the treatment of several diseases as a part of '*Rasayan Shastra*' or metal therapy. Using mercury in medicines has cured cases of blood cancer and multiple sclerosis. The therapeutic powers of metals like mercury have been the object of a constant fascination for the alchemists of the ancient and medieval world.[8]

Ayurveda and Rasathanthra (treatment using mercury): The Dravidians adopted this method of treatment in the Samhitha period. This treatment involves the purification of metals like gold, iron, etc, that later take the form of medicines. *Rasahridayathanthram* by Vagwadacharya is the first Sanskrit work on Rasathanthra. There are references to the uses of *rasa* (mercury) metals and gems in the Charaka and Sushrutha samhithas. It is ascertained that mercury has the ability to make the body strong and sturdy.[9]

Mercury in Other Products

Mercury is found in a variety of household products, including batteries, fluorescent light tubes and bulbs, electrical switches and thermometers. The use of mercury in many of these applications is regulated by government agencies or controlled voluntarily by industry groups. A brief summary of product-specific use of mercury:

Paints

Producers have progressively discontinued the use of mercury in most paints sold in the market. Mercury was earlier used as a biocide in two categories of paints. Marine anti-fouling paints utilised mercury (mercury oxide) as an agent to hinder the growth of algae after the paint was applied to the bottom of the ships. Latex paints used a variety of mercury compounds such as phenyl mercury acetate (PMA), as a biocide after its application as well as a preservative to control microbial growth in the paint can during storage.

Cosmetics

Mercury compounds were previously used in skin bleaching creams and as preservatives in a variety of cosmetics. Mercury is used as a preservative, especially in cosmetics intended for use in the area of the eye. Besides this, mercury sulphide, a red-coloured powder, is also present in the traditionally used sindoor, used by Hindu women in India. Mercury sulphide is also used in red colour making, especially during the festival of Holi.

Air Emissions

Mercury is released in the air by burning fossil fuels such as coal, mineral oil, incineration as well as goods and items containing mercury in trace amounts. This process does not use mercury, but mercury gets released and is further accumulated, as mercury remains persistent in the environment.

The major contributors of adding mercury to the environment via air emissions are:

- Coal fired thermal power plants.
- Medical waste incinerators.
- Municipal waste incinerators.

Thermal Power Plants

India is the third-largest producer of coal in the world. Coal is the most abundant fossil fuel resource and is the primary fuel for energy in India. The coal reserves of India have been estimated, by the Geological Survey of India, to be 2,11,593.61 million tonnes as on January 1, 2000.[10]

Coal is the dominant energy source in India, accounting for more than half of the country's requirements. Seventy per cent of India's coal production is used for power generation, with the remainder being used by heavy industry and public use. Domestic supplies satisfy most of India's coal demand.

In India, the power and steel sectors, at present, are the major consumers, taking 89 per cent share of the total coal produced. The installed capacity of coal-based electricity generation has increased from 800 MW in 1973 to 50,000 MW in 1994-95 and is expected to go up by another 50,000 MW in the next 15 years. Thermal power plants are currently using about 220 million tonnes of coal per year, which account for about 75 per cent of the total coal production. The demand of coal for thermal power stations will increase year after year. There are around 75 thermal power plants in the country, which currently generate around 75 per cent of India's power.[11]

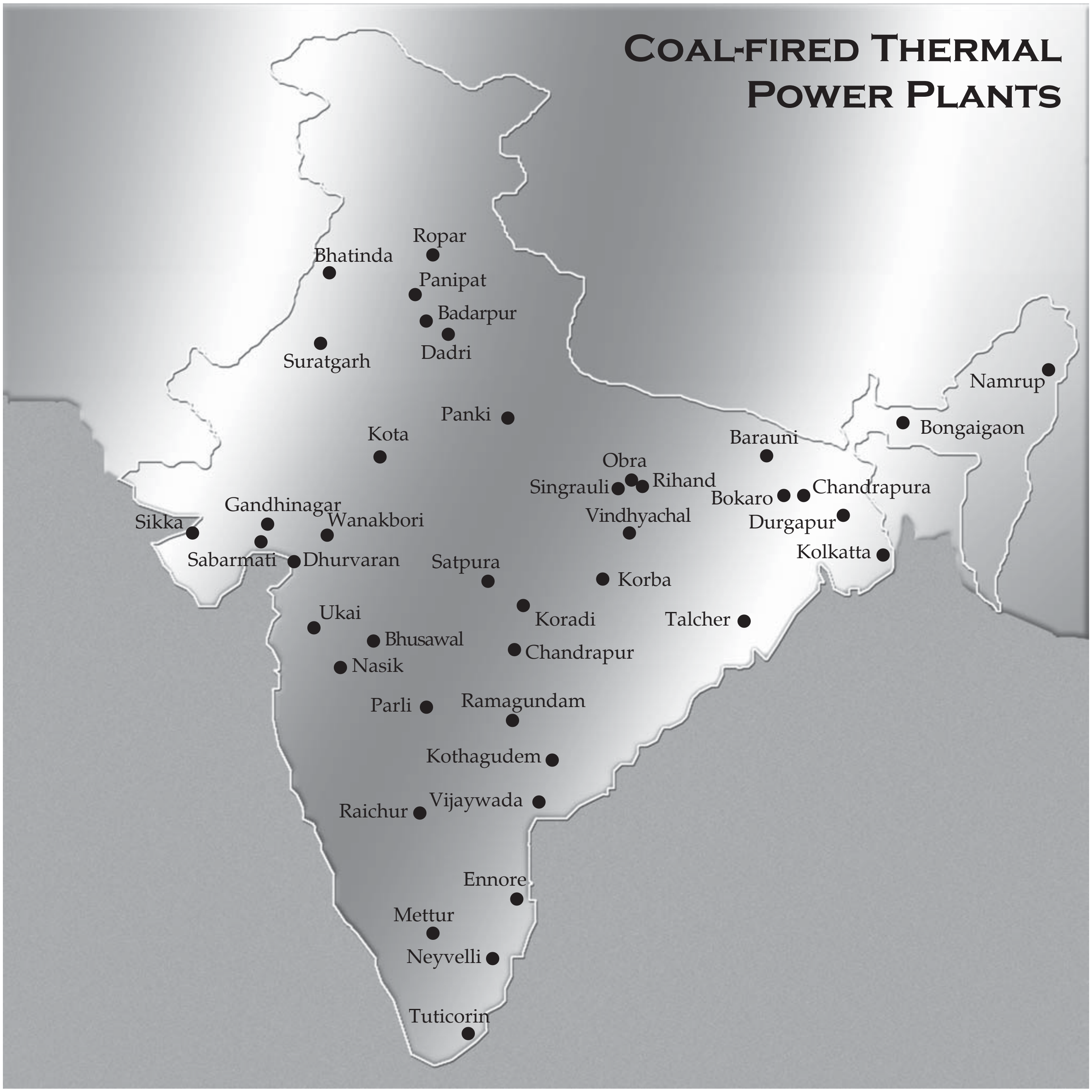
Most of India's coal is characterised by low trace element concentration. The quality of coal depends upon its rank and grade. Indian coal is of mostly sub-bituminous rank, followed by bituminous and lignite (brown coal). The ash content in Indian coal is approximately 35 to 55 per cent.[12]

Emissions from Coal Burning: The smokestacks of thermal power plants spew a broad range of toxic substances into the air. These vapours include known carcinogens such as mercury, heavy metals, dioxins, furans and PCBs. During combustion, many of these metals like Fe, Al, Mn, Co, Ni, Cd, Hg, Pb, Zn, Cd, As, etc, volatilise at furnace temperatures, and toxic and harmful quantities of these elements are released in the environment. Coal contains mercury as a natural component along with other elements in trace amounts (0.04-0.7 mg/kg).[13]

Given the large quantity of coal burned in thermal power plants as well as in industrial, commercial and residential burners, considerable amounts of mercury are released into the environment.

Thermal power plants are the second largest source of mercury emissions in India. As the coal is combusted in the utility boiler, mercury is vaporised and released as a gas. Pollution controls employed by utilities to curb other pollutants are not effective in removing mercury. At present, there are no commercially viable control technologies for mercury. As a consequence, this highly toxic form of air pollution continues to go largely unabated.

Thus coal becomes a repository of toxic metals. For example, a super thermal power plant consuming 8 million tonnes of coal containing x grams per tonne of any toxic metal, will pump into the surrounding eco-



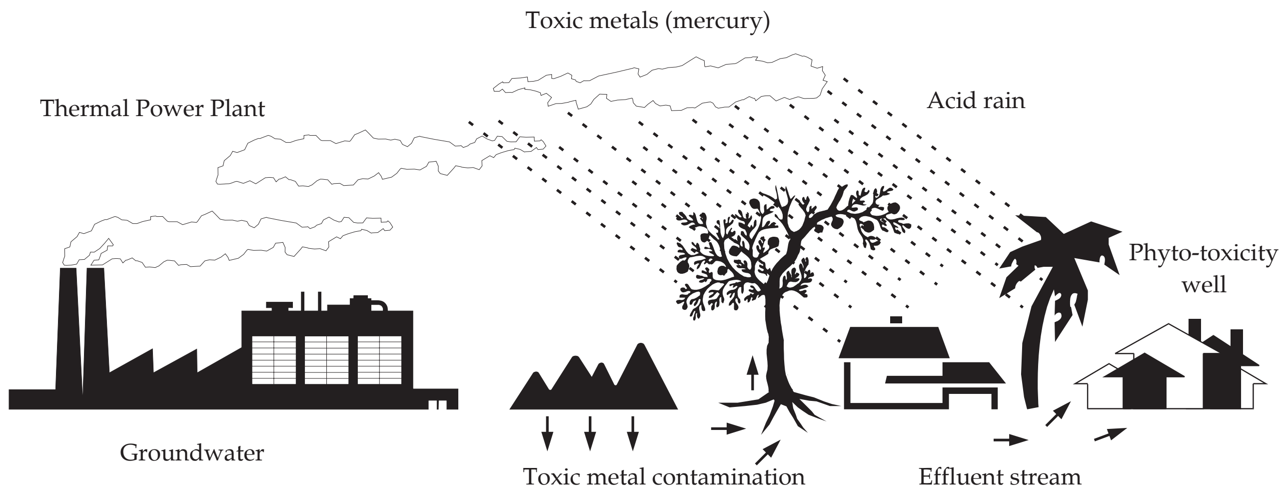
system 8x million grams of the metal.

Mercury in coal: In India there was uncertainty over the actual concentration of mercury in coal: there have been several studies, but not a single concrete one. The mercury content of coal produced by different mines varies widely according to the location, making it quite difficult to propose estimates.

The studies, which show concentration of mercury in coal samples in India, are mostly academic-oriented. A study by K.C. Sahu shows mercury content in a coal sample as 0.11 ppm. On the other hand, samples of Pathankhera coalfields in Gondwana basin, in Madhya Pradesh, analysed in a study by R.R. Nandgaonkar show mercury content in coal in the range of 0.8 to 0.20 ppm.[14]

A World Bank document in the year 2000 on the National Thermal Power Corporation (NTPC) showed results for mercury concentrations in coal analysis done by NTPC in the range of 0.11 to 0.14 ppm while another study of coal analysis, done by the Roorkee University, India, showed mercury to be in the range of 0.8 to 11.4 ppm. The Bank noted the discrepancy among the two results and requested NTPC to redo the study after consulting with other reputable laboratories and agencies in India to establish a standard test procedure that would be consistent with the coal testing procedures used in the USA. After a year, the new findings showed mercury concentrations in coal in the range of 0.17 to 0.32 ppm, significantly higher than coal in USA and

Fall-out of Coal Combustion from a Thermal Power Plant



Europe where mercury emission from thermal power plants has been of concern.

The Central Pollution Control Board (CPCB) conducted a study on 'Mercury balance in thermal power plants'.[15] The CPCB analysed 11 coal samples and found the average mercury concentration to be of 0.272 ppm (ranges between 0.09 to 0.487 ppm). Though these data are inadequate, it is still an attempt to assess the total mercury pollution potential from coal in India.

Mercury emissions from coal: On an average, India annually consumes 325 million tonnes of coal in sectors such as coal-fired thermal power plants, iron and steel plants, cement plants, foundries, fertiliser production, paper manufacturing, etc. The power sector, which accounts for over 70 per cent of the total coal consumption, annually consumes around 220 million tonnes.

The total mercury pollution potential from coal in India is estimated to be 77.91 tonnes per annum, considering average concentration of mercury in coal as 0.272 ppm. About 59.29 tonnes per annum mercury is mobilised from coal-fired thermal power plants alone.[16]

The mercury emanating from the thermal power plants' stacks is 58.05 per cent gaseous and 2.4 per cent in particulate form. About 32.5 per cent is retained in the ashes (fly ash and bottom ash). The remaining 7.05 per cent could not be accounted for.

Thus, mercury being persistent in the environment, its presence in the air in this amount could enter bodies through the oral route and prove a great threat to people, especially those living in the vicinity of these thermal power plants.

The 75 thermal power plants consume around 220 million tonnes of coal for power generation, producing 65-75 million tonnes of fly ash. Thermal power plants' coal consumption is likely to reach 400 million tonnes per year, which would represent 150 million tonnes of ash generation. With such high growth projections for these plants, the future of mercury emissions in India is really grim.

Beside this, the fly ash generated by thermal power plants is also a huge concern because of its environmental impacts. The impact of ash-ponds near thermal power plants on the local environments is usually stated to be the following:

- Leaching of trace elements, in particular heavy metals, into surface water and ground water.
- Accumulation of heavy metals in soils and plants around ash ponds.

On an average, around 65 million tonnes of fly ash are generated every year in India by 75 thermal power plants. For every megawatt of power generated, about 0.6 to 0.7 tonnes of ash is produced.[17] Heavy metals are largely concentrated on the surface of fly ash.

The disposal of fly ash is extremely water and land intensive. Large tracts of land are acquired for fly ash disposal, leading to air, water and soil contamination. In India, mercury is concentrated as 0.1 ppm as a trace element in the fly ash.[18] The present modes of disposal in water bodies pose grave danger for the populations.

The leachability of heavy metals from fly ash is well documented. However, the concentration of leached ions is not likely to have a significant impact on surface water bodies where periodic high flows will prevent accumulation of leached contaminants. The influence of leached trace elements on ground water quality is an area of major concern, because of the possibility of progressive accumulation of leached trace elements into ground water beneath an ash pond. Data pertaining to ground water contamination is scanty and more studies are required.[19]

Singrauli – hotbed of mercury pollution: The Singrauli region has a long and sorry history. Some 30 years ago, the Singrauli area in Central India was inhabited by a rural, self-sufficient population, and by rich wildlife. Today, it is considered the energy capital of India, with a huge artificial reservoir, giant coal mines, five super thermal power plants, and several industrial complexes.

The five giant super thermal power plants in Singrauli area, which supply 10 per cent of India's power, stand responsible for 16.85 per cent, that is, 10 tonnes per annum, of the total mercury pollution resulting from power generation.

Since 1988, there have been a number of studies on the presence of mercury in the water bodies of the Singrauli region. A study on mercury contamination in the Singrauli area was done by the Industrial Toxicology Research Centre for NTPC to assess the environmental risk to human population related to mercury contamination in the Singrauli area. Work monitoring and analysis of mercury contamination was completed in 1998 and a report was prepared, but it remained confined to the NTPC offices.

According to the World Bank's year 2000 document, the study indicates sufficiently high levels of mercury concentrations in humans, plants and animals to cause concern for the Singrauli area.

NTPC did not disseminate the results of this study to the general public, primarily because of its concern about the public reaction. The NTPC, indeed, claims that its power stations are not a major contributor to the mercury problem in the area!

The impact of mercury emissions from thermal power plants and fly ash on the environment and the health of people living in the area can be traced through a study done by the ITRC. A representative of the ITRC presented the study at a World Bank meeting; it is titled 'The status and magnitude of mercury contamination in the human population in and around industrial zones along Gobind Ballabh Pant Sagar (GBPS) Reservoir', in Singrauli, Madhya Pradesh. It is an epidemiological study, tracing mercury levels in the local people's bodies. The probable source of mercury contamination has mostly been food items.

The table below shows that the proportion of mercury in the blood samples was high in Dibulganj, Anpara, Renukoot and Parasi. The samples belonged to people between 10 and 60 years of age. The people from whom samples were taken had been living in the area for five to 10 years and had specific food consumption patterns. A regular monitoring and clinical surveying of subjects residing in the area is required. There is also

MERCURY LEVELS IN RELATION TO GEOGRAPHIC LOCATIONS IN SINGRAULI

Areas	Hg blood (μg/ml)		
	Numbers	Mean	SE
Anpara Bazar, Anpara Colony and Village	188	36.93	6.15
Balia Nala, Bansi and Bina	184	13.75	1.08
Chilka Dhand	118	12.61	0.86
Dibulganj	94	67.81	18.90
Dudhi, Kauwa Nala, Kakri and Kota Basti	58	6.76	0.75
Mamuar	60	13.17	1.17
Meurpur	117	10.00	0.86
Parasi	48	16.33	3.32
Rehata	75	16.21	1.04
Renukoot	21	31.15	1.94
Shakti Nagar	97	2.09	0.10

(Source: Paper presented by ITRC in World Bank meeting.)

a need for further and in-depth studies for accurate appraisal of the situation.

Another study by researchers concludes that serious mercury pollution is occurring in GBP reservoir and other surface waters of Singrauli, posing a grave threat to the health and livelihood of the population. The major cause of pollution, which appears in the study, is the deposition of mercury transported via the air route from the emissions of large thermal power plants.[20]

Medical Waste Disposal

According to the US Environment Protection Agency, medical waste incinerators are one of the largest sources of mercury pollution in the environment. Studies show that there is up to 50 times more mercury in hospital waste than in general municipal waste, and the amount of mercury emitted by medical waste incinerators represents more than 60 times the emissions' level from pathological waste incinerators.[21]

Mercury is found in blood pressure monitors, thermometers and thermostats, dental amalgams, oesophageal dilators, cantor tubes, miller abbot tubes, etc. Mercury-containing products are used in patient areas and pathology labs, in clinical procedures and in medicines. At least 20 different medical products contain mercury and many mercury-containing solvents and degreasers are found in labs, housekeeping departments, kitchens and maintenance areas.

The storage rooms may also be filled with used, damaged or outdated equipment or supplies that contain mercury. Mercury is an ingredient in some proprietary formulas used to manufacture medical and industrial supplies. Breakage, waste disposal or spills from these products release mercury into the atmosphere or drains, where it can persist.

Some products that formerly contained mercury are no longer manufactured. However, the old products are still a part of the environment. In fact, broken or obsolete equipment is often the primary source of mercury waste at many hospitals and clinics.

Industrial and chemical uses of mercury are manifold in the medical community: we use mercury intentionally in fluorescent and high-intensity lamps, in thermostats and switches and in a variety of generators, manometers and batteries. Non-medical uses of mercury are also present in a variety of products: in cleaning solutions, preservatives, paints and anti-fouling agents for wood and other surfaces.[22]

In India, hospitals and clinics generally dispose their waste by burning or incinerating it. Medical waste incinerators aim to disinfect wastes, but in the process, all the materials on which infections may exist are burnt.

Given that, much hospital material is also composed of mercury. Even if very expensive cleaners are installed in the stacks, there are still mercury emissions into the nearby ecosystem as mercury in medical waste is combusted at high temperatures, vaporises and exits the combusting gas exhaust stack.In India, medical waste incinerators are mostly small incineration units that burn around 50 to 175 kg/hour of infectious and non-infectious wastes generated from facilities involved in medical or veterinary care or research activities.

There is a serious lack of data on mercury emissions from medical waste incinerators. The city of Delhi alone has 61 medical waste incinerators. There is no account for the total number of incinerators in India.

Though the amount of mercury present in medical waste is very low in proportion to the total waste, it is enough to contaminate the ecosystem severely.

Municipal Solid Waste Disposal

Municipal solid waste is generally disposed off in three ways in India:

- ◆ Landfill dumping
- ◆ Open dumping
- ◆ Open burning

Municipal solid waste consists primarily of household garbage and other commercial, institutional and industrial solid wastes. Mercury is present in the form of various products in our day-to-day household items; clinical thermometers and blood pressure monitors are becoming an important part of our households. Besides this, mercury is present in electrical switches, mercury vapour lamps, fluorescent tube lights, alarm clocks, toys, singing greeting cards, talking refrigerator magnets, lighted athletic shoes, etc. Though present in trace amounts, it becomes very significant when assembled in garbage. Mercury batteries are a known source of mercury in municipal solid waste.

The disposal of any of the above-mentioned products in the municipal solid waste will lead to mercury emissions in the environment. Even if municipal solid waste is burnt openly or in a bhatti, the mercury present in the waste will be emitted in the environment and dispersed widely.

Municipal solid waste is dumped in landfills or even openly. The mercury present in waste can leach down to ground level and pollute ground water. In the rainy season, the mercury present in waste can be washed down to running water, later reaching rivers and oceans.

Sometimes improper municipal solid waste disposal practices in India lead to the dumping of waste into drains, the latter reaching and polluting other water sources.

Even though the amount of mercury present in municipal solid waste is small in proportion to the total amount of waste, the amount of mercury present in it is enough to cause environmental and health concerns to large population. In India, there are no estimates available for the annual uncontrolled mercury emissions from the disposal of municipal solid waste.

