

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 (vermillion) 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, printing, 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.

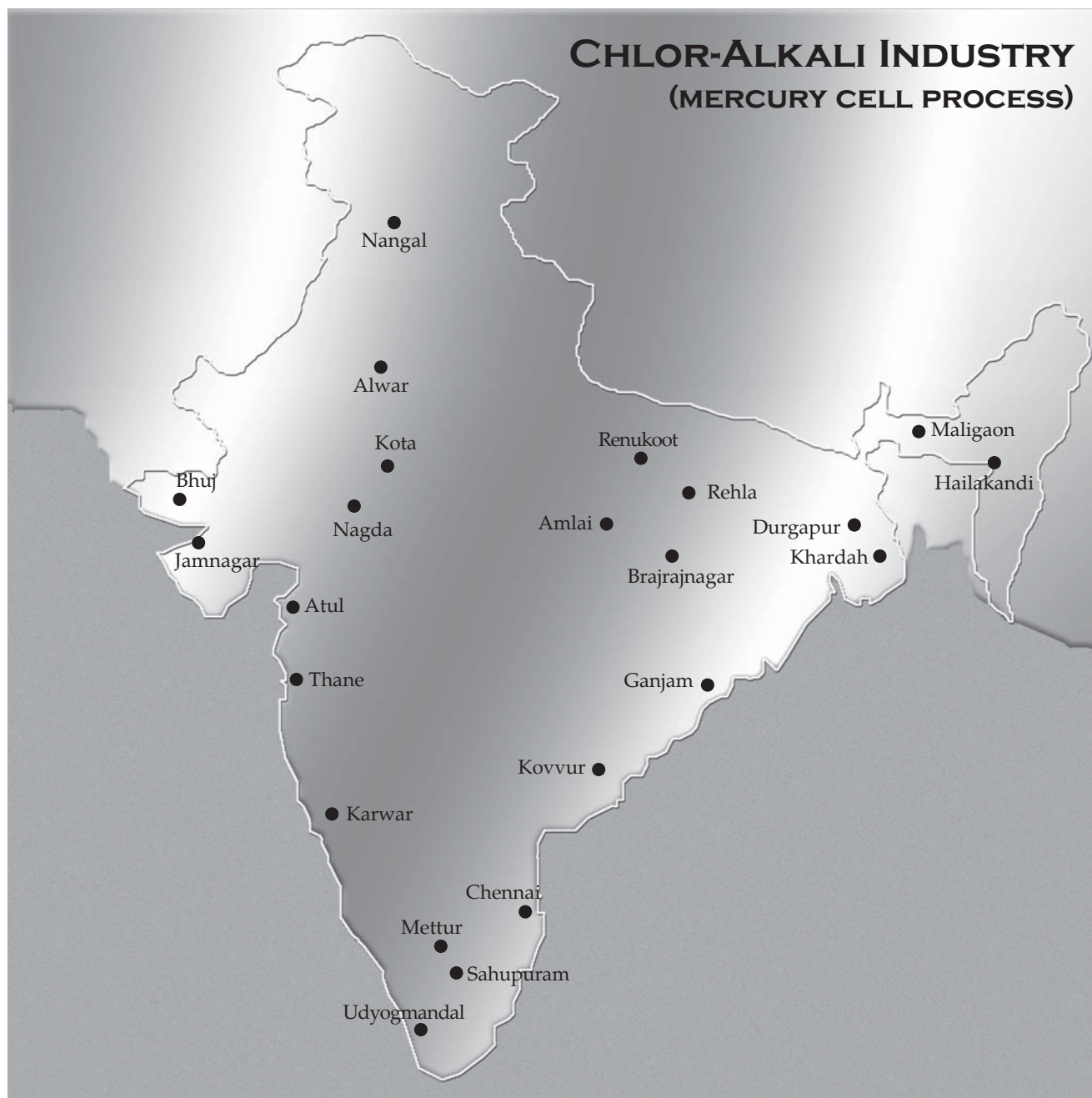
As mentioned earlier, caustic soda and chlorine are two basic chemicals being used in various products. The usage pattern of caustic soda is depicted in the table above.