Summary

Historically, mercury has a variety of applications in India. Though its use in various industries has been decreasing over time, in others, such as thermometer production has not gone down. Industries such as the chlor-alkali industry have not yet phased out mercury usage and some plants are extremely 'leaky'.

Clearly, there are substitutes in all cases and the human and natural environment is at risk. Mercury needs to be eliminated totally, and government policy as well as the industry need to proactively make this happen.

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MERCURY IN INDIA

ENVIRONMENTAL AND HEALTH ASPECTS

MERCURY IN INDIA

- Mercury occurs naturally in the environment and thus has a background concentration which is independent of anthropogenic releases. Volcanic sources emit an estimated global total of 60,000 kg of mercury per year.

- The quantity released by burning coal is estimated to 3,000 tonnes per year worldwide, which is about the same amount released through all industrial processes.

- Mercury is commonly found in urban sewage through point source discharges from dental offices and industrial manufacturing processes such as battery fabrication.

- The atmosphere is the dominant transport vector of mercury to most ecosystems. Most of the mercury found in the atmosphere is elemental mercury vapour, which circulates in the atmosphere for up to a year, and hence can be widely dispersed and transported thousands of miles from likely sources of emission.

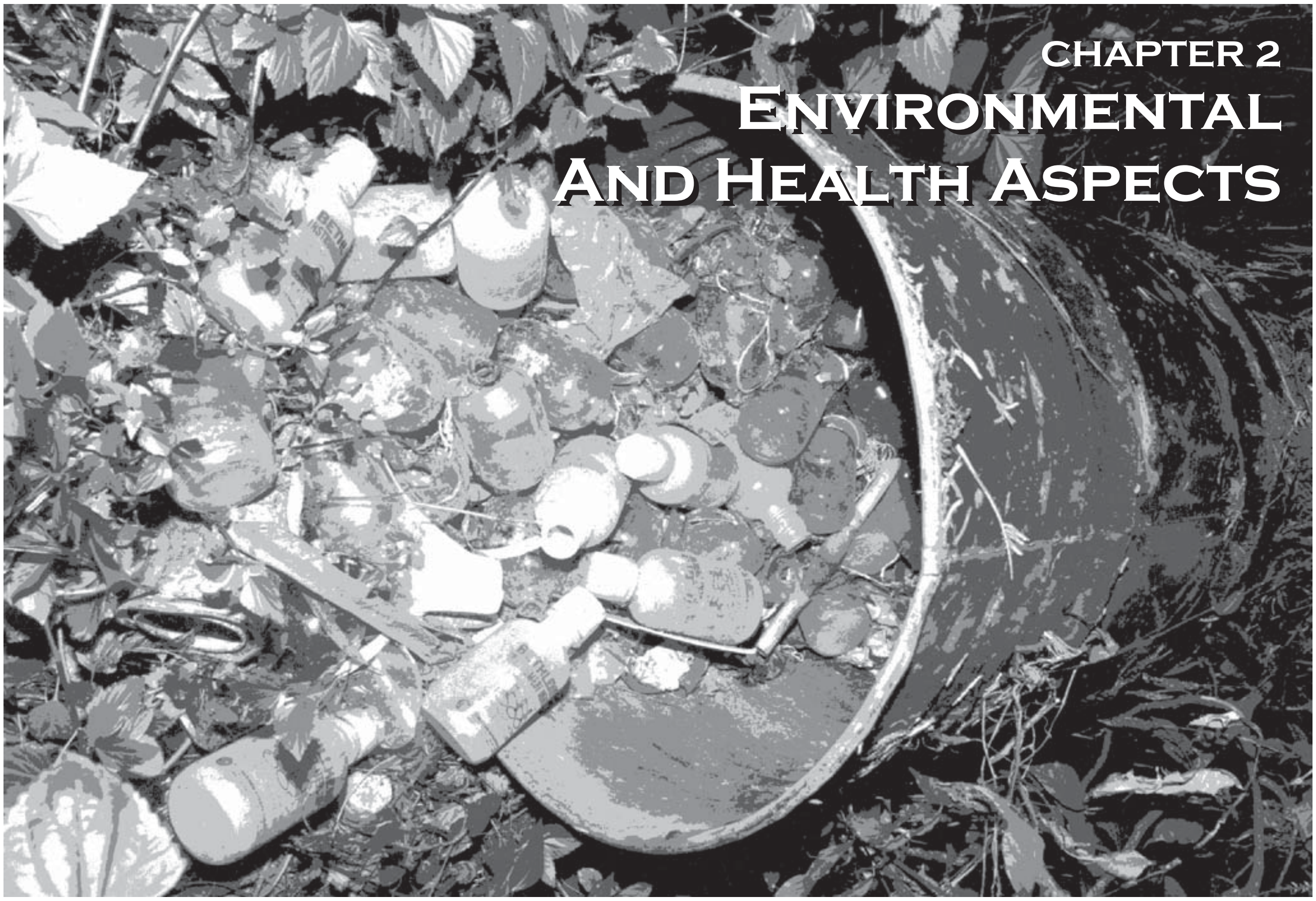
- Mercury undergoes a series of complex chemical and physical transformations as it cycles among the atmosphere, land and water as part of both natural and anthropogenic activities. Humans, plants and animals are routinely exposed to mercury and accumulate it during this cycle, potentially resulting in a variety of ecological and human health impacts.

- Mercury also has a long retention time in soils. As a result, mercury that has accumulated in soils may continue to be released to surface waters and other media for long periods of time, possibly hundreds of years.

- Fish-eating birds and mammals are more highly exposed to mercury than any other known component of aquatic ecosystems. Adverse effects of mercury on fish, birds and mammals include death, reduced reproductive success, impaired growth and development, and behavioural abnormalities.

- A 1999 study that tested and analysed groundwater samples from eight places in Gujarat, Andhra Pradesh and Haryana revealed that mercury levels were dangerously high in all the samples.

- Although environmental and health concerns of mercury have been well documented in India, there still has been no attempt from the government and the industry to reduce the usage of mercury in various industries and in our day-to-day life.



CHAPTER 2
Environmental And Health Aspects

Mercury occurs as a result of both natural and anthropogenic sources in our environment. The cycle involves different forms and types of mercury as a result of both chemical and biological reactions in aerobic and anoxic microenvironment. Until several years ago, estimates of the natural background level of mercury were unrealistically high due to erroneous data, giving the impression that anthropogenic contributions to the global mercury flux were less than what they truly are.[23] The generation of erroneous data arose because of a lack of sufficiently sensitive instrumentation to measure mercury in soil, water and air. A schematic of the cycle on page 34.

Pathways of Mercury Toxicity

Natural Sources

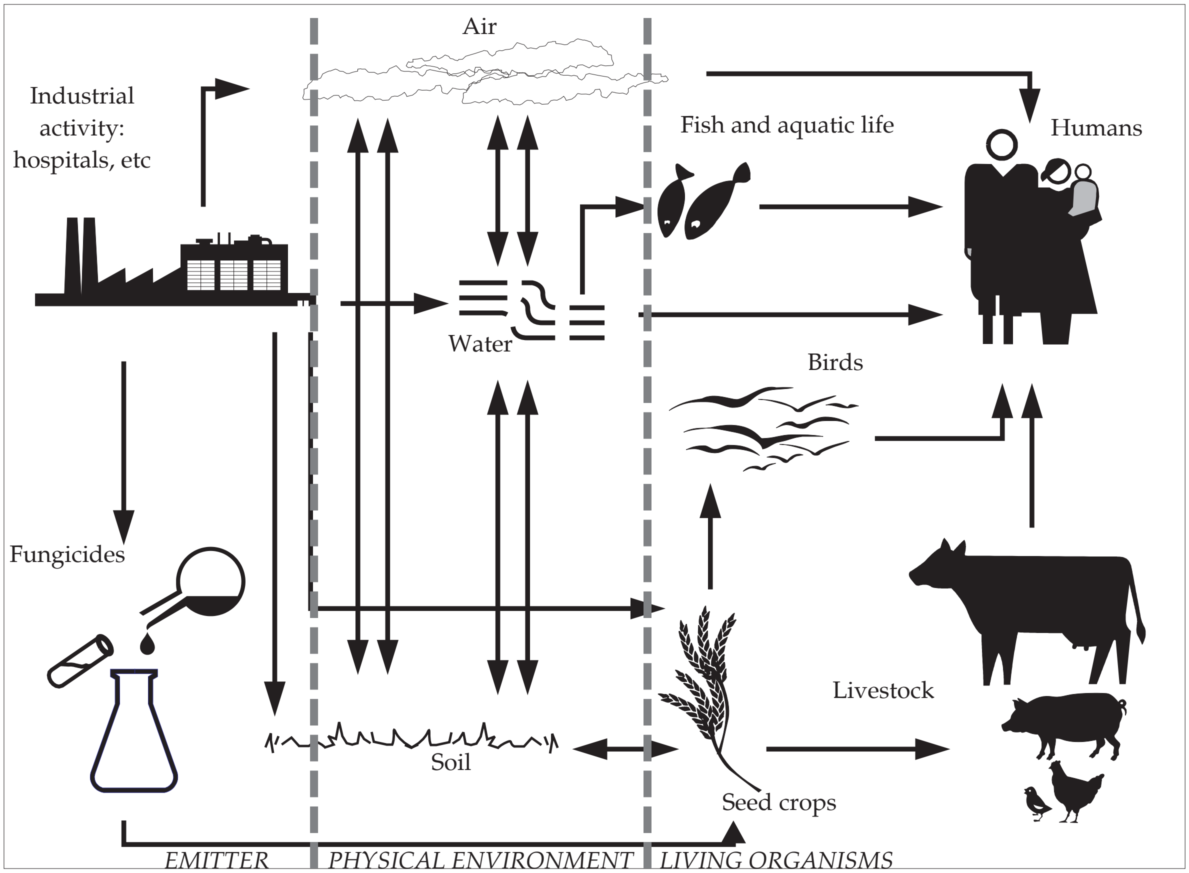
Mercury occurs naturally in the environment and thus has a background concentration which is independent of anthropogenic releases. Mercury can occur naturally in a variety of valence states and conjugations, such as elemental mercury, dissolved in rainwater or as the ore cinnabar and as an organo metal such as methyl mercury. Moreover, through natural chemical and biological reactions, mercury changes form among these species, becoming alternately more or less soluble in water, more or less toxic, and more or less biologically available.

Because of airborne mercury pathways, there is no part of the globe today untouched by the worldwide increase in both the use and release of mercury by man in this century.

Volcanic Release: Mercury is initially released into the biosphere through volcanic activity. Mercury, present in the earth's crust at a concentration of 0.5 ppm, typically forms the sulphide HgS because of the prevalence of sulphides in volcanic gases. In this fashion it is found naturally in deposits as the red sulphide ore, cinnabar. It is commercially mined in this form. Volcanic sources emit an estimated global total of **60,000 kg of mercury** per year.[24]

Forest Fires Release: Biomass, particularly trees and bushes, accumulate and harbour a substantial fraction of the biosphere's mercury. When forest fires heat these fuels to temperatures well above the boiling point of mercury (357 °C), mercury may be released into the atmosphere. The elemental mercury thus released may be oxidised in the atmosphere over time to ionic mercury, which is also soluble in water and can dissolve in the air's moisture when released in this fashion.

The Major Flows of Mercury within the Biosphere



Forest fires and rain are responsible for the transport and deposition of mercury over much of the world's surface, regardless of its source.

Oceanic Release: Mercury is also a component of seawater and is naturally released through the evaporation of elemental mercury from the ocean's surface. Both elemental and ionic mercury are soluble in water, the former to a much lesser degree. As less soluble elemental mercury evaporates, the equilibrium reaction is pulled towards more elemental mercury, which then releases more elemental mercury from the ocean's surface.

Anthropogenic Sources

Mercury is used in a broad array of more than 3,000 manufacturing industries and products. It is released into the atmosphere during various industrial production processes. Though mercury is released in trace amounts in the emissions as well as in effluents, their accumulation in the environment over time is harmful for both flora and fauna.

Thermal Power Plants Release: Coal is known to contain mercury as a result of testing done upon the gas emitted from thermal power plant stacks. The quantity released by burning coal is estimated to be **3,000 tonnes** per year worldwide, which is about the same amount released through all industrial processes.[25] The concentration of mercury in coal varies from as low as **70 µg/g up to 22,800 µg/g (parts per billion)**.[26] During the burning of coal, mercury is initially decomposed to elemental mercury and then, as the gas cools and exits the power plant, the majority of the mercury is quickly oxidised, probably catalytically due to the presence of other metals in the gas, to its water-soluble, ionic form.

Oil Combustion Release: Crude petroleum is known to contain small but measurable amounts of mercury. A study performed on the mass of metals in crude oils from 32 different sources stored in the USA has determined that the average amount of mercury in petroleum is 0.41 ppm.[27] The standard deviation for this average was rather large (0.90 ppm), with one crude oil (Arabian) containing 5.2 ppm mercury. Another study of metals performed on petroleum found mercury concentration rates ranging from 0.03 to 0.1 ppm.[28] Both these studies were performed using old mercury analysis methods, which rely on method detection limits of approximately 0.11 ppm. However, these studies also indicate minimum mercury concentrations in crude oil.

It is unclear whether the mercury present in crude oil is vaporised during the refining process or whether it remains in the refined petroleum. Because of the large volumes of oil consumed, even a small concentration of mercury clearly represents a major source of atmospheric deposition of mercury. More studies with the more sensitive analytical methods developed in the past few years should be undertaken to confirm these figures.

Smelting: The smelting of ores to yield pure metals is thought to release some mercury into the atmosphere. Most metal ores are thought to have higher concentrations of mercury than coal, although the volumes of ore that are smelted each year are low in comparison with the volume of coal burned for power generation.

Chlor-alkali Plants: Elemental mercury is employed as the electrode in the electrochemical production of chlorine gas and caustic soda (sodium hydroxide). Near most paper and pulp facilities, which employ this technology to bleach the paper product white, the sediment is contaminated with high concentrations of mercury.

Mildew Suppression, Laundry facilities: An infrequent and historical point source of mercury contamination has been the use of mercury compounds for mildew suppression by laundry facilities, which have a major problem with moisture and bacterial growth. This contamination source should no longer be a problem because many countries have banned the use of mercury as a fungicide in interior latex paints.

Sewage Treatment: Sewage treatment represents the focal point of today's urban industrial, commercial and domestic liquid waste streams. The secondary treatment of sewage involves de-watering, which necessarily concentrates the solids and all non-volatile contaminants, but does little to treat or remove inorganic dissolved contaminants. Mercury is commonly found in urban sewage through point source discharges from dental offices and industrial manufacturing processes such as battery fabrication. As the sewage is de-watered and the solids concentrated, mercury can be either sequestered by the organic humus of sludge or, if the sludge is caked and dried, can be released into the atmosphere in the drying process.

Pathways of Mercury Toxicity in India

The most significant anthropogenic activities giving rise to mercury (Hg) discharge into the land, water and air in India are:

- Industrial production processes, in particular, the mercury cell chlor-alkali process for production of caustic soda.
- Burning of fossil fuels, for example coal, mineral oil.
- Consumption-related discharges, including munici pal dumps and medical waste incineration.
- Use of agricultural fungicides and seed disinfectants.

All chemical compounds of mercury are toxic to humans, although mercury may have to be oxidised to ionic forms to show toxic effects. The main sources of emission are enumerated in the table below.

Environmental Aspects

Mercury has been used in a wide array of applications due to its unique physical and chemical properties. As a result, the amount of mercury present in the environment is constantly increasing. Studies have indicated that the amount of mercury mobilised and released into the biosphere has increased over the years.

The atmosphere is the dominant transport vector of mercury to most ecosystems. Several types of emission sources contribute to the total atmospheric load of mercury. Once in the air, mercury can be widely dispersed and transported thousands of miles from likely emission sources. The distance of this transport and eventual deposition depends on the chemical and physical form of the mercury emitted.

Mercury undergoes a series of complex chemical and physical transformations as it cycles among the atmosphere, land and water as part of both natural and

MAjor Emitters of Mercury

Mercury	Consumers	Amount (approx)
Mercury in effluents	Chlor-alkali industry (mercury cell process)	100-150 tonnes per annum
Mercury in effluents and soil	Instrument manufacturing industries	Data not available
Mercury in air and fly ash	Coal-based thermal power plants	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

anthropogenic activities. Humans, plants and animals are routinely exposed to mercury and accumulate it during this cycle, potentially resulting in a variety of ecological and human health impacts.

Most of the mercury found in the atmosphere is elemental mercury vapour, which circulates in the atmosphere for up to a year, and hence can be widely dispersed and transported thousands of miles from likely sources of emission. Most of the mercury in water, soil, sediments, or plants and animals is in the form of inorganic mercury salts and organic forms of mercury (for example, methyl mercury).

The inorganic form of mercury, when either bound to airborne particles or in a gaseous form, is readily removed from the atmosphere by precipitation and is also dry deposited. Wet deposition is the primary mechanism for transporting mercury from the atmosphere to surface waters and land. Even after it deposits, mercury is commonly emitted back to the atmosphere either as a gas or associated with particles, to be re-deposited elsewhere. As it cycles between the atmosphere, land, and water, mercury undergoes a series of complex chemical and physical transformations, many of which are not completely understood.

Mercury Emissions and Deposition

Roughly 80 per cent of these emissions are from combustion sources, including waste and fossil fuel combustion. Contemporary anthropogenic emissions are only one part of the mercury cycle.

Releases from human activities today are adding to the mercury reservoirs that already exist in land, water, and air, both naturally and as a result of human activities. The flux of mercury from the atmosphere to land or water at any one location comprises contributions from the natural global cycle, including re-emissions from the oceans, regional sources, and local sources. Local sources could also include direct water discharges in addition to air emissions.

Mercury is a persistent pollutant and its past uses are responsible for the present mercury burden on the environment. One estimate of the total annual global input to the atmosphere from all sources including natural, anthropogenic, and oceanic emissions is 5,500 tonnes.[29]

Studies indicate that the residence time of elemental mercury in the atmosphere may be a year, allowing its distribution over long distances, both regionally and globally, before being deposited on the earth. The residence time of oxidised mercury compounds in the atmosphere is uncertain, but is generally believed to be of a few days or less. Even after it deposits, mercury is commonly emitted back to the atmosphere, either as a gas or in association with particulate to be redeposited elsewhere.

Mercury Methylation and Bio-accumulation

Mercury cycling in the environment is a complex phenomenon that depends on various environmental parameters. 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 persists and travels in the environment.

Mercury also has a long retention time in soils. As a result, mercury that has accumulated in soils may continue to be released to surface waters and other media for long periods of time, possibly hundreds of years.

Mercury methylation is the key process in the entry of mercury into food chains. The transformation of inorganic mercury to methylated mercury in water bodies can occur in both the sediment and the water column.

Methyl mercury accumulation in the freshwater ecosystem is a process of mercury accumulation, which can then be ingested by fish-eating birds, animals and people. In addition, methyl mercury generally comprises a relatively greater percentage of the total mercury content at higher trophic levels. Accordingly, mercury exposure and accumulation is of particular concern for animals at the highest trophic levels in aquatic food webs and for animals and humans that feed on these organisms.

The pattern of mercury deposition worldwide shows that the aquatic ecosystem is more highly exposed to methyl mercury. Fish-eating birds and mammals are more highly exposed to mercury than any other known component of aquatic ecosystems. Adverse effects of mercury on fish, birds and mammals include death, reduced reproductive success, impaired growth and development, and behavioural abnormalities.

Mercury accumulates most efficiently in the aquatic food chain. Predatory organisms at the top of the food chain generally have higher mercury concentrations. Nearly all of the mercury that accumulates in fish tissue is methyl mercury. Inorganic mercury, which is less efficiently absorbed and more readily eliminated from the body, does not tend to bio-accumulate.

Mercury contamination has been documented in mammals such as polar bears, in the aArctic region. These species are at high risk of mercury exposure and impact because they are either fish-eating animals or because they eat animals which feed on fish.

High concentration of mercury in the tissues of wildlife species has been reported at levels associated with adverse health effects in laboratory studies on some species.

However, there is a lack of data and studies to conclude whether fish-eating birds or mammals have suffered adverse health effects due to airborne mercury emissions.

Plants, animals and humans can be exposed to mercury by direct contact with contaminated environmental media or ingestion of mercury-contaminated water and food.

Generally, mercury accumulates up the aquatic food chain, which means that organisms pertaining to higher trophic levels have higher mercury concentration levels. At the top of trophic levels are fish-eating mammals, such as humans, and other fish-eating species.

Environmental Load

The presence of mercury in the environment (air, water and land) in India can be traced back to the 1970s, when various studies conducted showed the presence of mercury in our environmental bodies.

Water

Both surface and ground water have become increasingly contaminated with wastes and pollutants from industry, agriculture and household. Over the years, water pollution has increased the concentration of mercury in Indian waters.

Ground water provides about 80 per cent of drinking water needs in India. A 1999 study tested and analysed ground water samples from eight places in three states — Gujarat, Andhra Pradesh and Haryana — where mercury contamination has been reported. The results are shocking: the mercury levels found are dangerously high in all the samples. The critical areas from where samples were collected were:

Patancheru (Andhra Pradesh): In Patancheru Industrial Area (PIA), Medak district, the level of mercury was *115 times the permissible limit.* In Patancheru, most of the 400 industrial units don't treat their effluents properly, so they dump them in the open or inject them directly into the ground, as suggested by the report. Most of the industrial units here deal with pharmaceuticals, paints, pigments, metal treatment and steel rolling. They use organic and inorganic chemicals as raw materials, which are reflected in appreciable amounts in the effluents.

Panipat (Haryana): In a tested sample of groundwater from Panipat, the mercury level was found to be *268 times the permissible limit.* The presence of chemicals was found to be more than what is permitted for industrial units. Most of the polluting wastewater comes from the 500-odd dyeing and processing units that have mushroomed in the city. It is common knowledge in Panipat that the industrial units involved in dyeing and dye-related operations pump effluents into the ground. Much of the effluents from these units either flow into open drains or on to vacant land. The water never reaches the end of the drains but percolates into the ground much before that.

◆ **Vatva (Gujarat):** "It has been common practice in Gujarat to pump effluents into the ground directly through borewells, a deliberate attempt to kill people," says the 1999 report by *Down to Earth*. Ground water within a range of 30-35 km of the Vatva Industrial Estate (VIE) in Ahmedabad district has been contaminated. In the absence of suitable modes of disposal, indiscriminate discharge of effluents has caused serious pollution of groundwater.

A ground water sample taken from Lali village, about 15 km from Vatva showed that the mercury level was *211 times the permissible limit.* The village is near a seasonal river Khari, which comes through Vatva and only carries industrial effluents and has been reduced to little more than a sewer. Other villages along the bank of the stream face a similar problem. People suspect leaching of effluents of groundwater for the contamination. For years, about 1,500 industrial units in Vatva, manufacturing chemicals such as H-acids, dyes, sulphonic acid and vinyl sulphones, have dumped chemical wastes on their premises or by the roadside.

Ankleshwar (Gujarat): A sample from a well in Sarangpur village in Ankleshwar Industrial Estate (AIE), Bharuch district, revealed that the mercury level was more than *100 times the permissible limit.* Water from a borewell in Bapunagar village near Ankleshwar had *170 times more mercury than the prescribed limit.* The 1605-hectare AIE has about 1,500 industrial units, which manufacture dyes, paints and pigments, pharmaceuticals, chemicals and pesticides, among other things. Effluents from these units have severely contaminated the underground aquifers.

Vapi (Gujarat): The situation in Vapi Industrial Estate (VIE) in Valsad district is no better than the other industrial estates of Gujarat. More than 1,900 industrial

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.)

units have jeopardised the groundwater resources of the area mainly by indiscriminate disposal of hazardous wastes and effluents. A fair share of the effluents is also being dumped into the ground. A sample of water from a borewell in Chiri village, near Vapi, showed a mercury level that was about *90 times more than the prescribed limit.*

Factories in VIE deal with some very hazardous chemicals, including pesticides and other agro-chemicals, organo-chlorine chemicals, dyes, acids like H-acid, liquid chlorine and chlorine gas. Most of these substances have been banned in developed countries. Nearly 32 hand pumps and 65 wells in the area reveal the presence of chemicals. The major source of groundwater pollution is Rata Khadi, a seasonal stream near Chiri, which carries effluents from Vapi to a CETP. The effluents carry organo-chlorines, heavy metals and other toxic chemicals.

Nandesari (Gujarat): The Nandesari Industrial Estate (NIE) near Vadodara is a major production centre for highly toxic chemicals, like H-acid, which are not easily biodegradable. "Disposal of untreated mercury contaminated effluent from caustic soda manufacturers has heavily contaminated the groundwater in Nandesari," says a report submitted by the Union Ministry of Environment and Forests to the World Bank.

NIE is situated along the Mini River, and has about 250 industrial units dealing with chemicals, pharmaceuticals, dyes, pesticides and plastics, among other things. Reckless dumping of effluent and hazardous waste is as common here as in other industrial areas of the state.

Mercury Hot Spots

Beside the above-mentioned places, there are other hot spots where various studies reported mercury pollution and contamination over time:

Ib River (Orissa): The Ib River valley area throws up numerous instances of industrial pollution, and the starting point of this is easily Orient Paper Mills (OPM) of Brajrajnagar in Jharsuguda district.

The mill uses chlorine for bleaching its pulp, and gas leaks are a common occurrence. Bleach plant effluents are a major source of toxicity. This is because OPM uses mercury cell technology, which is a polluting technology, and which is now being progressively replaced by membrane cell technology all over the world. In India, no new plant adopts mercury cell technology.

The Pollution Control Board is aware of the fact that the mill uses mercury cell technology. However, there has been no intervention because the plant is small! But within the electrolysis bleaching plant, there have been many cases of mercury poisoning. The villagers upstream and downstream complain of malaria, diarrhoea, dehydration, a number of water-borne diseases, and skin diseases like scabies.

According to a report prepared by Ib Paribesh, an NGO working in the area for more than four years now, almost all the surface water has become unfit for human consumption. The contamination of groundwater resources has also reached a critical stage.

Rushikulya River (Orissa): A study by the Council of Professional Social Workers (CPSW), Bhuvaneshwar, reports that the Rushikulya River, in Orissa, is polluted by a number of effluents from various industries. However, the most hazardous pollution of Rushikulya is due to the chlor-alkali factory (Jayashree Chemicals Ltd), in Ganjam, which discharges its mercury bearing effluents into the river, causing pollution in Ganjam and its nearby areas. Thousands of acres of agricultural fields have lost their crops. There were tests conducted by a research team of the Department of Botany from the Banaras Hindu University (BHU). The tests reported presence of mercury in fish, trees and river water as an effluent traced to Jayashree Chemicals.

A committee set up by the Orissa Government in 1985 to look into the pollution caused by Jayashree Chemicals also confirms the presence of mercury in the effluent drained into Rushikulya. The Orissa State Pollution Control Board (OSPCB) also complained of the mercury traceable in the effluents of the factory, though it had no estimate of the mercury level in the effluent. The reason stated was that the mercury analyser of the factory was defective.

Kalu River (Bombay): A series of investigations by Ramani Rao and Dr B.C. Haldar for the Institute of Science in Bombay in 1979 have revealed the presence of heavy metals in the aquatic environment of the Kalu River, on the outskirts of Mumbai. The river is recreating another pollution disaster. "The spectre of Minamata stares in the face of the village population that consumes fish and food from or near the Kalu River," says Dr Haldar.

Kalu is a small river which originates in the Western Ghats. It flows through the industrial suburbs of Ambarnath, Ulhasnagar and Kalyan in northeast Mumbai and finally empties into the Arabian Sea. It receives effluents from 150 industrial units. The Institute of Science investigated a stretch of 10 km from Ambivali to Titwala, along which toxic wastes from a rayon factory, a paper mill, a dye factory and a chemical plant pour into the river. During 1978 and 1979, they surveyed the water quality and the effect of pollutants on plants and animal life. Industrial effluents in the river at Ambivali contain metals (mercury, lead, copper, cadmium), chlorides, dyes, organic acids, etc. Sediments, soils and plants along the riverbank showed a fairly high content of mercury, lead, cadmium and copper. "The water at the point of discharge of effluents into the Kalu River has a mercury content equal to that at the centre of the Minamata Bay," emphasises Dr Haldar.

The metallic content of the effluents fluctuates, and at times lead and mercury concentrations rise above the permitted levels. These elements are insoluble in water and sink to the bottom. Certain bacteria in the riverbed convert the insoluble mercury into soluble methyl mercury, which is a deadly poison and can be absorbed by living organisms. Mercury enters the food chain, poisoning the fish and the cattle that graze on the plants in shallow water. "Heavy metal contents of pycreus plants, the most abundant at Ambivali, showed unusually high concentrations. The leaves of these plants contain 3 to 110 ppm of mercury. The rhizomes of the same plants contained 6.9 to 53.3 ppm," reveals the report of the Institute of Science.

There is 5 ppm of mercury in the milk of milch cattle that graze on the pycreus plants. A child drinking a litre of this milk every day consumes 35 ppm mercury in a week. Over a period of several months this can lead to an accumulations of over 0.3 mg of mercury, which is well above the safe level. Further studies carried out by the Institute of Science show that the problem of toxic chemicals may also be spreading to other areas in and around Mumbai.

Kodaikanal (Tamil Nadu): URS Dames & Moore had been commissioned by Hindustan Lever Ltd (HLL) to conduct an environmental site assessment and preliminary risk assessment for mercury at its wholly owned thermometer manufacturing facility located at Kodaikanal, in Tamil Nadu. This followed publicity by Greenpeace and the Palni Hills Conservation Council after their discovery of glass scrap illegally disposed of by the manufacturing facility in a scrap yard in Kodaikanal town.

The thermometer plant in Kodaikanal, one of the largest thermometer-manufacturing factories in the world, has been guilty of dumping mercury-containing glass waste. Till date, the factory has produced 165 million thermometers with 125,000 kg of mercury with a breakage rate of 30 to 40 per cent. The company, in its report to the Tamil Nadu Pollution Control Board, assesses the amount of mercury released into the environment from its factory site in Kodaikanal at *539 kg* (stating a statistical variance of between *43 kg minimum to 1,075 kg maximum).*

The glass scrap from the mercury-contaminated area contained residual mercury and until 1990 was dumped in the compound. During the monsoon season, the mercury used to be washed away into water bodies due to run-off, contaminating the water bodies in the area, especially the rivers.

Bhopal (Madhya Pradesh): The Peoples Science Institute (PSI) in Dehra Dun has found high levels of mercury in the groundwater sources of Bhopal, especially near the closed Union Carbide factory. The water is dangerous for human consumption, as the area of ground water contamination is increasing. Water samples from various localities were taken for testing. Analysis of the samples showed concentrations of mercury as high as 2 ppm in some places, which is above national and international standards.

Golden Corridor (Gujarat): The Paryavaran Suraksha Samiti (PSS) in 2002 collected samples from over 20 villages affected by industrial pollution in the Golden Corridor of Gujarat to investigate the water situation. The samples were also tested and analysed for mercury. The results of mercury concentration in the villages near the industrial areas were shocking: in Haria village and Atul Complex, the mercury level was shockingly high, at 12 ppb – 1200 per cent more than the permissible limit of 0.001 ppm. Another sample in Ankleshwar showed mercury at a high level of 2 ppb – 200 per cent above the standard. Samples in Vadodara-Nandesari ECP Area also showed high mercury levels, at 6 ppb and 1.3 ppb, which are, respectively, 600 per cent and 30 per cent more than the prescribed standards.

Delhi: A recent study conducted by the Environmental Science Department of the Guru Gobind Singh Indraprastha University, reveals that the concentration of contaminants like arsenic, mercury, nitrates, etc, in Delhi's ground water exceeds 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. 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 to leach at a rapid rate.

Mercury in Indian Rivers

A brief compilation by the Industrial Toxicology Research Centre (ITRC) of the heavy metal analysis (including mercury) of India's major rivers was presented in 2001 in the 'High Powered Committee on Management of Hazardous Wastes'.

The levels of various heavy metals including mercury were monitored in different water bodies by the ITRC, such as the Ganga river system including the main channel, its tributaries, viz, Yamuna, Gomti, Kalinadi, Ramganga, Ghaghra, Son, Gandak and Hugli estuarine system.

Surface and groundwater sources including minor streams, wells, hand pumps, ponds, reservoirs, lakes, etc, which are used for drinking water supplies in the north and north eastern states of India were also analysed.

Since there are no prescribed permissible limits of heavy metal for surface waters, the levels are compared with those of drinking water. The permissible limit for mercury in drinking water is 0.01 mg/l.

The River Ganga

From 1986 to 1992 water samples were regularly collected each month from 20 different locations: Rishikesh, Haridwar, Garhmukteshwar, Trighat, Buxar, Rajmahal, Behrampur, Palta, Dakshineshwar, Uluberia, as well as upstream and downstream of Kannauj, Kanpur, Allahabad, Varanasi and Patna. During this six-year period, some 1,400 river water samples were analysed for levels of 10 different metals including mercury. The concentration levels for mercury in the river Ganga are shown in the table at the right.

Tributaries of the Ganga River: From 1986 to 1992, water samples were regularly collected each month from the seven major tributaries of the river Ganga and analysed for different metals levels. Concentration levels of mercury are shown in the table on the next page.

Besides, mercury concentration was traced in sediments at the Hugli estuary, revealing a level of mercury of 0.25 mg/l.

Mercury in the Ganga (in mg/l)	
Kanpur upstream	0.02
Kanpur downstream	0.002
Allahabad upstream	0.01
Allahabad downstream	0.1
Varanasi upstream	Not detectable
Varanasi downstream	0.0
Rishikesh	0.08
Haridwar	0.08
Garhmukteshwar	Not detectable
Trighat	Not detectable
Buxar	0.08
Patna upstream	0.0
Patna downstream	Not detectable
Palta	0.00
Behrampur	0.01
Dakshineshwar	0.01
Rajmahal	0.10
Uluberia	0.02
Kannauj upstream	0.01
Kannauj downstream	0.008

Some Case Studies

There were some studies conducted and reports done by various scholars indicating the presence of mercury in the Indian environment, especially in water.

A survey by B.M. Tejam and Dr B.C. Haldar looked for mercury in 30 species of fish from seven sources in the Bombay and Thane environments. The results revealed that the bones of *Tilapia Mozambique, Mugil Dussumieri* and other varieties of fish from Thane and Mumbra creek contain mercury concentration levels higher than 500 µg/g on a fresh weight basis, though the upper limit of mercury concentration in fish has been estimated at 100-200µg/g.

In another study, water samples were collected from 12 spots in Chennai City for finding out the content of mercury, as well as its accumulation in toxic amounts. The samples were analysed by K. Ayyadurai, N. Kamalam and C.K. Rajagopal. The result of the analysis showed amounts of mercury ranging from 2.43 to 32.99 µg/ml. All the spots sampled had non-toxic levels of mercury.

There have been some more studies showing significant amounts of mercury in Indian sea water. There is continuous addition of heavy metals into the marine environment, mostly due to industrial and domestic releases. Dissolved inorganic mercury probably occurs mostly as $HgCl_4$. Its concentration in open ocean water usually lies in the range of 10-50 µg/l, but considerably higher concentrations may occur in inshore waters and especially in polluted estuaries.

A study by P. Kaladharan, V.K. Pillai, A. Nandkumar and P.K. Krishnakumar indicated that the distribution of mercury in the Arabian Sea had a conspicuous pattern showing very low values ranging from below detection level (BDL) to 0.058 µg/l during the pre-monsoon period. It remained more or less the same during the South West monsoon period, with an exceptionally higher level of 0.117 µg/l mercury observed in the shelf waters off Veraval. During the post monsoon season the mercury levels attained were higher than during the previous seasons, ranging from BDL to 0.117 µg/l with some pockets showing higher values.

Stray occurrences of higher levels of mercury were observed both in the southern and northern latitudes during the post monsoon period of 1996 ranging from 0.117 µg/l in the south adjacent to the Cape and Laccadive Sea to a concentration of 0.352 µg/l in the north adjoining the Veraval coast, where a similar higher trend prevailed during the South West monsoon season also. The seasonal average of mercury levels showed

Mercury in Ganga's Tributaries (in mg/l)	
Gomti (Udyarghat)	0.003
Gandak (Patna)	0.02
Ghaghra (Saran)	0.06
Kalinadi (Kannauj)	Not detectable
Ramganga (Kannauj)	0.02
Yamuna (Allahabad)	0.10
Son (Koelwar)	0.05
Hugli estuary water	0.29

a 100 per cent increase during the post monsoon period over the preceding monsoon as well as pre-monsoon seasons. The present study was limited to surface only.

Concentrations of mercury, measured at surface and at different depths in the Laccadive Sea by Sujata Sanzgiri, R. Sengupta and S.Y.S. Singbal ranged from 50-204 µg/l, which agreed with the earlier reported values (11-221µg/l) for the Arabian Sea. A few isolated values were higher than the average but these were low enough to show that the Laccadive Sea waters are currently free from mercury pollution. Average surface mercury concentration in the Laccadive Sea was 91 µg/l (range 60-120 µg/l). In the coastal waters of the Arabian Sea the average value at the surface was 136 µg/l; for the entire Arabian Sea the average surface value was 120 µg/l. Pooling the observations of all the cruises the average concentration at the surface for the northern Indian Ocean would be 106 µg/l.

Again, samples were lifted in Arabian Sea waters and the lowest and highest concentrations observed are 13 and 407 µg/l, respectively, among all the samples analysed from different depths. The values from the surface give an average concentration of 77µg/l.

Vasai creek is an important source of fish farming and is used for many other purposes such as salt pans, agriculture, etc. Due to the recently developed chemical industries, oil and grease spillage from ships and public sewage, the shores and water of Vasai creek are polluted and the water carries all these pollutants. Hence, an interridal collection of water samples was carried out to understand the physico-chemical and microbiological quality of water along with heavy metals in it. R.S. Lokhande and Nilima Kelkar conducted a study to determine the levels of heavy metals (Cd, Cu, Fe, Ni, Mn, Zn, Pb and Hg).

The heavy metals are the most harmful and insidious pollutants because of their non-biodegradable nature. The heavy metal toxicity (Fe, Pb and Hg) of the Vasai creek waters seriously reduces soil fertility and agricultural outputs. It is estimated that the major 18 industries release 7 tonnes of mercury along with other heavy metals yearly into the Ulhas river system.

Health Aspects and Exposure

Epidemics of mercury poisoning – following high level of exposure to mercury in Minamata, Japan, and in Iraq – demonstrated that neuro-toxicity is the health effect of the greatest concern when mercury exposure occurs.

The first cases of mercury poisoning were the people living on the shores of Minamata Bay, Kyushu, Japan. The source of methyl mercury was a chemical factory that used mercury as a catalyst. A series of chemical analyses identified methyl mercury in the factory waste sludge, which was drained into Minamata Bay. Once present in Minamata Bay, the methyl mercury accumulated in the tissue of shellfish and fish that were subsequently consumed by wildlife and humans. Fish was a routine part of these populations' diet.

Through the diet, methyl mercury is almost completely absorbed into the blood and distributed to all tissues including the brain. It also readily passes through the placenta to the foetus and foetal brain.

Fish consumption dominates the pathway for human and wildlife exposure to methyl mercury. Given the current scientific understanding of the environmental fate and transport of mercury, it is not possible to quantify how much methyl mercury the Indian population consumes through fish.

Critical elements in estimating methyl mercury exposure and risk from fish consumption include the species of fish consumed, the concentrations of methyl mercury in the fish and the quantity and frequency of fish consumption.

The Prevention of Food Adulteration Act, 1954, and Rules, 1955, limit the concentration of mercury to 0.5 ppm in fish. Methyl mercury concentration is limited to 0.25 ppm in all types of food items.

A typical Indian consumer eating fish regularly and frequently consumes large amounts of either marine species that typically have much higher levels of methyl mercury than the rest of seafood, or freshwater fish that has been affected by mercury pollution. In both cases, the consumers are highly exposed.

Consumers should be aware of The Prevention of Food Adulteration Act, 1954, and Rules, 1955, that suggest the limitation of contaminated fish's consumption. However, there is no warning against the consumption of certain species of fish contaminated with mercury and methyl mercury.

There is currently a need for research on the actual consumption patterns and estimated mercury and methyl mercury exposure of this sub-population.

Human Exposure Pathways and Health Effects

Humans are most likely to be exposed to methyl mercury through fish consumption. Exposure may occur through other routes as well (for example, the ingestion of methyl mercury-contaminated drinking water, other food sources than fish, and dermal uptake through soil and water). However, fish consumption dominates other contamination pathways for people who eat fish.

There is a great degree of variability among individuals who eat fish with respect to food sources and fish consumption rates. As a result, there is a great deal of variability in exposure to methyl mercury in these populations. The presence of methyl mercury in fish is, in part, the result of anthropogenic mercury releases from industrial and combustion sources. As a consequence of human consumption of the affected fish, there is also an incremental increase in exposure to methyl mercury.

The human exposure routes for mercury are: inhalation, consumption of water, consumption of fish, beef, beef liver, cow's milk, poultry, chicken eggs, pork, lamb, green plants (for example, leafy vegetables, potatoes, fruits, grains and cereals) and ingestion of soil.

Summary

Although environmental and health concerns of mercury have been documented in India to some extent, yet there has been no attempt from the government and the industry to reduce the usage of mercury in various industries and in our day-to-day life. European countries are already on the path of reducing mercury usage. Sometimes industries argue that it is very difficult to find a viable substitute to mercury in thermometer and other measurement-based industries.

Industries such as chlor-alkali and paper industries still use the mercury cell process to produce chlorine in India. The phase out of this obsolete technology is very slow. The government and the industry should both play a proactive role in phasing out these obsolete technologies. The units owned by the public sector, which produce chlorine using mercury cell technology, should lead the way in the phase out in the interim. Besides reducing the usage, it is also important on the part of the industry to follow the standards set up by the government for proper usage and disposal of mercury-related products. Consumers should be made aware of the mercury-containing products that they frequently use and of the hazards related to them. Moreover, proper care should be taken during the handling and disposal of these types of products.