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

CHLOR-ALKALI INDUSTRY (MERCURY CELL PROCESS)



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.

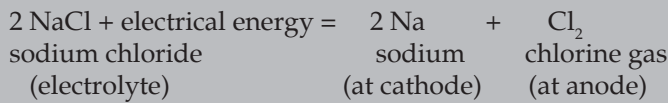
According to the Alkali Manufacturers Association of India, there are at present 42 caustic soda units

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.

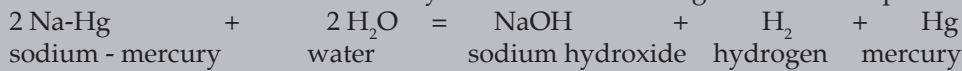
In other words, there are still 23 units, which wholly or partly use the mercury cell process for caustic-chlorine production. The list of these 23 units along with their respective production processes is given in

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:



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:



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.

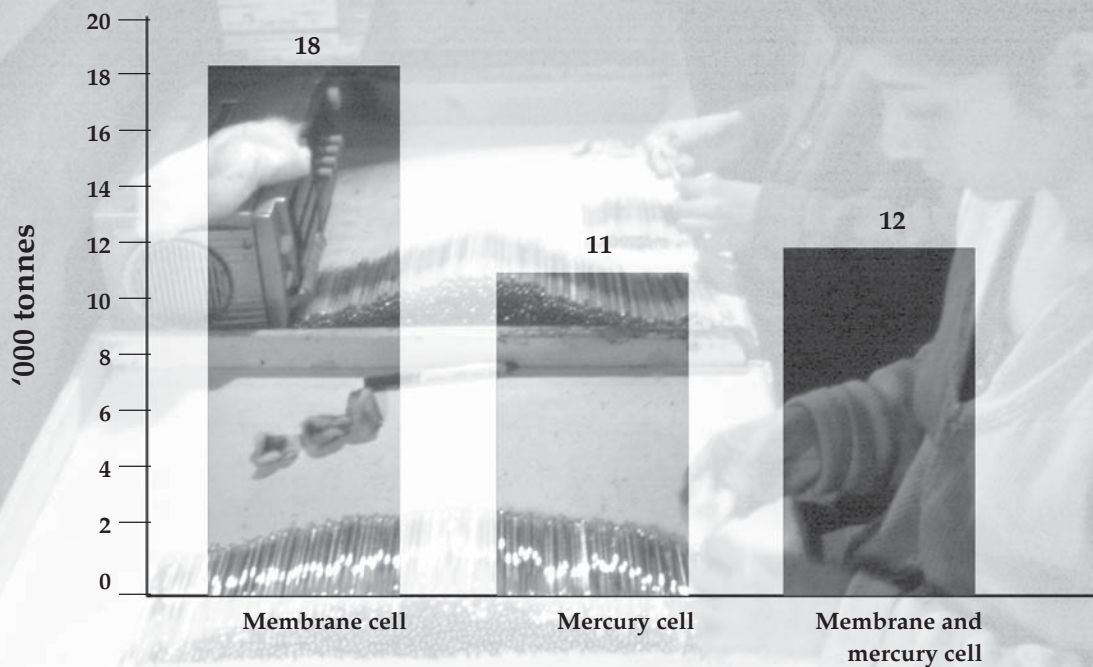
Thus the net reaction of chlor-alkali production can be rewritten as:



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.)