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MERCURY IN INDIA

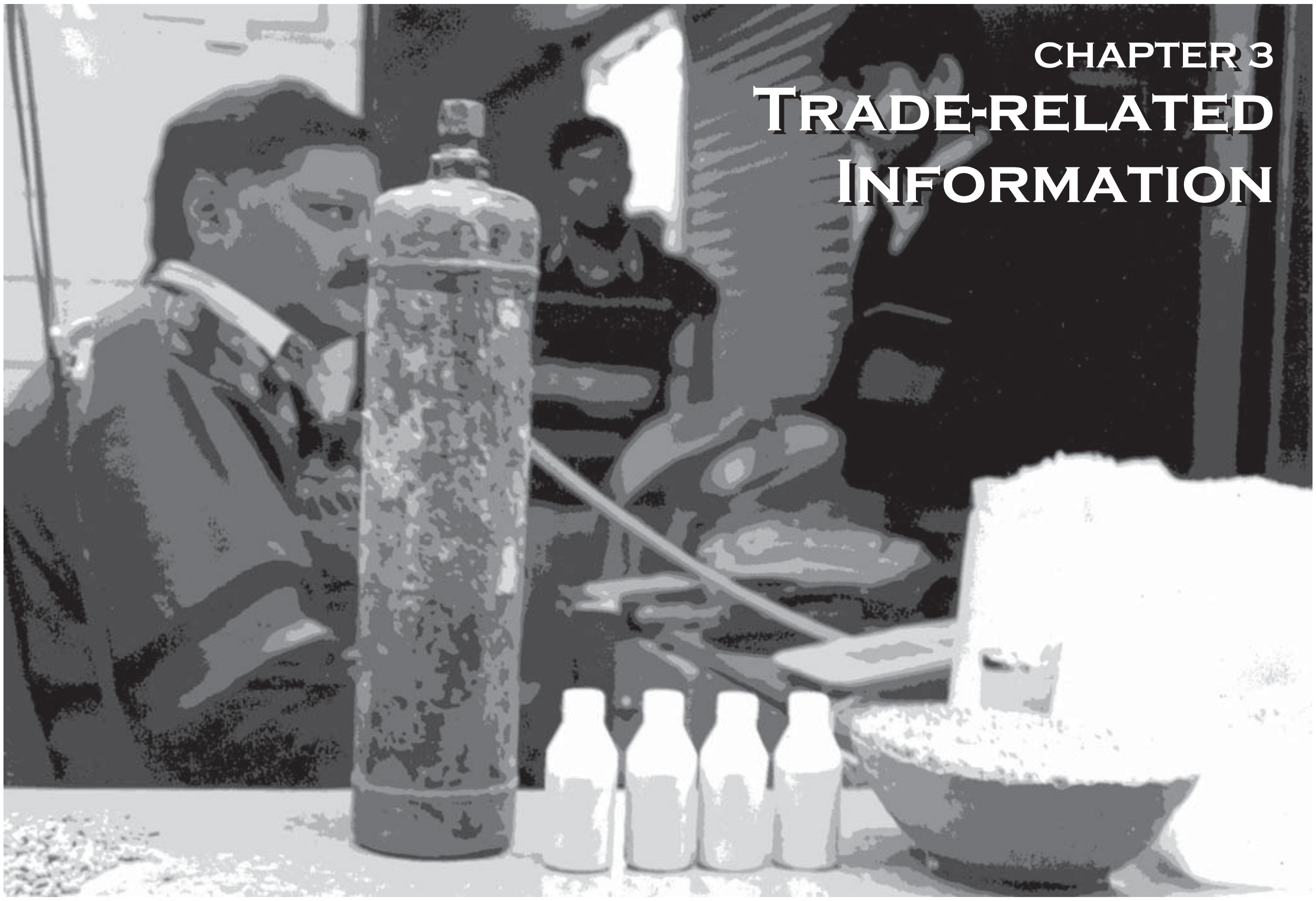
TRADE-RELATED INFORMATION

MERCURY IN INDIA

- The annual primary world demand for mercury approximates 5,000 tonnes
- By far the largest consumers are the industrialised countries of the OECD family, but an 'eastward' shift is observed. This trend is related to the phase out of industries using mercury or mercury-based compounds in industrialised countries and to the growing habit of shifting these industries to developing countries.
- Mercury is not mined in India and is completely imported.
- Despite mercury's toxicity and related-hazards, the Free Import Policy (1997-2002) has licensed mercury as a free product for imports
- The current major mercury exporting countries to India are the USA, the UK, Spain, Russia, the Netherlands, Finland and Algeria.
- Beside the import of virgin or elemental mercury, mercury compounds are also traded in India. In fact, mercury compounds such as oxides, chlorides and sulphides are both imported as well as exported from India.

CHAPTER 3

Trade-related Information



Mercury is a rare element. It is found in many areas, including the United States and Mexico, Southern Europe (Spain, Italy, the Balkans) and several states of the former Soviet Union and Central Asia. Not surprisingly, the natural mercury content in soil and water is relatively high in these areas.

The most important ore for production is cinnabar (HgS). Important deposits are found in mountain areas of late formation and in volcanic areas, particularly in the belt from Spain to the Himalayas and in the one around the Pacific Basin. Five areas within these belts have, for a long time, dominated mercury production: Almaden in Spain, Monte Amiata in Italy, Idria in Slovenia, California in the United States and Huancavelica in Peru. These days, due to environmental concerns and subsequent reduction in its use, it is only mined in Almaden, in Spain.[30]

The annual primary world demand for mercury is uncertain but approximates 5,000 tonnes, or 360 m^3. The value of the total world mercury market was estimated at $75 million in 1982, but this came down to just one-third of that figure, $25 million, 10 years later in 1992. It is difficult to get a detailed picture of global mercury flows. By far the largest consumers are the industrialised countries of the OECD family, but an 'eastward' shift is observed.[31] This trend is due to the phasing out of industries using mercury or mercury-based compounds in the developed world and the growing habit of shifting such industries to developing countries.

Trade in India

Mercury is not extracted in India; it is totally imported. Given its high density, the commercial unit for handling mercury is cast iron 'flask', which weighs about 2.5 litres. A mercury content of 34.5 kg is priced $150 to $250 on the international market.

Trade Policy

In exercise of the powers conferred by Section 5 of The Foreign Trade (Development and Regulation) Act, 1992 (No 22 of 1992), the Central Government has made mercury and its various forms (chloride, oxide and sulphide) freely importable to India.

Despite mercury's toxicity and related-hazards, the Free Import Policy (1997-2002) has licensed mercury as a free product for imports and *"Items which do not require any license under the export and import policy have been denoted as 'free' subject to licensing notes"*. Though mercury can be freely imported in India, its wastes and compounds are included in the waste streams of the

Free Import of Mercury

Exim Code	Articles/item/goods	Policy	Duty
280540 00	Mercury	Free	67.086
282739 01	Mercuric chloride	Free	67.086
282739 05	Mercurous chloride	Free	67.086
282590 04	Mercury oxide (mercuric oxide)	Free	67.086
283329 02	Mercuric sulphates	Free	67.086

Exim code 280540 00 includes quicksilver (as mercury) vide policy circular no 49 (RE-99)/97-02 dated Jan 20, 2000.

Free Import of Mercury-based Products

Exim Code	Item/goods	Policy	Duty
902511 00	Thermometers (all types)	Free	53.816
853932 00	Mercury or sodium vapour lamps, metal halide lamps	Free	67.086
853939 01	Mercury vapour lamps	Free	67.086
300640 00	Dental fillings	Free	67.086

Basel Convention on trans-boundary movements of hazardous waste and their disposal. Mercury compounds are also included as hazardous and toxic chemicals in the Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989.

Mercury and its various compounds are all 'free' for import to India. Import of other mercury compounds included as hazardous waste in the Hazardous Waste Rules, is permitted against a license and only for the purpose of processing and reuse.

Mercury and its various forms licensed as free for import are listed in the table above.

Along with mercury, other mercury-based products, items or goods can also be freely imported. These are listed in the table above right.

Since mercury is used in a number of products in India, it is difficult to monitor all of them.

Policy in International Trade: With effect from August 1, 1998, mercury oxide and some mercury-based products have been mentioned as free to import under the conditions that the listed items/goods are in new/prime condition and that they originate from SAARC countries (South Asian Association for Regional Cooperation), in accordance with the Customs Tariff (Determination of origin of goods under the agreement on SAARC Preferential Trading Arrangement) Rules, 1995.

The mercury goods/items included in the list to be free for import are listed in the table at right.

Trade in Mercury

Pre-1992: Mercury, though imported, has to go through various hands before reaching its final consumer, like any other product. It is thus traded like any other good. Prior to 1992, the Minerals and Metals Trading Corporation India Ltd (MMTC), a public sector undertaking, was the most important trading corporation. All major metals, ferrous, non-ferrous, heavy metals, were traded and canalised through the MMTC in the country. Mercury, like any other non-ferrous and heavy metal, was also imported and traded by MMTC and was imported as an industrial raw material.

All the users, traders, industries interested in mercury placed their order, for the required quantity, with the MMTC. The total quantity of mercury to be imported was then calculated.

Before 1992, therefore, MMTC was the only trading corporation in India dealing with the import of mercury. Industries, end-users and traders in India were totally dependent on MMTC for their mercury requirements.

Post-1992: The process of de-canalisation which took place during the liberalisation policy in the post-1992 period ended the domination of MMTC over the trade of non-ferrous metals including mercury.

There are two ways by which metals, including mercury, are traded and imported by MMTC:

- High seas sales
- Godown sales

High Seas sales: In the high seas sales' process, the dynamic is the same as the one mentioned earlier. Tenders are floated, supply order placed, expected ar-

Import Items Free for Import

Exim Code	Item/goods	Usage
850630 00	Mercuric oxide	Battery industry
853932 00	Mercury or sodium vapour lamps, metal halide lamps	Lighting purposes
853939 01	Mercury vapour lamps	Lighting purposes

The Process of Import of Mercury by Minerals and Metals Trading Corporation (MMTC) till 1992

- Floating of tender in the international market for
  required amount of mercury needed.
- Interested parties or brokers send their quotations with a price to MMTC.
- Lowest quoted price of mercury is selected by MMTC, also explaining their terms and conditions regarding price, etc.
- Order is booked for the purchase of mercury
- The required mercury is then bought, stored and
  later sold to various buyers interested in mercury, after adding the service charges of MMTC.

rival time of vessel carrying the supply calculated, deal is done before the vessel touches the port, payment taken, handing over of documents; custom clearance done by customer, custom papers on the name of customer. This process benefits big users and traders who import mercury in large quantities because they get tax exemptions.

Godown sales: In the godown sales' process, the price of mercury is declared as an ex-godown sales price, and the tax is paid by MMTC. The custom clearance papers are on MMTC's name and not on the customer's. Generally, small customers who require small orders of mercury are more interested in this type of sale.

These days, the traders and importers carry out the trade and import of mercury. Since mercury is mentioned as a 'free' item and no licence is required, the big industries, which use mercury in large quantities, do not depend on any trader anymore, and they directly import from the international market. Anyone can import mercury from anywhere and in any quantity.

Thus the policy of de-canalisation has tremendously helped all users, especially the small ones, as they do not have to be dependent on the MMTC any more for mercury and they can buy from the open international market.

Earlier, out of the total amount of imported mercury, 20 per cent remained with the importing agency, MMTC, and users and consumers such as the chlor-alkali industry would purchase the rest. The mercury trade carried out in the open market is explained by the flow diagram opposite:

Important mercury importers are:

- British Metal Corp (I) Pvt Ltd, Mumbai.
- Eastern Metallic, Kolkata.
- Global Marketing Company, Mumbai.
- Kejriwal Alloys and Metals Pvt Ltd, Kolkata
- Metal Link International. Mumbai.
- Enkaay Associates, Delhi.
- HBR Sales (Pvt) Ltd

The details of these traders have been enclosed in the Annexure.

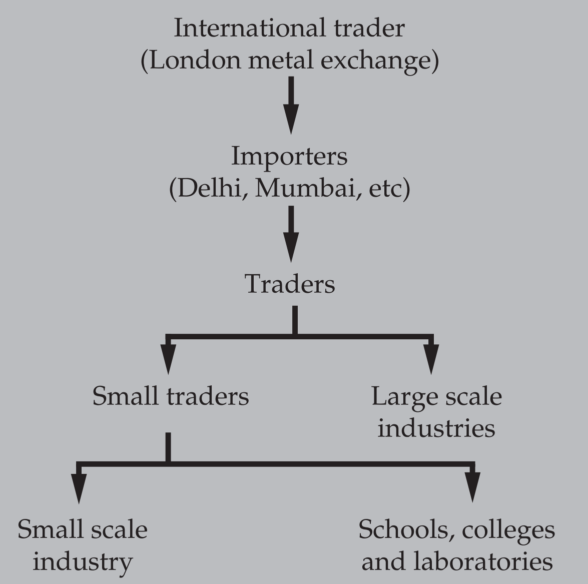
These importers buy mercury directly from the international market and later sell it to traders in Delhi, Mumbai, etc. In Delhi, for example, Tilak Bazaar in Chandni Chowk is a major market where all types of chemicals and heavy metals are traded and supplied to other parts of India. All the traders in Tilak Bazaar buy the required amount of mercury from importers in Delhi, such as Enkaay Associates, or through a broker in Mumbai called Padam Dalal, and later supply all major consumers in Delhi and North India.

Traders like Jagannath Janki Das supply mercury to companies such as Dabur, Baidhnath or Zandu, for the production of ayurvedic medicines. You can also buy mercury packaged in 1 litre bottles here, without any quantitative restrictions! Enkaay Associates, a Delhi-based importer, provides mercury to the Tilak Bazaar traders. From Tilak Bazaar, the mercury is directly sold to the consumer, mainly small-scale users.

It seems that the traders and importers are aware of the environmental hazards of mercury and of the various kinds of pressures faced by mercury trade, because the traders at Tilak Bazaar were very reluctant to speak about the trade, and it took a lot of convincing from our side before they spoke. The importer in Delhi, Enkaay Associates, also refused to speak.

This made us believe that something was wrong, and made us aware of the fact that there is pressure on the mercury trade in India.

MERCURY TRADE IN THE OPEN MARKET



Visit to Tilak Bazaar

Tilak Bazaar, situated in Khari Baoli, Chandni Chowk, Old Delhi, is a combination of a few dingy lanes and small congested shops. The market is a specialised chemical market; everything is available there. The market caters to the chemical needs of North India, and sometimes of other parts of India too. Your first look at the market leaves you horrified: the congestion, chemicals' smell, labourers and other workers unaware of the dangers of their surroundings… There is no concept of chemical safety in this market.

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

Many traders deal with mercury: Girdharilal & Sons, Jagannath Janki Das, Pioneer Chemicals, Kamal Traders, Vishnu Sharma, etc.

There is a general lack of awareness about mercury and other chemicals and their ill effects on human health among workers and labourers.At Jagannath Janki Das's shop, I was horrified to see two boys pouring mercury from one flask to another, with bare hands and uncovered faces, as if they were merely pouring water from one jar to another one! The boys and the trader seemed fully unaware of mercury's toxicity. It was a gross violation of Indian Standard: 7812 (1975) 'Code of Safety of Mercury'.

Import of Mercury

As mentioned earlier, mercury is imported to India from various countries as it is not found or mined in the country. Mercury import in India depends on usage as well as the demand pattern in the country. Besides the industry, institutes' research laboratories schools, colleges, etc, also represent an important consumer in India.

India imports mercury from a number of countries which keep on changing over time. The current major mercury exporting countries to India are the USA, the UK, Spain, Russia, the Netherlands, Finland and Algeria. The detail of country-wise import data of mercury for the decade is enclosed in the Annexure.

The import figures as well as the rates vary from one country to another one. The rate or value of mercury also varies from country to country on a monthly basis. It shows how unpredictable mercury is in the international market.

The import data of mercury for the decade do not follow a smooth trend, as shown in the table below. The quantity of mercury imported has fallen from 603.5 tonnes in 1993-94 to as low as 124.8 tonnes in 1998-99. The influence of demand pattern of mercury in the industries is clearly influencing the import pattern over the years.

In the figure on the next page, the decade shows a

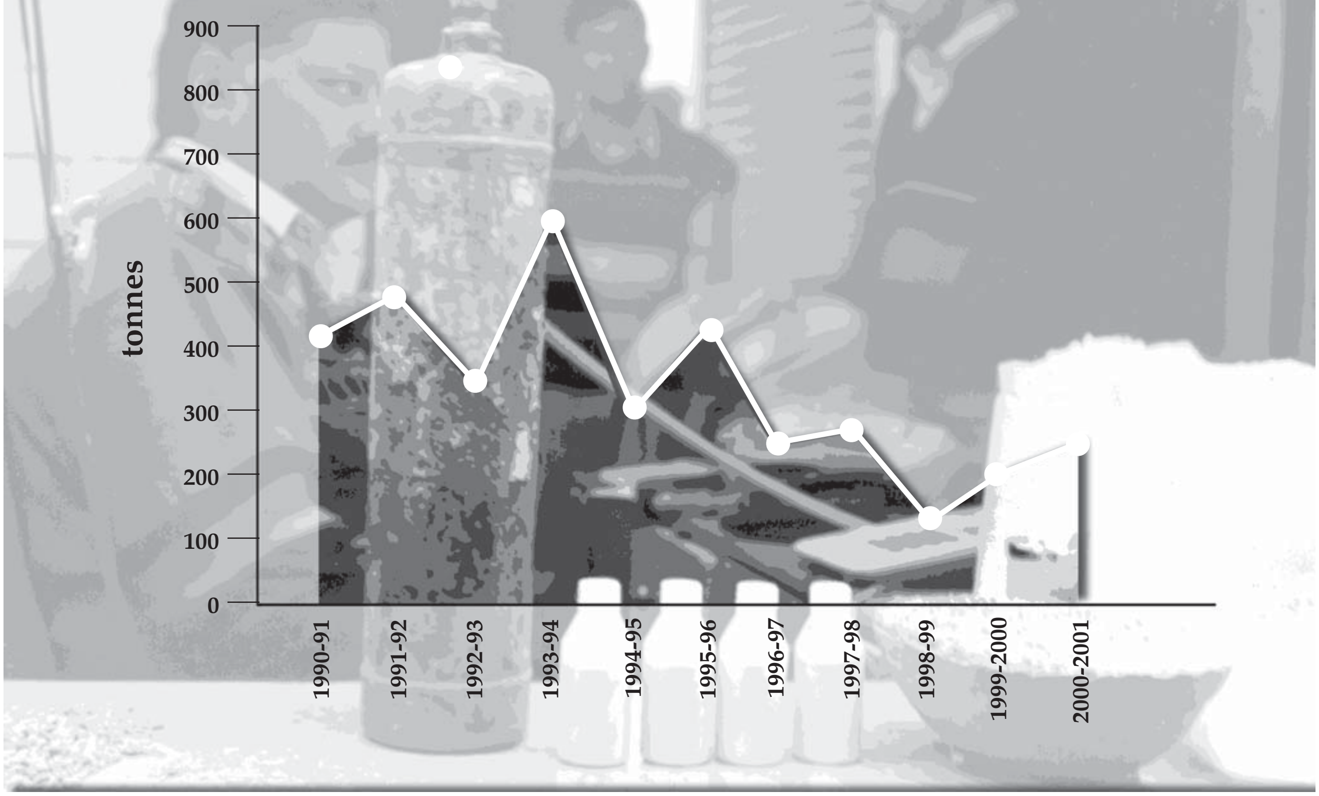
Import of Mercury in India

Years	Quantity (tonnes)	Value (Rs)
1990-91	426.5	45,448,934
1991-92	482.9	39,780,816
1992-93	338.9	30,682,572
1993-94	603.5	49,933,144
1994-95	292.2	25,522,551
1995-96	428.4	49,225,076
1996-97	253.7	31,526,640
1997-98	267.7	43,945,502
1998-99	124.8	20,617,946
1999-2000	207.3	29,233,141
2000-01	251.8	48,336,371

(Source: Monthly Statistics of the Foreign Trade in India, Annual no. (imports), 1990-2000.)

FIGURE 1

Import of Mercury in India



very fluctuating import pattern for mercury in India. As said earlier, the fluctuating demand of mercury influences the import pattern of mercury in India. Though the import of mercury shows a decline, the import of mercury still hovers around 200-250 tonnes annually.

The table *(on page 52)* shows the quantities of mercury imported by the major consumers for 1999-2000 and 2000-01.

The table for import data shows that industries like Champa Purie-Chem Industries, DCW Ltd, GE Lighting India Ltd, Indian Dyestuff Industries Ltd, Shriram Alkalies & Chemicals Ltd, Surya Roshni Ltd, Beri Merurio Ltd, Excel Industries Ltd, Goa Instrument Industries Ltd, Mehta Flint, L S Chemicals & Pharmaceuticals Ltd, Shriram Vinyl & Chemical Industries Ltd, Lalwani Industries Ltd, etc, are major industries which import mercury themselves.

Big importers such as Enkay Associates, Major Metals Ltd, HBR Sales P Ltd, etc, were the major importers of mercury for 1999 and 2000.

Export of Mercury

As the report mentions earlier, India does not mine mercury, and has to import to meet the needs of mercury-based domestic industries. But sometimes India re-exports some of its imported mercury to other countries. It exports to both developed as well as developing countries such as Sri Lanka and the USA. The detail of country-wise export data of mercury is enclosed in the Annexure.

Though it is difficult to understand the dynamics of international trade as far as mercury is concerned, the only logical conclusion must be that this trade exercise must be very profitable. The data in the table opposite shows that exporting mercury has been a regular phenomenon for the last two years.

Export of Mercury from India

Years	Quantity (in kg)	Value (Rs)
1993-94	2,500	437,780
1999-00	35,837	2,502,254
2000-01	359,534	31,179,773

(Source: Monthly Statistics of the Foreign Trade in India, Annual No (Exports), 1990-2000.)

Import of Mercury Compounds				
Years	Mercury oxide		Mercuric chloride	
	Quantity (kg)	Value (Rs)	Quantity (kg)	Value (Rs)
1990-91	-	-	863	73,059
1991-92	-	-	-	-
1992-93	-	-	-	-
1993-94	-	-	-	-
1994-95	-	-	-	-
1995-96	-	-	251	38,289
1996-97	21,435	2,634,356	600	1,011,020
1997-98	-	-	60	64,204
1998-99	2,725	1,300,019	22,225	3,317,458
1999-2000	2,041	268,900	16,876	2,563,937

(Source: Monthly Statistics of the Foreign Trade in India, Annual No (Imports), 1990-2000.)

Trade in Mercury Compounds

Beside the import of virgin or elemental mercury, mercury compounds are also traded in India. In fact, mercury compounds such as oxides, chlorides and sulphides are both imported as well as exported from India. As mentioned earlier, this trade of importing and later re-exporting is probably profitable.

Apart from being traded, these compounds have a wide industrial usage in India.

The import data for both mercury oxide and mercuric chloride do not show any pattern. There is no trend for their import over the years. Only 60 kg mercuric chloride was imported in 1997-98, but in 1998-99, the import of mercuric chloride was to the tune of 22,225 kg. The story is the same for mercury oxide: 21,435 kg was imported in 1996-97, dropping to 2,041 kg in 1999-2000.

The export data for mercuric chloride does not show any pattern either. There is no trend for its import over the years. In 1996-97, 6,620 kg of mercuric chloride was exported but the next year it dropped to 3,350 kg.

Trade of Mercury-based Products

A number of mercury-based products are traded (imported and exported) in the country, on an annual basis. These products, such as caustic soda and chlorine, are either raw materials or end products, such as fluorescent lamps and mercury vapour lamps. They represent a big market. Industries related to these products command a presence in the international market because of these products and their trading pattern in the international market. The wide trading pattern and usage of these products underline the importance of mercury and its compounds as raw materials.

Major Importers of Mercury		
Importer's name	Quantity (2000-01)	Quantity (1999-2000)
Champa Purie-Chem Industries Ltd	6,900 kg	3,450 kg
DCW Ltd	60 nos.	-
Enkay Associates	1,622 kg	-
GE Lighting India Ltd	25 pc	50 nos.
Indian Dyestuff Industries Ltd	50 kg	1,725 kg
Indian Dyestuff Industries Ltd	50 nos.	-
Major Metals Ltd	47,334 kg	-
Major Metals Ltd	954 nos.	-
Shriram Alkalies & Chemical Industries Ltd	8,493 kg	-
Surya Roshni Ltd	1,725 kg	3,450 kg
Beri Merurio Ltd	-	16,380 kg
Excel Industries Ltd	-	3,174 kg
Goa Instrument Industries Ltd	-	6 nos.
HBR Sales Pvt Ltd	-	1,000 kg
L S Chemicals & Pharmaceuticals	-	500 nos.
Mehta Flint	-	2,000 kg
Shriram Vinyl & Chemical Industries Ltd	-	1,725 kg
Lalwani Industries Ltd	-	2,000 kg

(Source: Minerals and Metals Review, 2000.)

Export of Mercury Compounds						
Years	Mercuric chloride		Mercury oxide		Mercurous chloride	
	Qty (kg)	Value (Rs)	Qty (kg)	Value (Rs)	Qty (kg)	Value (Rs)
1990-91	11,950	1,866,146	3,151	484,250	-	-
1991-92	12,829	1,812,998	475	169,452	13,151	1,608,804
1992-93	30,250	7,498,134	-	-	26,750	8,118,193
1993-94	4,000	971,523	-	-	1,000	270,769
1994-95	12,900	1,934,742	16	14,072	96	30,720
1995-96	18,076	1,556,951	-	-	4,065	739,401
1996-97	6,620	1,811,201	-	-	-	-
1997-98	3,350	1,277,674	-	-	-	-
1998-99	3,900	741,935	-	-	-	-
1999-2000	54,602	27,146,132	-	-	20,630	691,660
2000-01	74,416	4,942,059	11,000	6,110,120	2,400	420,082

(Source: Monthly Statistics of the Foreign Trade in India, Annual No (Exports), 1990-2000)

Import of Mercury-based Products

Some major articles imported by India, which use mercury or mercury compounds as raw materials, are:

- Primary cells and batteries of mercuric oxide.
- Fluorescent, hot cathode discharge lamps.
- Mercury or sodium vapour lamps, metal halide lamps.
- Blood pressure instruments (sphygmomanometers).
- Clinical thermometers.

These products, though made in India, are also imported to meet the wide Indian consumption pattern.

The import data in the table on the next page bottom does not show any import pattern: primary cells were widely imported in 1996-97, but this figure dropped down to a mere seven in 1998-99. While there is a steady increase in the import of fluorescent and mercury vapour lamps, only 10 blood pressure monitoring instruments were imported in 1996-97, and this figure jumped to 5,780 the next year. Clinical thermometers are also imported in very unpredictable patterns, from about 6 lakh in 1996-97 to around 3 lakh in 1999-2000.

Import of Mercury-based Products					
Years	Quantity (in numbers)				
	Primary cell (mercury oxide)	Fluorescent lamps	Mercury vapour lamps	Sphygmo-manometers	Clinical thermometers
1996-97	1,170	405,885	2,126	10	670,283
1997-98	70	1,228,210	32,114	5,780	308,808
1998-99	7	4,520,184	34,038	2,541	431,322
1999-2000	NA	9,692,561	115,487	170	338,990

(Source: Monthly Statistics of the Foreign Trade in India, Annual No (Imports), 1996-2000)

Export of Mercury-based Products					
Years	Quantity (in numbers)				
	Primary cell (mercury oxide)	Fluorescent lamps	Mercury vapour lamps	Sphygmo-manometers	Clinical thermometers
1996-97	-	3,569,477	235,849	1,958	4, 497,326
1997-98	2,104,100	2,312,740	166,680	22,786	1,873,458
1998-99	1,030,000	1,313,505	91,165	-	6,057,029
1999-2000	200,172	9,692,561	NA	NA	3,799,636

(Source: Monthly Statistics of the Foreign Trade in India, Annual No (Exports), 1996-2000.)

Export of Mercury-based Products

As discussed in earlier chapters, mercury and its compounds have a very wide usage pattern in India. End products such as chlorine and caustic soda are used as raw materials in many industries. Besides, mercury-based products have a great export potential.

Some of the major articles exported, which use mercury or mercury compounds as raw materials, are:

- Primary cell and batteries of mercuric oxide.
- Fluorescent, hot cathode discharge lamps.
- Mercury or sodium vapour lamps, metal halide lamps.
- Blood pressure instruments (sphygmomanometers).
- Clinical thermometers.

Beside these products, chlorine and caustic soda also have a great export potential for India. However, it is difficult to estimate the amount of chlorine and caustic soda (produced from mercury cell technology) that is exported. There is no break-up for this category in the export data.

The export data in the table above does not show any import pattern: Nearly 20 lakh primary cells were exported in 1996-97 and this figure dropped to 2 lakh in 1999-2000. There is an increase in the export of fluorescent lamps and a prominent decrease in the export of mercury vapour lamps. Blood pressure monitoring instruments are also exported in a very unpredictable manner. This position is not different for clinical thermometers: around 60 lakh were exported in 1998-99, and this number dropped to 37 lakh in 1999-2000. This is probably due to the closure of the HLL thermometer plant in Kodaikanal in 2001.

The export pattern of these products shows a gradual rising pattern for blood pressure monitors, but it is difficult to predict the rising trend due to the unavailability of data. There is a decrease in the export of clinical thermometers, though the export of mercury oxide primary cell, fluorescent and mercury vapour lamps has been steady over the years.

Beside the above-mentioned products, chlorine and caustic soda both have a great export potential to developing countries. They are exported to Asian countries on a regular basis. Every year, on an average, around 225 tonnes of chlorine and 6,000 tonnes of caustic soda, both in solid form and flakes, are exported out of India to Asian as well as African countries.

Summary

It can be concluded that the intricacies of the mercury trade are very difficult to understand. As we have seen, articles which are not produced in India are imported from developed countries but later re-exported. Goods and products made in India are also imported and re-exported. The logical conclusion that can be applied to this kind of trade is maximisation of profits by the traders.

We can say that mercury plays an important role in the international trade of India.

References

30. Vonkeman, Gerrit H., 'Data and Trends on Mercury', Institute for European Environmental Policy.
31. Ibid.

MERCURY IN INDIA

STANDARDS AND LEGISLATIONS

MERCURY IN INDIA

- In 1976, when the Parliament passed the 42nd Amendment to the Constitution, India became the first country in the world to provide protection and improvement of the environment in the Constitution itself.

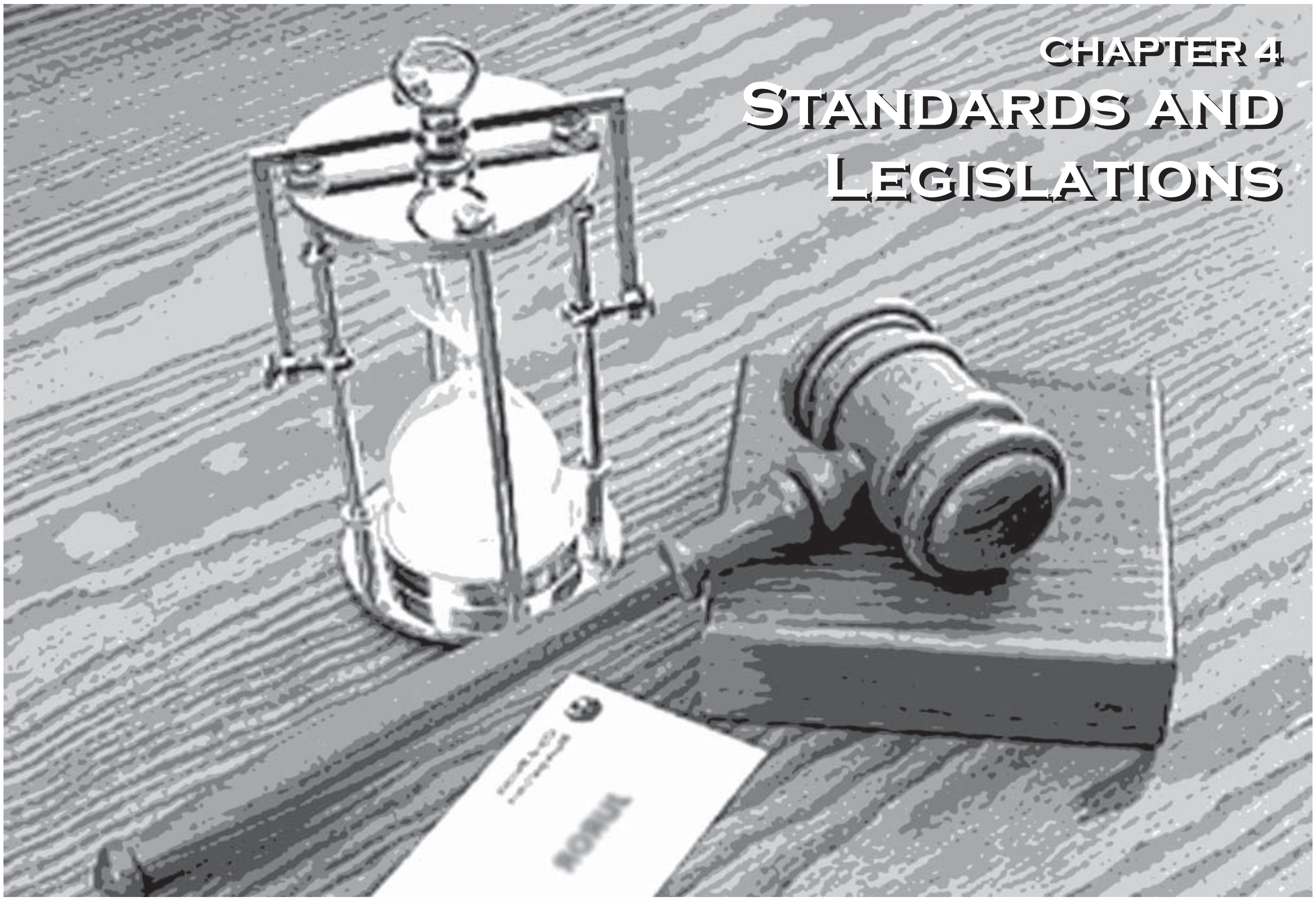
- Mercury has been the focus of regulatory activity because of its documented toxic and carcinogenic effects, as well as its persistent prevalence in the environment.

- Comprehensive standards have been set for all the major industries which emit mercury, except coal-based thermal power plants. The government has not taken serious note regarding this aspect of mercury emission from thermal power plants, which emit tonnes of mercury in to the environment every year.

- India signed the Basel Convention on March 15, 1990 and ratified it on June 24, 1992. The Ministry of Environment and Forests has been designated as the competent authority in India under this Convention. As a party to the convention, it is obligatory for India to comply with the requirements of this convention for any trans-boundary movements of hazardous wastes, and it is obligatory, for all parties, to incorporate the provisions of this convention in their national legislation.

- The Central Pollution Control Board (CPCB) has developed National Standards for Effluents and Emission Standards under the statutory powers of the Water Act, 1974, and the Air Act, 1981. These standards have been approved and notified by the Government of India, Ministry of Environment and Forest, under Section 25 of the Environment Protection Act, 1986.

- The main problem of our standards and legislations lies in the poor level of implementation by the various implementing agencies.



CHAPTER 4
Standards and Legislations

In 1976, when the Parliament passed the 42nd Amendment to the Constitution, India became the first country in the world to provide protection and improvement of the environment in the Constitution itself. India is one of the top 20 industrialised countries in the world with 16 per cent of the world's population and 2.4 per cent of land area. Protection of the environment now forms an integral part of the nation's Constitution.[32]

Standards and legislation are the software for environmental pollution control. These are not a mere vision or an ideal in their intrinsic nature, but provide the administrative targets to be reached as common objectives of a diversity of measures, organised and pushed forward to prevent the contamination of environment.[33]

Mercury has been the focus of regulatory activity because of its documented toxic and carcinogenic effects, as well as its persistent prevalence in the environment. Since mercury is volatile and readily mobilised, and often travels great distances before being deposited, regulatory concern about the environmental impacts of mercury appear to be quite justified.

Legislative control of environmental pollution caused by toxic mercury and the protection of workers engaged in the related industries involves:

- Laying down a set of rules on the expert recommendations to control environmental pollution.
- Adopting international conventions and recommendations concerning the prevention of occupational risks.
- Observing the codes of practice and guides on prevention.

The Ministry for Environment and Forests is the focal point in the Government of India for all matters relating to the environment. As the nodal Ministry, its first and foremost responsibility is to ensure coordination with all other ministries that come into the picture.

LEGISLATIONS

Legislation, defined as preparing a law or the exercise of making or giving of laws having the force of authority by virtue of their promulgation by an official organisation of a state or other organisation, is most necessary to meet the goal for protection of environment and human health. Many developed and developing countries have proper legislation in place to maintain environment quality.[34]

There are various Provisions and Acts pertaining to the prevention and control of pollution, and protection of the environment. In the 42nd Amendment to the

Constitution of India, under Article 48A, a provision that deals with the protection and improvement of our environment, reads: "*The State shall endeavour to protect and improve the environment and safeguard the forest and wildlife of the country*". All the Acts have drawn immense inspiration from the proclamation adopted by the UN Conference on the Human Environment, which took place in Stockholm in 1972.

ENVIRONMENTAL LEGISLATION

The various laws related to mercury in the environment are:

The Water (Prevention and Control of Pollution) Act, 1974

Passed in 1974, this Act is a specialised legislative measure, meant to tackle one facet of environmental pollution. Its main objectives are to provide:

i) The prevention, control and abatement of water pollution.
ii) The establishment of central and state boards, to implement the above objective.
iii) Conferring on such boards the power and assigning to such boards functions relating to that purpose.
iv) All matters connected therewith.

The Act specifies areas affected by water pollution in the country and prohibits the use of streams or wells for disposal of polluting matter. It restricts new outlets and new discharges for discharge of sewage. The Act, however, does not provide effluent standards.

The Water (Prevention and Control of Pollution) Rules, 1975

The Rules specify details of budget estimates on an annual basis.

Schedule IV

It gives rates of fees payable for reports conducted by the Central Water Laboratory.
VI. Test of Water, Sewage or Trade Effluent
(c) Heavy metals (qualitative test)
Mercury: Rs 24 (for each test)

The Water (Prevention and Control of Pollution) Cess Act, 1978

The Act was primarily intended to levy and collect a cess for the purposes of the Water (Prevention and Control of Pollution) Act, 1974, and utilisation thereunder to make provision of adequate funds for the state boards for their efficient and effective functioning. The

(continued on page 65)

SUMMARY OF LEGISLATION RELATED TO MERCURY

S No	Acts and Rules	Nature	Remarks
1.	The Water (Prevention and Control of Pollution) Act, 1974.	To provide for the prevention, control and abatement of water pollution; and the establishment of central and state boards to implement that objective.	It specifies areas affected by water pollution in the country and prohibits the use of streams or wells for disposal of polluting matter.
	i) The Water (Prevention and Control of Pollution) Rules, 1975.	Specifies details of budget estimates; and shows rates of fees payable for test of water, sewage or trade effluents.	Heavy metals (qualitative test). Mercury: Rs 24 (each test).
	ii) The Water (Prevention and Control of Pollution) Cess Act, 1978.	Primarily intended to levy and collect a cess for the purposes of the Water (Prevention and Control of Pollution) Act, 1974.	
	iii) The Water (Prevention and Control of Pollution) Cess Rules, 1978.	Specifies quantity of water consumed.	Specified quantity for mercury cell process of caustic soda production.

SUMMARY OF LEGISLATION RELATED TO MERCURY (CONTINUED FROM PAGE 62)

S No	Acts and Rules	Nature	Remarks
2.	The Environment Protection Act, 1986.	Provides for the protection and improvement of environment.	
	i) The Environment (Protection) Rules, 1986.	Formed to regulate environmental pollution, with power given to central and state boards.	Standards for emission, effluents given in the schedules. Limits to the pollutants given according to the industries. Mercury was included in the standards of all the major emitting industries, but there were no regulations or standards for thermal power plants emitting mercury in the air.
	ii) The Environment (Protection) 3rd Amendment Rules, 1993.	Structures of the Rules were the same.	Some more industries and standards were added to the rules. The amendments again missed out on mercury emissions from thermal power plants.
	iii) The Hazardous Wastes (Management and Handling) Rules, 1989.	Formed to regulate hazardous waste in the country.	Mercury included in the waste category.
	iv) The Hazardous Wastes (Management and Handling) Amendment Rules, 2000.	The amendments were made to specify the waste categories in detail.	Hazardous waste generating processes were taken into consideration.
	v) The Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989.	Formed to regulate hazardous chemicals in the country.	Chemicals included according to the degree of toxicity. Several mercury compounds were included in the Rules.
	vi) The Manufacture, Storage and Import of Hazardous Chemicals (Amendment) Rules, 2000.	Specifies the degree of toxicity in greater detail.	Some more mercury compounds were included.
3.	The Basel Convention.	International convention to regulate the trans-boundary movement of hazardous waste.	Mercury was included in some categories of hazardous waste.

(continued on page 64)

Summary of Legislation Related to Mercury (continued from page 63)

S No	Acts and Rules	Nature	Remarks
4.	The Workmen's Compensation Act, 1923.	Provides for compensation payment by certain classes of employers to their workmen for compensation for personal injury by accident.	Diseases caused by mercury or its toxic compounds are included. However, all this becomes useless because generally mercury poisoning occurs after the retirement of the worker.
5.	The Factories Act [Act No. 63 of 1948] as amended by the Factories (Amendment) Act, 1987.	Covers all the aspects of health and safety of workers.	Permissible limits of exposure to mercury in the work environment.
6.	The Public Liability Insurance Act, 1991.	Provides for public liability insurance for the purpose of providing immediate relief to the person affected by accident.	The schedule provides reimbursement of medical expenses incurred.
	i) The Public Liability Insurance Rules, 1991.	Provides the list of chemicals with quantities for application of the Act.	Only one mercury compound is on the list.
7.	The Bureau of Indian Standards.	The BIS provides standards to maintain products' quality.	Mercury-related standards are present in the Indian Standards.
8.	The Prevention of Food Adulteration Act, 1955.	'Consumer legislation' to regulate and protect consumers from adulterated food.	The Act has limits to all categories.
9.	The Prevention of Food Adulteration Rules, 1955.	Lays down the standards of quality of various food articles.	Mercury and methyl mercury are included as poisonous metals.
10.	The Foreign Trade (Development and Regulation) Act, 1992, No 22 of 1992 (7th Aug 1992).	Regulates trade in the country.	Mercury and its compounds are included as 'free' to import and export.
11.	The Municipal Solid Wastes (Management and Handling) Rules, 2000.	Regulates municipal solid waste.	Standards set for mercury in ground water, composts and leachate.