CAUSTIC SODA PRODUCTION PROCESS



Process

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 serv-

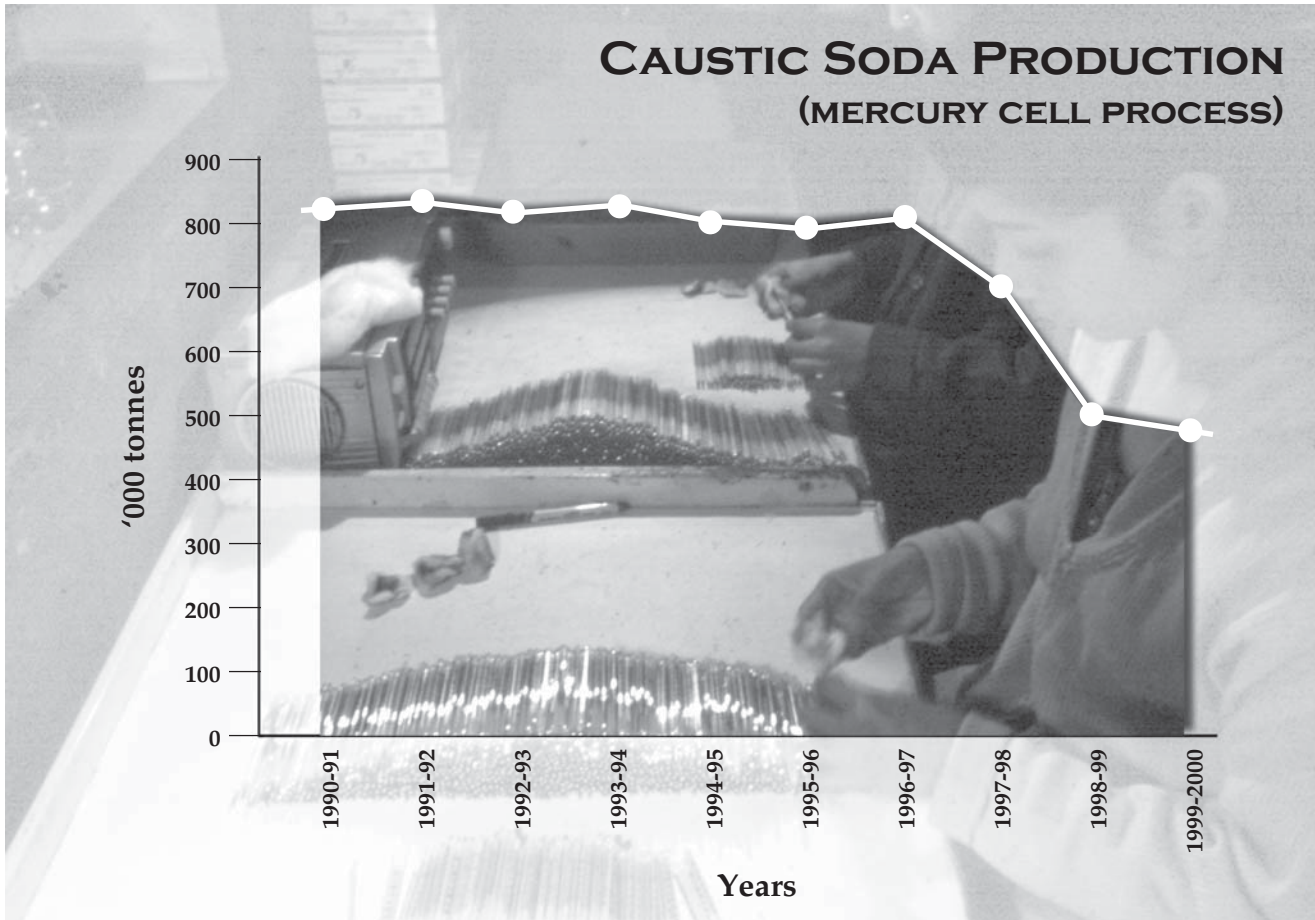
icing of this capital will nullify the savings made in energy consumption.

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.