(continued from page 62)
cess, as contemplated under the Act, is categorised into two groups: industrialists and local authorities.

The Water (Prevention and Control of Pollution) Cess Rules, 1978

The Rules specify the quantity of water consumed by industries.

Water Consumed by Industries		
Name of Industry	**Category**	**Maximum Quantity of Water**
Chemical	a) Caustic soda i) Mercury cell process	5 cubic metres per tonne of caustic soda produced (excluding cooling water) and 5 cubic metres per tonne of caustic soda produced for cooling water.

The Environment Protection Act, 1986

The Bhopal Gas Tragedy in 1984 was an eye-opener for the Government of India; it made the government realise that the Water Act and the Air Act were not sufficient. Thus, an Act to provide for the protection and improvement of the environment and for related connected matters was deemed a priority.

This need was fulfilled by the decisions taken at the United Nations Conference on the Human Environment held in Stockholm in June 1972 (in which India participated) which laid down appropriate steps for the protection and improvement of the human environment.

It is considered necessary further to implement the decisions aforesaid as far as they relate to the protection and improvement of the environment and the prevention of the hazards to human beings, other living creatures, plants and property.

In this Act, powers were given to the central government to take measures to protect and improve the environment and rules were formed to regulate environmental pollution.

The Environment (Protection) Rules, 1986

The Rules were formed under the Environment Protection Act, 1986, to regulate environmental pollution. The central and state boards under the Water Act and the Air Act were given powers to regulate and lay down guidelines to implement the Rules. In Article 3 of the Rules, various Standards for emission, effluents or discharge of environmental pollutants are given in the schedules. Pollutants' limits are given according to the industries.

The Environment (Protection) 3rd Amendment Rules, 1993

In the Amendment, more standards were added to the Rules. More pollutants and more industries were also added to the Rules.

Hazardous Waste

The Basel Convention

The Basel Convention on the trans-boundary movement of hazardous wastes and their disposal came into force in May 1992. The Government of India is a party to the Basel Convention; it signed the convention on March 15, 1990, and ratified it on June 24, 1992. The Ministry for Environment and Forests has been designated as the competent authority in India under this Convention.

As a party to the convention, it is obligatory for India to comply with the requirements of this convention for any trans-boundary movement of hazardous wastes, and it is obligatory, for all parties, to incorporate the provisions of this convention in their national legislation.

The categories of waste to be controlled are specified. Mercury and mercury compounds are included in the category 'waste having as constituents'. *(see table below.)*

The Hazardous Wastes (Management and Handling) Rules, 1989

The Rules were designed under the Environment Protection Act, 1986, to regulate hazardous waste in the country. The central and state boards, under the Water Act and the Air Act, were given powers to regulate and guidelines to implement the rules. *(see table on next page)*

Y 29 Mercury; Mercury Compounds					
Basel no	**OECD no**	**Desc of metal**	**Annex I**	**Annex III**	**Customs code**
A 1		Metal and metal bearing wastes			
A 1010	AA 100	Mercury (see A 1030)	Y 29	6.1, 11, 12	Ex 2620.9

CATEGORIES OF HAZARDOUS WASTES		
Waste categories	**Types of waste**	**Regulatory quantities**
Waste category no 4	Mercury, arsenic, thallium and cadmium bearing wastes	5 kilograms per year the sum of the specified substance calculated as pure metal

The Hazardous Wastes (Management and Handling) Amendment Rules, 2000

The Amendments were made in the Rules to specify the waste categories in detail. The processes generating hazardous wastes were also taken into consideration.

Schedule 1

Processes Generating Hazardous Wastes

2. Natural gas production.

2.1 Mercury-containing sludge.

2.2 Mercury-containing filter material.

13. Production of chlorine.

13.1 Asbestos containing discards by means of mercury.

13.2 Mercury bearing sludge diaphragm-electrolysis process.

Schedule 2

Limits have been prescribed for toxic constituents in the wastes, which will lead to their being classified as hazardous in the 2000 Amendments to the Hazardous Wastes Rules. Following are the prescribed limits, which could not be considered as acceptable limits:

Class A: Concentration limit: 50 mg/kg

A 6 Mercury and mercury compounds

Under the Environment (Protection) Rules, 1986, Rule 13 notifies the procedure for prohibition/restriction of hazardous substances. Following the procedures, prescribed notifications have been issued after expert consultations to prohibit/restrict hazardous chemicals/hazardous wastes. Following are the details of hazardous wastes banned for imports so far:

Based on the recommendation of the Mashelkar Committee, the Ministry for Environment and Forests has prohibited/restricted the import of the following wastes:

A. (i) Cyanide wastes.

(ii) Mercury and arsenic bearing wastes.

The Hazardous Wastes (Management and Handling) Amendment Rules, 2003

Recently, therre were amendments made to the existing rules. However, mercury related Rules remined unchanged.

The Municipal Solid Waste (Management and Handling) Rules, 2000

The Rules were formed under the Environment Protection Act, 1986, to regulate the municipal solid waste in the country and every municipal authority shall, within the territorial area of the municipality, be responsible for the implementation of the provisions of these Rules. The Rules provide standards for mercury in the ground water, composts and the leachates, while the disposal of municipal solid waste as per the provisions of these Rules.

The Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989

The Rules were formed under the Environment Protection Act, 1986, to regulate hazardous chemicals in the country; The central and the state boards under the Water Act and the Air Act were given powers to regulate and guidelines to implement the Rules.

Schedule 1: Indicative Criteria and List of Chemicals

Part 1: Toxic Chemicals

Chemicals, which have the following values of acute toxicity and which, owing to their physical and chemical properties, are capable of producing major accident hazards: *(see table below)*

HAZARDOUS TOXICITY – I			
Degree of toxicity	**Oral toxicity LD (50 mg/kg)**	**Dermal toxicity LD (50 mg/kg)**	**Inhalation toxicity LD (50 mg/kg**
Extremely toxic	1-50	1-200	0.1-0.5
Highly toxic	51-500	201-2000	0.5-2.0

Part 2: List of Hazardous and Toxic Chemicals (Mercury)

- Mercury alkyl
- Mercury fulminate
- Mercury methyl
- Methoxy ethyl mercuric acetate
- Phenyl mercury acetate

The Manufacture, Storage and Import of Hazardous Chemicals (Amendment) Rules, 2000

In the amended Rules the degree of toxicity was more specific. There was an increase in the number of hazardous chemicals.

Schedule 1: Indicative Criteria and List of Chemicals

Part 1: Toxic Chemical

Chemicals, which have the following values of acute toxicity and which, owing to their physical and chemical properties, are capable of producing major accident hazards *(See table on next page, top left)*

Part 2: List of Hazardous and Toxic Chemicals (Mercury)

- Mercuric chloride
- Mercuric oxide
- Mercury acetate

HAZARDOUS TOXICITY – II

Degree of toxicity	Oral toxicity LD 50 (mg/kg)	Dermal toxicity LD 50 (mg/kg)	Inhalation toxicity LD 50 (mg/kg)
Extremely toxic	1-5	1-40	0.1-0.5
Highly toxic	5-50	40-200	0.5-2.0
Toxic	50-200	200-1,000	2-10

- Mercury fulminate
- Mercury methyl chloride
- Methoxy ethyl mercuric acetate
- Methyl mercuric di-cyanamide
- Phenyl mercury acetate

OCCUPATIONAL HEALTH LEGISLATION

The Workmen's Compensation Act, 1923

This is an important social legislation, which provides for payment by certain classes of employers to their workmen for compensation for personal injury by accident. Out of 22 occupational diseases described in A-C of Schedule III of the Act, five pertain to metals and/or their compounds. They include poisoning by mercury and its compounds.

Schedule III: List of Occupational Diseases

Part B

LIST OF OCCUPATIONAL DISEASES

S no	Occupational disease	Employment
2	Diseases caused by mercury or its toxic compounds	All work involving exposure to the risk concerned

The above Act sometimes becomes useless because mercury poisoning, as included in the Schedule, generally happens when a worker has already retired from the job and not during the production process.

The Factories Act [Act No 63 of 1948] as Amended by the Factories (Amendment) Act, 1987

This is a comprehensive piece of legislation and covers all aspects of health and safety of workers. It is mandatory on the part of the factories to ensure the effective disposal of the wastes and effluents and controlling the levels of dust and fumes injurious or offensive to the workers.

The Act was set up to protect factory workers from the dangers to their health from machines and from bad working conditions in the factory. It has detailed provisions relating to the health, safety and welfare of workers. It also concerns their working conditions, safety measures and other facilities to enhance their welfare.

It applies to every factory established in India, including the ones owned by the government.

Schedule I: List of Industries Involving Hazardous Processes

This includes mercury specific industries, where mercury is involved in the production process or is emitted as a result of the industrial process.

1. Power generating industries (for example, thermal power plants, etc)
2. Pulp and paper (including paper products) industries

3. Fertiliser industries
    - Nitrogenous
    - Phosphoric
    - Mixed
4. Cement industries
5. Petroleum industries
    - Oil refining
    - Lubricating oils and greases
6. Petrochemical industries
7. Drugs and pharmaceutical industries
    - Narcotics, drugs and pharmaceuticals
8. Paints and pigment industries
9. Chemical industries
    - Alkalis and acids
    - Halogens and halogenated compounds (chlorine, fluorine, bromine and iodine)
    - Explosives (including industrial explosives and detonators and fuses)
10. Insecticides, fungicides, herbicides and other pesticides industries
11. Synthetic resin and plastics
12. Man-made fibre (cellulosic and non-cellulosic) industry
13. Manufacture and repair of electrical accumulators
14. Dyes and dyestuff including their intermediates
15. Highly flammable liquids and gases

Schedule 2: Permissible Levels of Certain Chemical Substances in Work Environment

Permissible Limits of Exposure

Substance	Time average weighted concentration (8 hrs)		Short-term exposure limits (15 min)	
	ppm	mg/m^3	ppm	mg/m^3
Mercury (as Hg) - skin alkyl compounds	–	0.01	–	0.03

Schedule 3: List of Notifiable Diseases

4. Mercury poisoning or its sequelae.

The inclusion of mercury poisoning does not specify poisoning noticeable after retirement from the factory. Besides, there are chapters on health, safety and exposure to hazardous processes in the Act.

The Public Liability Insurance Act, 1991

An Act was created to provide public liability insurance, which means providing immediate relief to a person affected by an accident occurring while handling any hazardous substance. It also provides for liability to provide relief in certain cases on the principle of no fault. It will be the duty of the owner to take out insurance policies.

The Schedule provides a reimbursement of medical expenses incurred up to a maximum of Rs 12,500.

The Public Liability Insurance Rules, 1991

In application of the Public Liability Insurance Act, the Rules provide a list of chemicals, organised in four groups, with authorised quantities:

- Toxic substances
- Highly reactive substances
- Explosive substances

Surprisingly, only one category of mercury compound, which is used as an explosive, is found on this list. *(See table below)*

Mercury As An Explosive

S no	Name of hazardous substance	Quantity	Chemical abstract service number
GROUP 4 - EXPLOSIVE SUBSTANCES			
1	Mercury fulminate	10 tonne	20820-45-5 628-86-4

Consumer-related Legislation

Bureau of Indian Standards

The Bureau of Indian Standards provides specific and strict standards to maintain the quality of the products, thus providing safety to the consumers. Mercury-related standards are given in the annexure.

The Bureau of Indian Standards provides thousands of standards for every aspect related to quality control, which covers manufacturing, etc. The standards mentioned above are all related to mercury and its compounds. The standards are good but should be updated to match with international standards. An example is the Indian Standards No. 7812, passed in 1975, which deals with 'Code of Safety of Mercury'. It provides all the basic information about mercury to the consumers, giving details about its properties, health hazards and toxicity, storage and handling, packing and labelling and some other preventive measures.

However, safety measures during storage and handling should be made more stringent and their implementation should be overseen.

The Prevention of Food Adulteration Act, 1955

The Prevention of Food Adulteration Act is a 'consumer legislation' directed to regulate consumer-supplier relationships. The aim is to protect consumers from adulterated food and to ensure safe foodstuffs. The Act has limits for all categories that could be present in the food and harmful to the consumer.

The Prevention of Food Adulteration Rules, 1955

The quality standards of the various specified food articles are present in the Rules. The Rules give authority and power to the implementing agencies to implement the rules. The limits for all poisonous metals are expressed in Part XI.

Part XI: Poisonous Metals

- Chemicals described in the Indian monographs of the Indian pharmacopoeia, when used in foods, shall not contain poisonous metals beyond the limits specified in the appropriate monographs of the Indian pharmacopoeia for the time being in force.
- Notwithstanding the provisions of the sub-rule (1), no article of food specified in column 2 of the table below shall contain any metal specified in excess of the quantity specified in column 3 of the said table:

Mercury Levels In Food

Name of poisonous metal	Article of food	ppm by weight
Mercury	i) Fish ii) Other food	0.5 1.0
Methyl mercury	All foods (calculated as the element)	0.25

Trade-related Legislation

The Foreign Trade (Development and Regulation) Act, 1992, No 22 of 1992 (7th Aug 1992)

Mercury

"Items which do not require any license under the export and import policy have been denoted as 'free' subject to licensing notes."

Trade Regulations

Exim code	Item/goods	Policy	Duty
280540 00	Mercury	Free	67.086
282739 01	Mercuric chloride	Free	67.086
282739 05	Mercurous chloride	Free	67.086
282590 04	Mercury oxide (mercuric oxide)	Free	67.086
283329 02	Mercuric sulphates	Free	67.086

- "Exim code 280540 00 includes quicksilver (as mercury) vide policy circular No.49 (RE-99)/97-02 dated 20.1.2000.
- Import of hazardous waste is permitted against a license and only for the purpose of processing and reuse.

Trade Regulations for Mercury-related Products

Exim code	Item/goods	Policy	Duty
902511 00	Thermometers (all types)	Free	53.816
853932 00	Mercury or sodium vapour lamps; metal halide lamps	Free	67.086
853939 01	Mercury vapour lamps	Free	67.086
300640 00	Dental fillings	Free	67.086

It is really surprising that a toxic metal like mercury and its various forms are still under the free licensing policy of the government.

Other Mercury-related Legislation

This includes Acts, which, in one way or the other, are related to mercury.

The Insecticides Act, 1968

The Insecticides Act regulates the import, manufacture, sale, transport, distribution and use of insecticides to prevent risk to people, animals and for other matters connected to it. Under the Act, there is a Central Insecticides Board to advise governments on matters under the Act. The Registration Committee under the Act registers insecticides after scrutinising the formula and verifying claims made by the importer or manufacturer about the safety and efficacy of the pesticides vis-a-vis people and animals. There is little scope for third parties to intervene at this stage.

A major flaw in the Act is that once a substance is specified in the Schedule of the Act, there is no power to cancel the Registration Certificate issued in respect of that particular substance even if, in a scientific study, it appears that the substance in question is grossly detrimental to health.

Mercury-based compounds registered on a regular basis under Section 9(3) of the Act are:

The Schedule

List of mercury-based insecticides

- Ethyl mercury phosphate
- Ethyl mercury chloride
- Ethoxy ethyl mercury chloride
- Mercuric chloride
- Methoxy ethyl mercury chloride — agallol, aretan
- Methyl mercury chloride
- Phenyl mercury acetate (PMA) — ceresan
- Phenyl mercury chloride
- Phenyl mercury urea
- Tolyl mercury acetate

Out of the above mercury-based insecticides registered in the Act, phenyl mercury, acetate and ethyl mercury chloride are banned in India. Methoxy ethyl mercury chloride is banned for seed dressing except for potato and sugarcane.

STANDARDS

The Standards are available as countermeasures to environmental pollution by toxic pollutants like the heavy metals. Many developed and developing countries and international agencies have formulated such standards. Standards for trace metals like mercury should be stringent since they are highly toxic to human beings, and human health should always be given preference over anything else.[35]

The Central Pollution Control Board (CPCB) has developed National Standards for Effluents and Emission Standards under the statutory powers of the Water Act, 1974, and the Air Act, 1981. These Standards have been approved and notified by the Government of India, Ministry for Environment and Forests, under Section 25 of the Environment Protection Act, 1986. Till now, effluent standards for 37 categories and emission standards for 31 categories of industries have evolved and been notified, besides standards for ambient air quality, ambient noise, automobile and fuels quality specification for petrol and diesel.

This report provides emission and effluent standards only with regard to mercury. These standards are present in both Schedules of the Environment Protection Rules, 1986, and 1993.

Parameter Standards

Industry	Parameters	Standards
i) Battery manufacturing industry ii) Dry cell manufacturing industry	Pollutants	Concentration (not to exceed mg/l)
Effluent standards	Mercury	0.02 mg/l
Caustic soda industry	Total concentration of Hg in final effluent*	0.01 mg/l
	Mercury bearing waste water generation (flow)	10 kilolitres/tonnes of caustic soda produced

* Final effluent is the combined effluent from: a) cell house; b) brine plant; c) chlorine handling; d) hydrogen handling; and e) hydrochloric acid plant.

Emission Standards		
Chlor-alkali (caustic soda)	**Emissions**	**Standard (concentration in mg/m^2 {normal})**
a) Mercury cell	Mercury (from hydrogen gas holder stack)	0.2 mg/m^2

Effluent Standards		
Industry	**Effluents**	**Standard (concentration not to exceed mg/l)**
Dye and dye intermediate industries	Mercury	0.1 mg/l
Pharmaceutical industry (bulk drugs)	Mercury	0.1 mg/l
Pesticide manufacturing and formulation industry	b) Heavy metals Mercury	0.1 mg/l
Inorganic chemicals industry (waste water discharge)	Mercury	0.1 mg/l
Organic chemicals manufacturing industry	b) Additional parameters Mercury	0.1 mg/l

General Standards for Discharge of Environmental Pollutants

Part A: Effluents

Effluents				
Parameter	**Standards**			
	Inland surface water	Public sewers	Land for irrigation	Marine coastal area
Mercury (mg/l) max	0.01	0.01	–	0.01

Part B: Wastewater Generation Standards

Wastewater Generation Standards	
Industry	**Quantum**
Caustic soda b) Mercury cell process	4[1] [m^3/tonne] of caustic soda produced (mercury bearing), 10% blow down permitted for cooling tower

Part D: Concentration Based Standards

General Emission Standards	
Parameter	**Standard (concentration not to exceed {in mg/Nm^3})**
Mercury	0.2

Oil Drilling and Gas Extraction Industry

Standards for Liquid Effluents	
Parameter	**Toxicity limit (mg/l)**
Mercury	0.01

i) Oil and gas drilling and processing facilities, situated on land and away from saline water sink, may opt either for disposal of treated water by on-shore disposal or by re-injection in abandoned wells; effluent has to comply only with respect to suspended solids and oil and grease at, respectively, 100 mg/l and 10 mg/l. For on-shore disposal, the permissible limits are outlined in the tables on the following page.

On-shore Disposal		
S No	**Parameter**	**On-shore discharge standards (not to exceed)**
20	Mercury	0.01 mg/l

Common Effluent Treatment Plants			
a) Primary treatment	Mercury		0.01 mg/l*
b) Treated effluent quality of common effluent treatment plant	Into inland surface waters	On land for irrigation	Into marine coastal areas
Concentration in mg/l			
Mercury	0.01	–	0.01

*Notes: *1) These standards apply to small scale industries, and total discharge up to 25 kl/day.*
2) For each CETP and its constituent units, the state board will prescribe standards as per the local needs and conditions; these can be more stringent than those prescribed above. However, in case of clusters of units, the state boards with the concurrence of CPCB in writing, may prescribe suitable limits.

Water Quality Standards for Coastal Waters Marine Outfalls

Coastal Water Standards	
Class	**Designated best use**
SW-1 salt pans, shell fishing, mariculture and ecologically sensitive zone	Salt pans, shell fishing, mariculture and ecologically sensitive zone

Primary Water Quality Criteria for Class SW-1 Waters

Water Quality Criteria		
Parameters	**Standards**	**Rationale/ remarks**
Heavy metals: Mercury	0.01mg/l	Value depends on: Concentration in salt, fish and shell fish

The Municipal Solid Wastes (Management and Handling) Rules, 2000, have also developed standards for groundwater, composting and leachates while disposing of waste.

Water Quality Monitoring

Usage of groundwater in and around landfill sites for any purpose (including drinking and irrigation) is to be considered after ensuring its quality. The following specifications for drinking water quality shall apply for monitoring purpose for mercury:

Water Quality Monitoring		
S No	**Parameters**	**IS 10500: 1991 Desirable limit (mg/l except for pH)**
7.	Mercury	0.001

Compost

In order to ensure safe application of compost, the following specifications for compost quality shall be met:

Specifications For Compost Quality	
Parameters	**Concentration not to exceed* (mg/kg dry basis, except pH value and C/N ratio)**
Mercury	0.15

* Compost (final product) exceeding the above stated concentration limits shall not be used for food crops. However, it may be utilised for purposes other than growing food crops.

Leachates

Leachates			
Parameter	**Standards (mode of disposal)**		
	Inland surface waters	**Public sewers**	**Land disposal**
Mercury (as Hg), mg/l, max	0.01	0.01	-

SUMMARY

Standards have been set for all the major industries which emit mercury, except coal-based thermal power plants. The government has not taken serious note regarding this aspect of mercury emission from thermal power plants, which emit tonnes of mercury in the environment annually.

The main problem of our standards and legislations lies in the poor level of implementation by the various implementing agencies. If the legislation and standards were properly implemented, half of India's environmental problems would be solved.

References

32. Sharma, H.C., 'Pollution Regulations in India,' *Indian Journal of Environmental Protection*, Vol. 13, No 9, 1993.
33. Tiwari, R.S. and D.S. Bhargava, 'Trace Metals (Cd, Pb and Hg) in the Environment,' *Indian Journal of Environmental Protection*, Vol. 12, No 4, 1992.
34. Ibid.
35. Sharma, H.C., Op cit, page 1.

Caustic Soda Manufacturing Units using Mercury Cell Process		
S. No.	Name and address of the industry	Process type
1.	M/s Bihar Caustic and Chemicals Ltd, Ghanshyam Kunj, Garhwa Road, P.O. Rehla 822 124, Distt Palamau, Bihar.	Mercury cell
2.	M/s Chemplast Sanmar Ltd (Caustic-chlor Divn) Plant- I, II and III, Mettur Dam 636 402 Distt Salem, Tamil Nadu.	Mercury cell
3.	M/s DCW Ltd, Caustic soda unit, P.O Arumuganeri,Sahupuram 628 229, Tamil Nadu.	Mercury cell
4.	M/s DCW Shriram Consolodated Ltd, Shriram Fertilisers and Chemicals (SFC), Shriram Nagar, Kota 324 004, Rajasthan.	Mercury cell
5.	M/s Durgapur Chemicals Ltd, Dr Hanemann Sarani, Durgapur 713 214, West Bengal.	Mercury cell
6.	M/s Hindustan Heavy Chemicals Ltd, 19 Barrackpur Trunk Road, Khardah P.O. Balaram Dharma, Sopan 743 121, Distt. 24 Parganas (N), West Bengal.	Mercury cell
7.	M/s Hindustan Paper Corporation Ltd, Nagaon Paper Mill, P.O. Kagaz Nagar, Distt Maligaon 782 413, Assam.	Mercury cell
8.	M/s Hindustan Paper Corporation Ltd, Cachar Paper Mill, P.O. Panchgram, Distt Hailakandi 788 802, Assam.	Mercury cell
9.	M/s Jayashree Chemicals Ltd, P.O. Jayashree, Distt Ganjam 761 025, Orissa.	Mercury cell
10.	M/s Kanoria Chemicals and Industries Ltd, P.O. Renukoot 231 217, Distt Sonbhadra, UP.	Mercury cell
11.	M/s Orient Paper Mill, P.O. Brajraj Nagar 768 216, Distt Jharsuguda, Orissa.	Mercury cell
12.	M/s Andhra Sugars Ltd, P.O. Kovvur 534 350, Distt West Godavari, Andhra Pradesh.	Mercury cell Membrane cell
13.	M/s Atul Ltd, P.O. Atul 396020, Distt Valsad, Gujarat.	Mercury cell Membrane cell
14.	M/s BILT Chemicals Ltd, P.O. Binaga, Uttar Kanara, Distt Karwar 581 361, Karnataka.	Mercury cell Membrane cell
15.	M/s BILT Chemicals Ltd, Khavda Marine Chemical Complex, Himmat Nagar, Revenue Colony, Near Jubilee Ground, Bhuj 370 001, Gujarat.	Mercury cell Membrane cell
16.	M/s BILT Chemicals Ltd, Unit: Singach, Vill and P.O. Singach, Distt Jamnagar 381 010, Gujarat.	Mercury cell Membrane cell
17.	M/s Grasim Industries Ltd (Chemical Division), P.O. Birlagram, Nagda 456 331, Madhya Pradesh.	Mercury cell Membrane cell

Caustic Soda Manufacturing Units using Mercury Cell Process		
S. No.	**Name and address of the industry**	**Process type**
18.	M/s Hukumchand Jute and Industries Ltd, P.O. Amlai Paper Mill, Distt Shahdol 484 117, Madhya Pradesh.	Mercury cell Membrane cell
19.	M/s Modi Alkalies & Chemicals Ltd, SP-460, M.I.A., Alwar 301 030, Rajasthan.	Mercury cell Membrane cell
20.	M/s Punjab Alkalies & Chemicals Ltd, Nangal-Una Road, Nayanangal 140 126, Punjab.	Mercury cell Membrane cell
21.	M/s Southern Petrochemicals Industries Corporation (SPIC) Ltd, Express Highway, Manali, Chennai 600 068.	Mercury cell Membrane cell
22.	M/s Standard Industries Ltd, P.O. Ghansoli, Thane-Belapur Road, Thane 400 601, Maharashtra.	Mercury cell Membrane cell
23.	M/s Travancore Cochin Chemicals Ltd, Udyogmandal, P.O. Kochi 683 501, Kerala.	Mercury cell Membrane cell

Abstracts of References

◆ **B.M. Tejam** and **B.C. Haldar**, *'A Preliminary Survey of Mercury in Fish from Bombay and Thane Environment'*, ***Indian Journal of Environmental Health*, Vol 17 (1), 1975, 9-16.**

The results of a survey for mercury in 30 species of fish from seven sources in Mumbai and Thane environment are reported in this paper. Neutron activation techniques have been used in the present investigation to estimate mercury in muscle, bone and brain in fish samples. The upper limit of natural mercury concentration in fish has been estimated at 100-200μg/g. The results reveal that bones and brain of *Tilapia Mozambique, Mugil Dussumieri* and other varieties of fish from Thane and Mumbra creek have mercury concentration greater than 500 μg/g on fresh weight basis.

◆ **R.R. Khan**, *'Environment and Health Effects of Toxic Metals'*, ***Indian Journal of Toxicology*, Vol 6 (2), 1999, 1-2.**

An overview of the problem of toxic metals in the environment in India is given. Studies and surveys done on the status of pollution due to toxic metals in air, water, soil and food in India have been reviewed. The paper also covers metal concentrations in human blood, tissue and urine. Salient findings of the study done under the Integrated Environmental Programme on Heavy Metal Pollution sponsored by the Union Ministry of Environment and Forests during 1983-89 have also been given.

◆ **K. Ayyadura, N. Kamalam** and **C.K. Rajagopal**, *'Mercury Pollution in Water in Madras City'*, ***Indian Journal of Environmental Health*, Vol 25 (1), 1983, 15-20.**

Water samples were collected from 12 spots in Chennai City for analysing the content of mercury and its accumulation in toxic amounts. The samples were then taken up for analysis and mercury determined by flameless atomic absorption spectrophotometer. The result of the analysis showed amounts of mercury ranging 2.43 to 32.99 μg/ml. All the spots sampled had non-toxic levels of mercury. The fact that the levels of mercury observed in these waters was low, and that none of the places where analysis of mercury was done showed any significant difference between them, point to the conclusion that these water sources have not been contaminated so far.

◆ **A.M. Komerwar, K. Asokan, S. Krishnamurthy, P. Subbaiah, B.R. Yadav** and **H.V.K. Udupa**, *'Mercury Pollution from Chlor-alkali in India and role of TSIA for its Abatement'*, ***Indian Journal of Environmental Health*, Vol 20 (3), 1978, 284-289.**

In India, during 1976 about 4 lakh tonnes of caustic soda was produced by the mercury cell process. About 0.23 kg of mercury is lost per tonne of caustic soda produced. As a result, the effluents and emissions from chlor-alkali industries contain around 90,800 kg of mercury contaminating the air, rivers and other waterways into which the emissions are let out and the effluents are discharged, thereby creating a serious pollution problem. This paper aims at bringing to light the area of the pollution problem that arises due to the use of mercury in chlor-alkali industries and suggests a way for its abatement by the use of Titanium Substrate Insoluble Anodes (TSIA).

◆ **Manju Agrawal** and **H.D. Kumar**, *'Physico-chemical and Phycological Assessment of two Mercury-polluted Effluents'*, ***Indian Journal of Environmental Health*,**

Vol 20 (2), 1978, 141-155.

Physico-chemical and biological analyses of mercury-containing effluents discharged by the Kanoria Chemicals Factory, Renukoot, and the Rohtas Paper Industry, Dalmiyanagar, were made. The effluents of the Rohtas Paper Industry are discharged directly without any dilution. It was highly toxic and did not harbour any algae populations.

A biological assessment of effluent toxicity using the unicellular algae *Chlorella* and *Anacystis nidulans* revealed that the main cause of absence of algae in the effluent channel was the presence of mercury. Subsidiary factors possibly responsible for the lack of algae in the effluent include the presence of some amounts of zinc, copper, chlorides and organic matter and the deficiency of nutrients such as phosphate and nitrate.

◆ **P. Kaladharan, V.K. Pillai, A. Nandkumar** and **P.K. Krishnakumar**, *'Mercury in Seawater along the Coast of India'*, ***Indian Journal of Marine Science*****, Vol 28, 1999, 338-340.**

The present study indicated that the distribution of mercury in the Arabian Sea had a conspicuous pattern showing very low values ranging from below detection level (BDL) to 0.058 µg/l during the pre-monsoon period and remained more or less same during the SW monsoon period, with an exceptional higher value of 0.117 µg/l mercury observed in the shelf waters off Veraval. During the post monsoon season the Hg levels attained were higher than the levels during the earlier seasons, ranging from BDL to 0.117 µg/l, with some pockets showing stray high values.

Stray occurrences of higher levels of Hg were observed both in the southern and northern latitudes during the post monsoon period of 1996 ranging from 0.117 µg/l in the south adjacent to the Cape and Laccadive Sea, to a concentration of 0.352 µg/l in the north adjoining the Veraval coast, where a similar higher trend prevailed during the SW monsoon season also. The seasonal average of Hg levels showed a 100 per cent increase during the post monsoon period over the preceding monsoon as well as pre-monsoon seasons. The present study was limited to surface only.

◆ **Sujata Sanzgiri, R. Sengupta** and **S.Y.S. Singbal**, *'Total Mercury Concentrations in Waters of the Laccadive Sea'*, ***Indian Journal of Marine Science*****, Vol 8, Dec 1979, 252-254.**

Concentrations of mercury, measured at surface and at different depths in the Laccadive Sea, ranged from 50-204 µg/l, which agreed with the earlier reported values (11-221µg/l) for the Arabian Sea. A few isolated values were higher than the average but these were low enough to show that the Laccadive Sea waters are at present free from mercury pollution. Average surface mercury concentration in the Laccadive Sea was 91µg/l (range 60-120 µg/l). In the coastal waters of the Arabian Sea the average surface value was 136 µg/l and for the entire Arabian Sea the average value at the surface was 120 µg/l. Pooling the observations of all the cruises the average concentration at the surface for the northern Indian Ocean would be 106 µg/l.

◆ **S.Y.S. Singbal, Sujata Sanzgiri** and **R. Sengupta**, *'Total Mercury Concentrations in the Arabian Sea Waters off the Indian Sea Coast'*, ***Indian Journal of Marine Science*****, Vol 7, Dec 1978, 124-126.**

There is continuous addition of heavy metal ions into the marine environment mostly due to industrial and domestic releases. Dissolved inorganic mercury probably occurs mostly as $HgCl_4$. Its concentration in open ocean water usually lies in the range 10-50 µg/l, but considerably higher concentrations may occur in inshore waters, especially in polluted estuaries. The lowest and highest concentrations observed are 13 and 407 µg/l, respectively, among all the samples analysed from different depths. The rest of the values from the surface give an average concentration of 77µg/l.

◆ **P.R. Kamath, Y.K. Agrawal , B.M. Sankhesara** and **N.G. Laghate**, *'Control of Mercury Pollution from Discharge of Industrial Effluents to the Environment'*, ***Chemical Engineering World*****, Vol XI (9), Sept 1976, 59-63.**

The largest industrial use of mercury is in the chlor-alkali industry employing mercury cells. The study was carried out in the laboratory to remove mercury present in waste waters as sulphide by passing the effluents at pH 3.5 through a bed of iron sulphide (FeS). H_2S is produced when the effluent comes in contact with FeS. It reacts with Hg to precipitate HgS. The techniques are further discussed in the report.

◆ **Shams Pervez** and **G.S. Pandey,** *'Contamination of River Water and Sediments by Thermal Power Ash Pond Discharge'*, ***Indian Journal of Environmental Health*****, Vol 36 (1), 1994, 8-12.**

Contamination of Hasdeo river water, due to effluents from a thermal power plant ash pond, is discussed. The data presented here are related to Hasdeo River, which receives the ash pond discharge of a thermal power plant located in Korba. The discharge from the ash pond reaches Hasdeo River after flowing about 1 km. Data show that toxic elements (Pb, Cu, Cd, Zn, Cr, Mn, Ni, As and Hg) which were not detected earlier in river water and sediments were found introduced to it as a result of the merging of the ash pond effluents.

◆ **Rathin N. Sharma, Anil K. Baruah, Gobin C. Borah** and **Parash K. Chowdhary**, *'Assessment of Heavy Metals in Surface Water Around Oil Installations'*, ***Indian Journal of Environmental Health*****, Vol 37 (4), 1995, 243-250.**

Levels of 13 heavy metals in pond/stagnated water bodies around few well sites and two group gathering stations of Rudrasagar field in Sibsagar districts of Assam have been assessed and their seasonal variations as well as extent of lateral spread out have been investigated. Heavy metals (Fe, Mn, Ni, Pb, Cr, Cu, Zn, Hg, As and V) have been found marginally above background levels in close proximity to the group gathering stations and new/ongoing well sites, whereas metal levels around production sites and abandoned wells lie within background levels. Results show marked seasonal variation; the extent of lateral spread out was insignificant.

◆ **R.S. Lokhande** and **Nilima Kelkar**, *'Studies on Heavy Metals in Water of Vasai Creek, Maharashtra'*, ***Indian Journal of Environmental Protection*, Vol 20 (6), 1999, 441-446.**

Vasai creek is an important source of fish farming and is used for many other purposes such as salt pans, agriculture, etc. Due to the recently developed chemical industries, oil and grease spillage from ships and public sewage, the shores as well as water of Vasai creek is polluted and all these pollutants are carried by water. Hence interridal collection of water samples was carried out to understand physico-chemical and microbiological quality of water, along with what heavy metals were present in it. Heavy metals are the most harmful and insidious pollutants because of their non-biodegradable nature. The study was conducted to determine the levels of heavy metals (such as Cd, Cu, Fe, Ni, Mn, Zn, Pb and Hg). The water of Vasai creek, carrying toxic heavy metals, like Fe, Pb and Hg, seriously reduces soil fertility and agricultural output. It is estimated that the major 18 industries release 7 tonnes of mercury along with other heavy metals yearly into the Ulhas river system.

International Occupational Exposure Limits

Comparision of the limits regarding mercury and its compounds prescribed by some international organisations such as ILO, OSHA, NIOSH, etc.

Mercury and its compounds

Mercury: Occupational exposure limits

TLV: 0.025 mg/m^3 (as TWA) (skin, A4) (ACGIH 2000).

MAK: 0.01 ppm; 0.1 mg/m^3; (1992).

Mercuric acetate: Occupational exposure limits

TLV (as Hg): 0.025 mg/m^3 (skin) A4 (ACGIH 1999).

MAK as Hg: 0.01 mg/m^3; BAT 25 mg/l in blood, 100 μg/l in urine (1999)

MAK as Hg STEL: 1 mg/m^3; (1999)

MAK: class Sh (1999)

Mercuric chloride: Occupational exposure limits

TLV (as Hg): 0.025 mg/m^3 (skin, A4) (ACGIH 1999).

Mercuric nitrate: Occupational exposure limits

TLV (as Hg): 0.025 mg/m^3 (skin) A4 (ACGIH 1999).

MAK as Hg: 0.1 mg/m^3; BAT 25 μg/l in blood; 100 μg/l in urine (1999)

MAK as Hg STEL: 1 mg/m^3; (1999)

MAK: class Sh (1999)

Exposure Limits and Guidelines for Mercury

Agency	Form of mercury	Exposure limits/ guidelines	Reference
HSE	Mercury and mercury compounds except alkyls	0.025 mg/m^3 (OES; 8-hr TWA RP)	HSE, 1996
	Mercury alkyls	0.01 mg/m^3 (OES; 8-hr TWA RP) 0.03 mg/m^3 (OES; 15-min RP)	
OSHA	Mercury vapour	0.05 mg/m^3	IRIS, 1996
NIOSH	Mercury vapour	0.05 mg/m^3	IRIS, 1996
WHO	Mercury in indoor air	1 μg/m^3	WHO, 1987

Mercuric oxide: Occupational exposure limits
TLV (as Hg): 0.025 mg/m³ A4 (skin) (ACGIH 2000).
Mercuric sulphate: Occupational exposure limits
TLV (as Hg): 0.025 mg/m³ (skin, A4) (ACGIH 1999).
Mercurous chloride: Occupational exposure limits
TLV (as Hg): 0.025 mg/m³ (skin) A4 (ACGIH 1999).
MAK as Hg: 0.1 mg/m³; BAT 25 µg/l in blood; 100 µg/l in urine (1999)
MAK as Hg STEL: 1 mg/m³; (1999)
MAK: class Sh (1999)

Notes:
MAK *(Maximum Arbeits Konzentration = maximum working concentration) is the German OEL.*
TWA *means time-weighted average; most OELs are expressed as average exposures over the whole working day (for example, 1 part per million of chlorine gas all morning and 3 ppm all afternoon adds up to a 2 ppm TWA).*
ACGIH *is the American Conference of Governmental Industrial Hygienists, a professional non-governmental group that has authored recommended OELs that were called TLVs (Threshold Limit Values).*
BAT *(Biological Tolerance Value).*

Sources:
- HSE (1996) *Occupational exposure limits 1996* (Health and Safety Executive EH40/96), Sudbury, UK, HSE Books.
- IRIS (1996) *Integrated risk assessment system, mercury*, US Environmental Protection Agency, Online search conducted January 1996.
- WHO (1990) *Methyl mercury* (International Programme on Chemical Safety, Environmental Health Criteria, 101), Geneva, Switzerland, World Health Organisation.
- WHO (1991) *Inorganic mercury* (International Programme on Chemical Safety, Environmental Health Criteria, 101), Geneva, Switzerland, World Health Organisation.