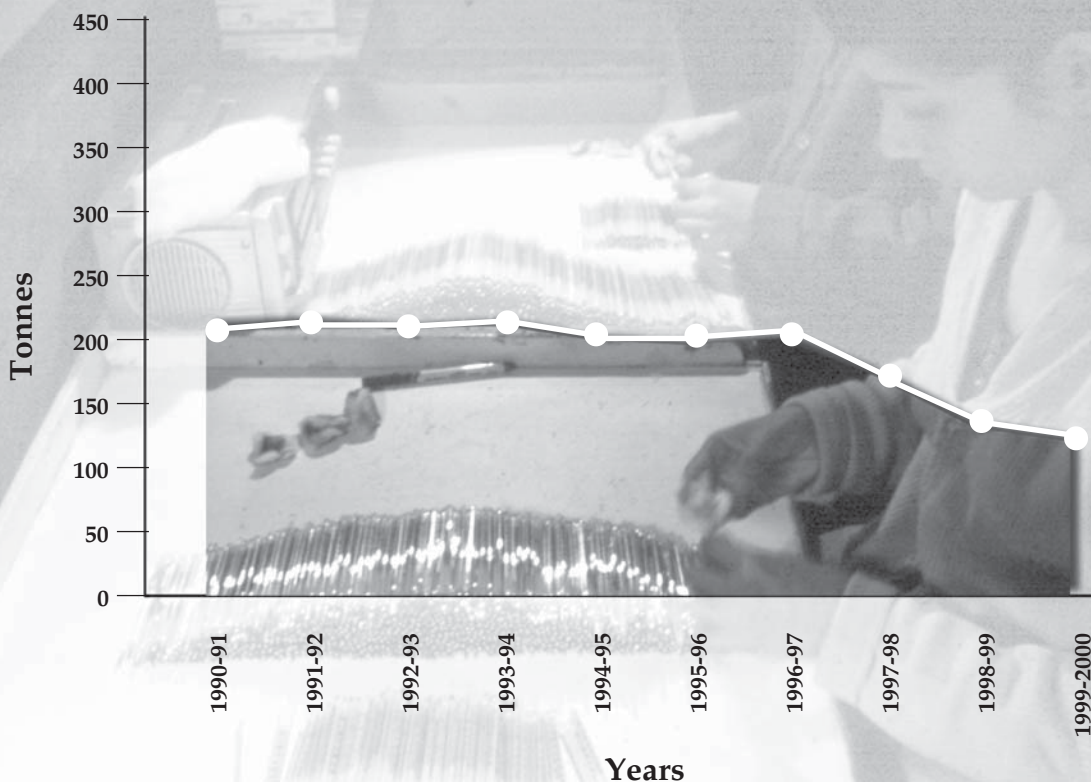
The graph on the next page shows reducing mercury consumption in the mercury cell process of chlor-alkali production over time because of mercury's toxicity concerns for the environment and the Government of India's mandate (as mentioned earlier).

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!

CONSUMPTION OF MERCURY (CAUSTIC SODA PRODUCTION)



Thus it can be said that 90 to 100 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 produc-

tion 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.

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.

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

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°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, Sonapat, 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,

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 (Sonapat)	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)

mostly in the unorganised sector.

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 200°C, 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.

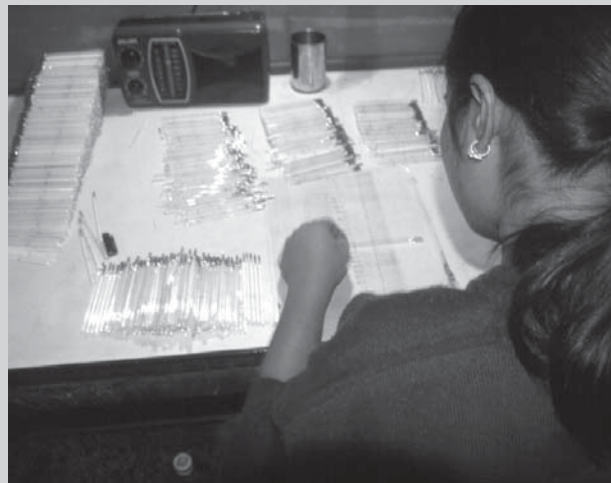
Excess mercury in the tube stems is forced out the open ends by heating the bulb ends of the tubes in a hot water or oil bath. The mercury column is shortened to a specific height by flame heating the open ends. The tubes are cut to a finished length just above the mercury column, and the ends of the 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.