Mercury Related Standards by Bureau of Indian Standards (BIS)

- IS: 71 (1950): Mercuric oxide for paints (Status: withdrawn)
- IS: 2183 (1973): Schedule for high pressure mercury vapour lamps (1st revision) with amendment 1, (Status: superseded by IS: 9900 (part 1 to part 4), 1981)
- IS: 2305 (1988): Method for Mercurous nitrate test for copper and copper alloys (1st revision)
- IS: 2353 (1963): Phenyl mercury chloride (PMC), technical (amendment 1.) *(Status: reaffirmed 1993)*
- IS: 2354 (1963): Ethyl mercury chloride (EMC), technical (amendment 1.) *(Status: reaffirmed 1993)*
- IS: 2355 (1963): Stablised ethoxy ethyl mercury chloride concentrate. *(Status: withdrawn)*
- IS: 2356 (1963): Formulation based on phenyl mercury salicylate. *(Status: withdrawn)*
- IS: 2357 (1963): Formulation based on phenyl mercury acetate. *(Status: withdrawn)*
- IS: 2358 (1984): Formulation based on stablised methoxy ethyl mercury chloride, concentrate (1st revision) *(Status: reaffirmed 1989)*
- IS: 2359 (1963): Formulation based on stablised ethoxy ethyl mercury chloride *(Status: withdrawn)*
- IS: 3025 (1994): Methods of sampling and test (physical and chemical) for water and waste water, Part 48, mercury (1st revision)
- IS: 4705 (1985): Dental mercury (1st revision) (Status: reaffirmed 1990)

IMPORT OF MERCURY

			1990-91		1991-92		1992-93	
Article code	**Articles**	**Countries**	**Qty (kg)**	**Value (Rs)**	**Qty (kg)**	**Value (Rs)**	**Qty (kg)**	**Value (Rs)**
28054000	**Mercury**	Algeria	152,189	16,688,157	62,500	5,695,272	63,577	5,311,930
		Belgium	-	-	6,900	743,492	-	-
		Canada	-	-	3,000	257,067	6,900	815,708
		Chile	-	-	-	-	-	-
		Chinese Taipei	39,389	4,059,643	6,450	677,506	14,092	1,380,850
		China	5,963	678,348	-	-	14,000	1,656,806
		Denmark	200	30,876	-	-	-	-
		Finland	-	-	12,350	807,070	15,313	1,503,691

- IS: 6616 (1982): Ballast from high pressure mercury vapour lamps (1st revision) *(Status: reaffirmed 1990)*
- IS: 7023 (1973): Methods of test for high pressure mercury vapour lamps. *(Status: superseded by IS: 9900 Part 1 to 4)*
- IS: 7244 (1974): Thermometer for mercury barometer *(Status: reaffirmed 1996)*
- IS: 7812 (1975): Code of safety for mercury *(Status: reaffirmed 1996)*
- IS: 9900 (1981) Part 1 to 4: High pressure mercury vapour lamps (amendment 4). *(Status: reaffirmed 1992)*
- IS: 9931 (1981): Mercurimetric method for determination of chloride in inorganic chemicals (Status: reaffirmed 1988)
- IS: 12398 (1988): Mercury barometer (for educational use) *(Status: reaffirmed 1998)*
- IS: 2490 and 3306 (1974): for drinking water, Mercury concentration: 0.01 mg/l

Import of Mercury

			1990-91		1991-92		1992-93	
Article code	Articles	Countries	Qty (kg)	Value (Rs)	Qty (kg)	Value (Rs)	Qty (kg)	Value (Rs)
28054000	**Mercury**	France	-	-	-	-	7,900	608,810
		Germany	6,000	699,555	13,925	1,030,471	12,075	1,102,184
		Hong Kong	1,725	212,907	-	-	-	-
		Indonesia	-	-	-	-	-	-
		Italy	-	-	4,350	348,012	28,800	2,350,254
		Japan	27,200	2,540,016	6,900	440,928	4,313	241,139
		Kyrgyzstan	-	-	-	-	-	-
		Morocco	-	-	-	-	-	-
		Netherlands	5,225	674,296	33,200	2,711,165	10,200	1,744,548
		Norway	3,000	404,156	6,900	420,285	-	-
		Poland	-	-	-	-	-	-
		Russia	-	-	-	-	-	-
		Singapore	-	-	126,990	816,446	-	-
		Slovak Republic	-	-	-	-	-	-
		Spain	27,251	2,806,961	-	-	40,550	5,169,057
		South Africa	-	-	-	-	-	-
		Sweden	-	-	-	-	-	-
		Switzerland	-	-	-	-	-	-
		Turkey	5,175	571,223	4,905	424,291	-	-
		UAE	-	-	-	-	-	-
		UK	24,519	3,024,445	13,625	951,683	1,898	185,448
		Ukraine	-	-	-	-	-	-
		USA	128,679	13,058,351	170,901	13,148,627	119,329	8,612,125
		Venezuela	-		-		-	-
		Total	**426,515**	**45,448,934**	**482,901**	**39,780,816**	**338,947**	**30,682,572**

Import of Mercury

Countries	1993-94 Qty (kg)	1993-94 Value (Rs)	1994-95 Qty (kg)	1994-95 Value (Rs)	1995-96 Qty (kg)	1995-96 Value (Rs)	1996-97 Qty (kg)	1996-97 Value (Rs)
Algeria	-	-	-	-	-	-	4,000	62,429
Belgium	-	-	-	-	-	-	-	-
Canada	-	-	-	-	-	-	-	-
Chile	305,039	24,966,572	-	-	-	-	-	-
Chinese Taipei	-	-	10,350	837,157	-	-	-	-
China	-	-	-	-	-	-	-	-
Denmark	-	-	-	-	-	-	-	-
Finland	32,974	2,655,959	3,450	383,283	-	-	17,250	2,357,979
France	-	-	-	-	-	-	-	-
Germany	690	80,147	-	-	150	19,213	828	137,526
Hong Kong	13,835	1,751,751	-	-	-	-	-	-
Indonesia	-	-	-	-	-	-	-	-
Italy	130,660	8,924,895	-	-	5,000	654,837	-	-
Japan	-	-	23	4,500	-	-	-	-
Kyrgyzstan	-	-	-	-	-	-	-	-
Morocco	-	-	-	-	39,130	4,471,756	-	-
Netherlands	8,121	941,743	32,775	3,462,092	21,250	2,040,145	7,000	1,237,972
Norway	-	-	-	-	-	-	-	-
Poland	-	-	-	-	-	-	207	28,856
Russia	-	-	6,450	774,331	235,285	2,6,438,906	171,674	19,470,039
Singapore	-	-	-	-	-	-	-	-
Slovak Republic	-	-	-	-	-	-	-	-
Spain	30,383	3,112,899	23,390	2,381,314	42,705	6,485,719	18,993	3,826,894
South Africa	-	-	-	-	-	-	-	-
Sweden	-	-	-	-	-	-	1,000	118,495
Switzerland	-	-	-	-	130	16,176	10	1,500

Import of Mercury

Countries	1993-94 Qty (kg)	1993-94 Value (Rs)	1994-95 Qty (kg)	1994-95 Value (Rs)	1995-96 Qty (kg)	1995-96 Value (Rs)	1996-97 Qty (kg)	1996-97 Value (Rs)
Turkey	-	-	-	-	1,725	282,965	-	-
UAE	-	-	20,000	1,016,593	-	-	-	-
UK	6,210	701,998	27,563	2,183,744	27,600	3,919,476	1,898	352,158
Ukraine	-	-	41,400	3,604,071	-	-	-	-
USA	75,666	6,128,387	126,894	10,875,466	55,360	4,868,228	-	-
Venezuela	-	-	-	-	-	-	30,878	3,382,792
Total	**603,578**	**49,933,144**	**292,295**	**25,522,551**	**428,473**	**49,225,076**	**253,738**	**31,526,640**

Import of Mercury

Countries	1997-98 Qty (kg)	1997-98 Value (Rs)	1998-99 Qty (kg)	1998-99 Value (Rs)	1999-2000 Qty (kg)	1999-2000 Value (Rs)	2000-01 Qty (kg)	2000-01 Value (Rs)
Algeria	14,635	2,593,201	-	-	3,450	637,532	-	-
Australia	-	-	-	-	-	-	18,040	7,262,833
Belg-ium	36,363	5,048,851	-	-	-	-	230	53,003
Canada	-	-	-	-	-	-	-	-
Chile	-	-	-	-	-	-	-	-
Chinese Taipei	-	-	-	-	-	-	3,000	605,701
China	-	-	-	-	5,175	829,462	-	-
Denmark	-	-	-	-	-	-	-	-
Finland	23,287	3,412,525	10,316	2,010,329	-	-	-	-
France	-	-	-	-	-	-	4	36,105
Germany	1,725	306,951	-	-	600	135,385	3,003	539,822
Hong Kong	-	-	-	-	-	-	-	-
Indonesia	11,750	1,573,912	-	-	-	-	-	-
Italy	24,002	2,740,034	13,217	1,964,488	-	-	-	-
Japan	-	-	-	-	-	-	-	-
Kyrgyzstan	1,725	292,334	-	-	-	-	-	-

Import of Mercury

	1997-98		1998-99		1999-2000		2000-01	
Countries	Qty (kg)	Value (Rs)	Qty (kg)	Value (Rs)	Qty (kg)	Value (Rs)	Qty (kg)	Value (Rs)
Mauritius	-	-	-	-	-	-	10,000	1,647,310
Morocco	8,500	1,320,262	9,000	1,300,779	-	-	-	-
Netherlands	20,311	4,176,564	5,484	1,035,497	6,827	1,248,859	13,181	2,367,870
Norway	-	-	-	-	-	-	-	-
Poland	-	-	-	-	-	-	-	-
Russia	6,959	1,234,006	22,890	3,099,390	38,127	6,352,673	12,900	2,005,986
Singapore	-	-	36	27,899	-	-	850	238,082
Slovak Republic	-	-	-	-	4,000	574,439	-	-
Spain	54,480	10,015,474	29,120	6,155,878	19,699	3,071,364	80,786	15,835,136
South Africa	24,150	3,592,450	-	-	-	-	7,000	1,148,208
Sweden	-	-	-	-	-	-	-	-
Switzerland	-	-	-	-	-	-	-	-
Turkey	-	-	-	-	-	-	-	-
UAE	-	-	-	-	-	-	-	-
UK	17,250	2,748,324	34,500	4,752,068	11,212	1,466,254	79,145	12,497,310
Ukraine	-	-	-	-	-	-	-	-
USA	22,660	5,190,610	260	271,618	118,294	14,917,170	23,661	4,099,005
Venezuela	-	-	-	-	-	-	-	-
Total	**267,797**	**43,945,502**	**124,823**	**20,617,946**	**207,384**	**29,233,141**	**251,800**	**48,336,371**

Import of Mercuric Chloride

Article code	Articles	Countries	1990-91 Qty (kg)	1990-91 Value (Rs)	1991-92 Qty (kg)	1991-92 Value (Rs)	1992-93 Qty (kg)	1992-93 Value (Rs)
28273901	Mercuric chloride	Belgium	-	-	-	-	-	-
		China	-	-	-	-	-	-
		Germany	-	-	-	-	-	-
		Hong Kong	-	-	-	-	-	-
		Indonesia	-	-	-	-	-	-
		Japan	-	-	-	-	-	-
		Netherlands	863	73,059	-	-	-	-
		South Africa	-	-	-	-	-	-
		UK	-	-	-	-	-	-
		USA	-	-	-	-	-	-
		Total	**863**	**73,059**				

Import of Mercuric Chloride

Countries	1993-94 Qty (kg)	1993-94 Value (Rs)	1994-95 Qty (kg)	1994-95 Value (Rs)	1995-96 Qty (kg)	1995-96 Value (Rs)	1996-97 Qty (kg)	1996-97 Value (Rs)
Belgium	-	-	-	-	-	-	-	-
China	-	-	-	-	-	-	-	-
Germany	-	-	-	-	-	-	-	-
Hong Kong	-	-	-	-	-	-	-	-
Indonesia	-	-	-	-	-	-	-	-
Japan	-	-	-	-	-	-	600	1,011,020
Netherlands	-	-	-	-	-	-	-	-
South Africa	-	-	-	-	-	-	-	-
UK	-	-	-	-	-	-	-	-
USA	-	-	-	-	251	38,289	-	-
Total	**-**	**-**	**-**	**-**	**251**	**38,289**	**600**	**1,011,020**

Import of Mercuric Chloride

	1997-98		1998-99		1999-2000	
Countries	**Qty (kg)**	**Value (Rs)**	**Qty (kg)**	**Value (Rs)**	**Qty (kg)**	**Value (Rs)**
Belgium	-	-	-	-	900	273,129
China	-	-	-	-	10,000	530,250
Germany	-	-	-	-	4,310	1,340,510
Hong Kong	-	-	-	-	150	14,762
Indonesia	60	64,204	160	176,563	-	-
Japan	-	-	-	-	600	143,712
Netherlands	-	-	-	-	-	-
South Africa	-	-	-	-	500	54,288
UK	-	-	-	-	16	7,301
USA	-	-	22,065	3,140,895	400	197,985
Total	**60**	**64204**	**22,225**	**3,317,458**	**16,876**	**2,563,937**

Import of Mercuric Oxide

			1990-91		1991-92		1992-93	
Article code	**Articles**	**Countries**	**Qty (kg)**	**Value (Rs)**	**Qty (kg)**	**Value (Rs)**	**Qty (kg)**	**Value (Rs)**
28259004	**Mercury oxide**	-	-	-	-	-	-	

Import of Mercuric Oxide

	1993-94		1994-95		1995-96		1996-97	
Countries	**Qty (kg)**	**Value (Rs)**	**Qty (kg)**	**Value (Rs)**	**Qty (kg)**	**Value (Rs)**	**Qty (kg)**	**Value (Rs)**
Indonesia	-	-	-	-	-	-	20,897	2,497,184
Netherlands	-	-	-	-	-	-	500	37,735
USA	-	-	-	-	-	-	38	99,437
Total	**-**	**-**	**-**	**-**	**-**	**-**	**21,435**	**2,634,356**

Import of Mercuric Oxide

Countries	1997-98 Qty (kg)	1997-98 Value (Rs)	1998-99 Qty (kg)	1998-99 Value (Rs)	1999-2000 Qty (kg)	1999-2000 Value (Rs)	2000-01 Qty (kg)	2000-01 Value (Rs)
Germany	-	-	2,600	1,158,145	2,016	182,382	-	-
Spain	-	-	100	56,207	25	86,068	-	-
USA	-	-	25	85,667	-	-	-	-
Total	**-**	**-**	**2,725**	**1,300,019**	**2,041**	**268,900**	**-**	**-**

Export of Mercury

Article code	Articles	Countries	1993-94 Qty (kg)	1993-94 Value (Rs)	1999-2000 Qty (kg)	1999-2000 Value (Rs)	2000-01 Qty (kg)	2000-01 Value (Rs)
28054000	**Mercury**	Ethiopia	-	-	-	-	1,126	45,315
		France	-	-	-	-	44,400	4,113,283
		Israel	-	-	-	-	85,026	4,215,909
		Malaysia	-	-	7,200	734,262	-	-
		Spain	-	-	-	-	38,273	4,190,556
		Singapore	21,000	868,836	9,600	1,018,725	-	-
		Sri Lanka	200	61,400	19,037	749,267	2,000	461,154
		Sweden	-	-	-	-	6,708	1,017,741
		Thailand	-	-	-	-	10,001	1,169,368
		UK	-	-	-	-	1,000	124,749
		USA	-	-	-	-	171,000	31,179,773
		Yemen Republic	2,500	437,780	-	-	-	-
		Total	**23,900**	**1,368,016**	**35,837**	**2,502,254**	**359,534**	**6,712,899**

IMPORTERS OF MERCURY (2000-2001)

Date	Product	Importers	Country	Port	Qty	Value (Rs)	CIF rate
4.5.2000	Prime virgin mercury	Indian Dyestuff Industries	Spain	Mumbai	50 kg	3,69,387	7,387.74
17.7.2000	Supply of mercury purity 99.99%	Shriram Alkalies & Chemicals	Spain	Mumbai	7,590 kg	13,45,683.6	177.80
17.7.2000	Mercury purity 99.99 %	Shriram Alkalies & Chemicals	Spain	Mumbai	903.25 kg	1,81,774.75	201.25
21.7.2000	Flakes prime virgin mercury metal 99.9% min	Champa Purie-Chem Ind	Spain	Mumbai	4,246.87 kg	8,70,847	205.06
21.7.2000	Prime virgin mercury metal 99.9% min	Champa Purie-Chem Ind	Spain	Mumbai	265.3 kg	5,44,042	205.07
27.7.2000	Prime virgin mercury 99% 25 flasks	GE Lighting India Ltd	S. Africa	Mumbai	25 pcs	1,97,091	7,883.64
28.7.2000	Prime virgin mercury 99.99%	Indian Dyestuff Ind	Spain	Mumbai	50 pcs	3,64,964	7,299.28
29.8.2000	Mercury	Major Metals Ltd	UK	Mumbai	13,800 kg	18,54,758	134.40
25.9.2000	Merc. Min 99.99% Hg adr 8/IMCO 8/UN 2809	Enkay Associates	The Netherlan-ds	Mumbai	1,621.5 kg	2,51,935	155.37
28.9.2000	Mercury	Major Metals Ltd	UK	Mumbai	462 kg	21,02,123	4,550.05
28.9.2000	Mercury	Major Metals Ltd	UK	Mumbai	492 kg	22,38,625	4,550.05
10.1.2001	Mercury metal	Dow Ltd	Germany	Chennai	48 nos	3,22,867	6,72640
10.1.2001	Mercury metal	Dow Lt.	Germany	Chennai	12 nos	80,717	6,726.42
6.2.2001	Flakes prime virgin mercury Min 99.99% Hg	Surya Roshni Ltd	Algeria	Mumbai	1,725 kg	3,60,004	208.70
16.3.2001	Mercury	Major Metals Ltd	UK	Mumbai	16,974 kg	23,78,010	140.10
21.3.2001	Mercury	Major Metals Ltd	UK	Mumbai	16,560 kg	23,21,374	140.18

Importers of Mercury (1999-2000)

Date	Products	Importers	Country	Port	Qty (units)	Value (Rs)	CIF rate
24.8.1999	Mercury 99.99%	Shriram Vinyl and Chemical	USSR	Mumbai	1,725 kg	333,522	198.35
25.8.1999	Misc metal trem 99% Min	HBR Sales (P) Ltd	China	Kolkata	1,000 kg	175,538	175.54
8.4.1999	Misc metal	Mehta Flint	China	Mumbai	2,000 kg	301,182	150.59
15.4.1999	Misc metal	Lalwani Ind Ltd	Chile	Kolkata	2,000 kg	335,997	168.00
23.8.1999	Flakes prime virgin mercury metal 99.9%	Champa Purie-chem Industries	Russia	Mumbai	1,300 kg	238,468	188.44
2.3.2000	Mercury	Beri Mercurio Ltd	USA	Mumbai	16,380 kg	2,093,194	127.79
12.11.1999	50 flasks each of 34.5 kg	Indian Dyestuff Ind Ltd	Spain	Mumbai	1,725 kg	368,966	213.89
15.1.2000	90 flasks prime virgin mercury	Excel India Ltd	Spain	Mumbai	3,174 kg	585,887	184.59
23.8.1999	Flasks prime virgin mercury metal 99.99%	Champa Purie-Chem Industries	Russia	Mumbai	2,150 kg	389,080	180.97
19.4.1999	Under duty	Surya Roshni Ltd	Algeria	Mumbai	344 kg	63,545	184.79
6.4.1999	Flasks, mercury	Surya Roshni Ltd	Algeria	Mumbai	1,725 kg	318,766	184.79
19.4.1999	Flasks, mercury	Surya Roshni Ltd	Algeria	Mumbai	1,381 kg	255,221	184.79
25.8.1999	Mercury	L.S. Chem & Pharma Ltd	USA	Mumbai	300 nos.	1,514,015	5046.72
16.4.1999	25 flasks prime virgin mercury	GE Lighting India Ltd	Russia	Mumbai	25 nos	181,785	7271.40
9.4.1999	Mercury of purity 99.999%	Goa Instruments Industries	Spain	Mumbai	6 nos	60,235	10039.17

Importers of Mercury (1999-2000)

Date	Products	Importers	Country of origin	Port	Qty (units)	Value (Rs)	CIF rate
25.8.1999	Mercury	L.S. Chem & Pharma	USA	Mumbai	200 nos	1,009,344	5,046.72
20.9.1999	Flasks prime virgin	GE Lighting India Ltd	Germany	Mumbai	25 nos	182,121	7,284.84

Distribution of Imports by Company (Mercury) 2000-2001

Importers name	Quantity	Value (Rs)	CIF rate
Champa Purie-Chem Industries	6,900 kg	1,414,889	205.0602
DCW Industries	60 nos	403,584	6,726.4
Enkay Associates	1,622 kg	251,935	155.3716
GE Lighting India Ltd	25 pcs	197,091	7,883.64
Indian Dyestuff Industries Ltd	50 kg	369,387	7,387.74
Indian Dyestuff Industries Ltd	50 nos	364,964	7,299.24
Major Metals Ltd	47,334 kg	6,554,142	138.4658
Major Metals Ltd	954 nos	4,340,748	4,550.05
Shriram Alkalies & Chemicals	8,493 kg	1,527,458	179.8438
Surya Roshni Ltd	1,725 kg	360,004	208.698

Distribution of Imports by Company (Mercury) 1999-2000

Importers name	Quantity	Value (Rs)	CIF rate
Beri Mercurio Ltd	16,380 kg	2,093,194	127.79
Champa Purie-Chem Industries	3,450 kg	627,548	181.90
Excel Industries Ltd	3,174 kg	585,887	184.59
GE Lighting India Ltd	50 nos	363,906	7,278.12
Goa Instruments Industries	6 nos	60,235	10,039.17
HBR Sales P Ltd	1,000 kg	175,538	175.54
Indian Dyestuff Industries Ltd	1,725 kg	368,966	213.89
Lalwani Industries Ltd	2,000 kg	335,997	168.00
L S Chemicals & Pharmaceuticals	500 nos	2,523,359	5,046.72
Mehta Flint	2,000 kg	301,182	150.59
Shriram Vinyl & Chemical Industries	1,725 kg	333,522	193.35
Surya Roshni Ltd	3,450 kg	637,532	184.79

Distribution of Imports 1999-2000

Port	Quantity	Value (Rs)	CIF rate
Kolkata	3,000 kg	511,534.7	170.51
Mumbai	31,904 kg	4,947,831	155.08
Mumbai	556 nos	2,947,500	5,301.26

Distribution of Imports 2000-2001

Port	Quantity	Value (Rs)	CIF rate
Chennai	60 nos	403,584	6,726.40
Mumbai	66,123.62	10,477,815.35	158.46
Mumbai	1,004	4,705,712	4,686.96
Mumbai	25 pcs	197,091	7,883.64

Distribution of Import by Country 2000-2001

Country	Quantity	Value (Rs)	CIF rate
Algeria	1,725 kg	360,004	208.70
Germany	60 nos	403,584	6,726.40
Netherlands	1,622 kg	251,935	155.37
Spain	15,443 kg	3,311,734	214.45
Spain	50 nos	364,964	7,299.28
South Africa	25 pcs	197,091	7,883.64
UK	47,334 kg	6,554,142	138.47
UK	954 nos	4,340,748	4,550.05

Distribution of Import by Country 1999-2000

Country	Quantity	Value (Rs)	CIF rate
Algeria	3,450 kg	637,532	184.79
Chile	2,000 kg	335,996.7	168.00
China	3,000 kg	476,720	158.91
Germany	25 nos	182,121	7,284.84
Russia	3,450 kg	627,548	181.90
Russia	25 nos	181,785	7,271.40
Spain	4,899 kg	954,853	194.91
Spain	6 nos	60,235	10,039.17
USA	16,380 kg	2,093,194	127.79
USA	500 nos	2,523,359	5,046.72
USSR	1,725 kg	333,522	193.35

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