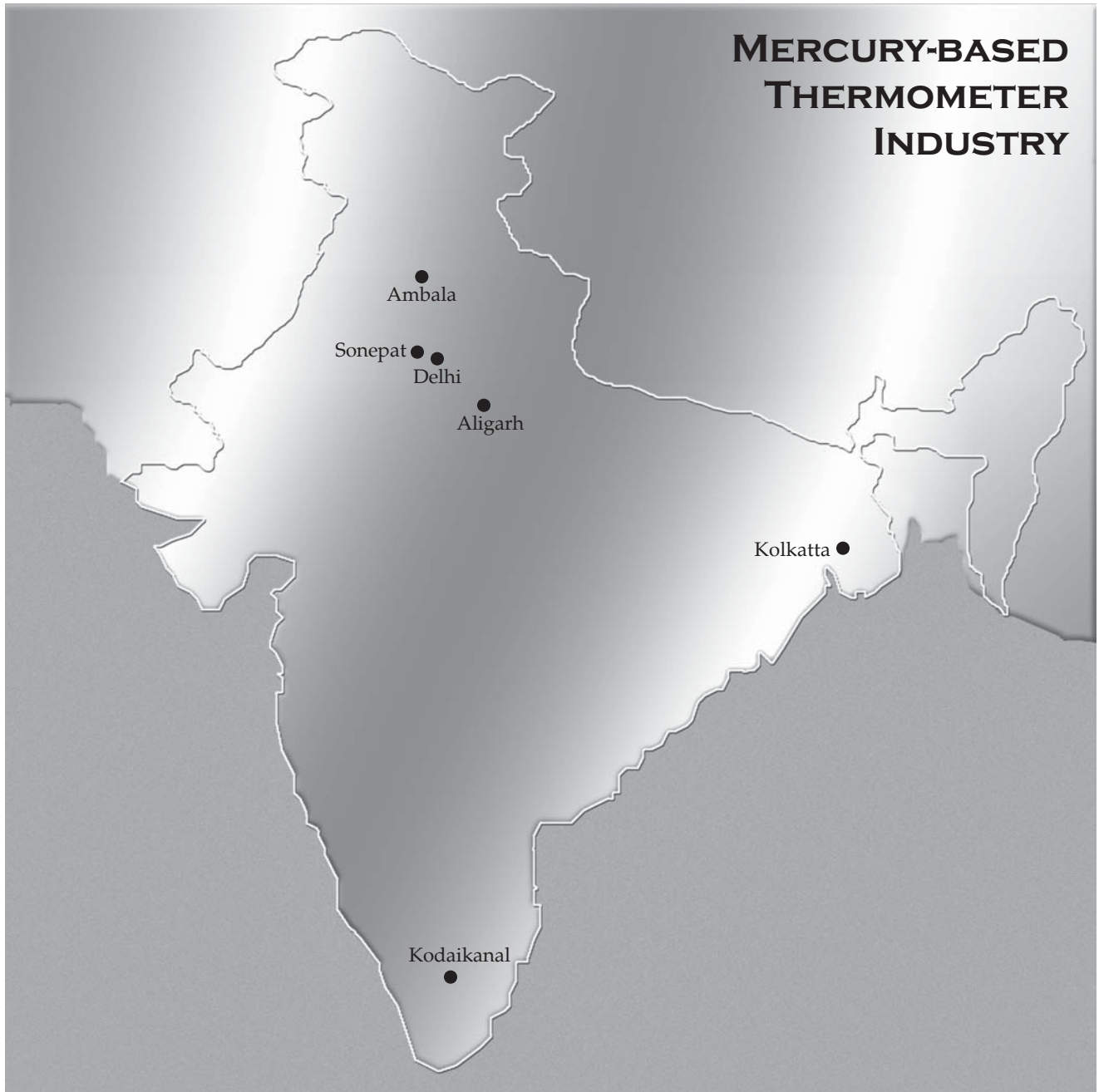
There has been a tremendous decline in the growth of these industries because, since the early 1990s, China has been dumping its mercury-based clinical thermometers in the Indian market. Chinese thermometers are said to look attractive, be accurate and, above all, be cheaper than Indian thermometers. 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.

MERCURY-BASED THERMOMETER INDUSTRY



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, espe-

cially 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.

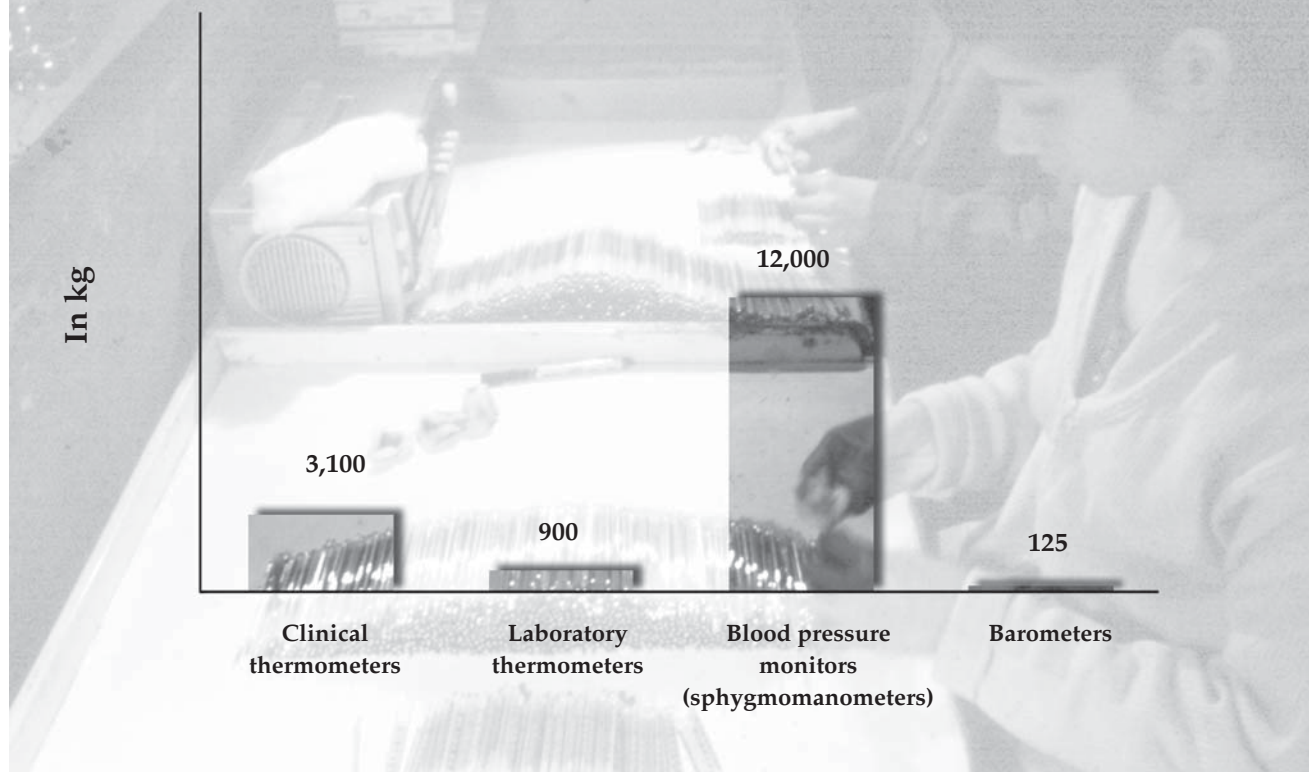
The Kodaikanal thermometer factory has highlighted the harm a mercury-based thermometer plant can do to the environment. The Hindustan Lever Ltd thermometer plant has been guilty of dumping tonnes of broken glass waste (with traces of mercury in it) in the local forest and of selling some of it to the 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 statis-

tical 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



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 elec-

tric 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 (HgCl₂), or mercurous chloride (Hg₂Cl₂).

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; cop-

per, 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 wide-spread 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 ac-

etate. 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
- ◆ Toly 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 mer-

cury 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 Rasathantra (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 Rasathantra. There are references to the uses of *rasa* (mercury) metals and gems in the Charaka and Sushruta 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

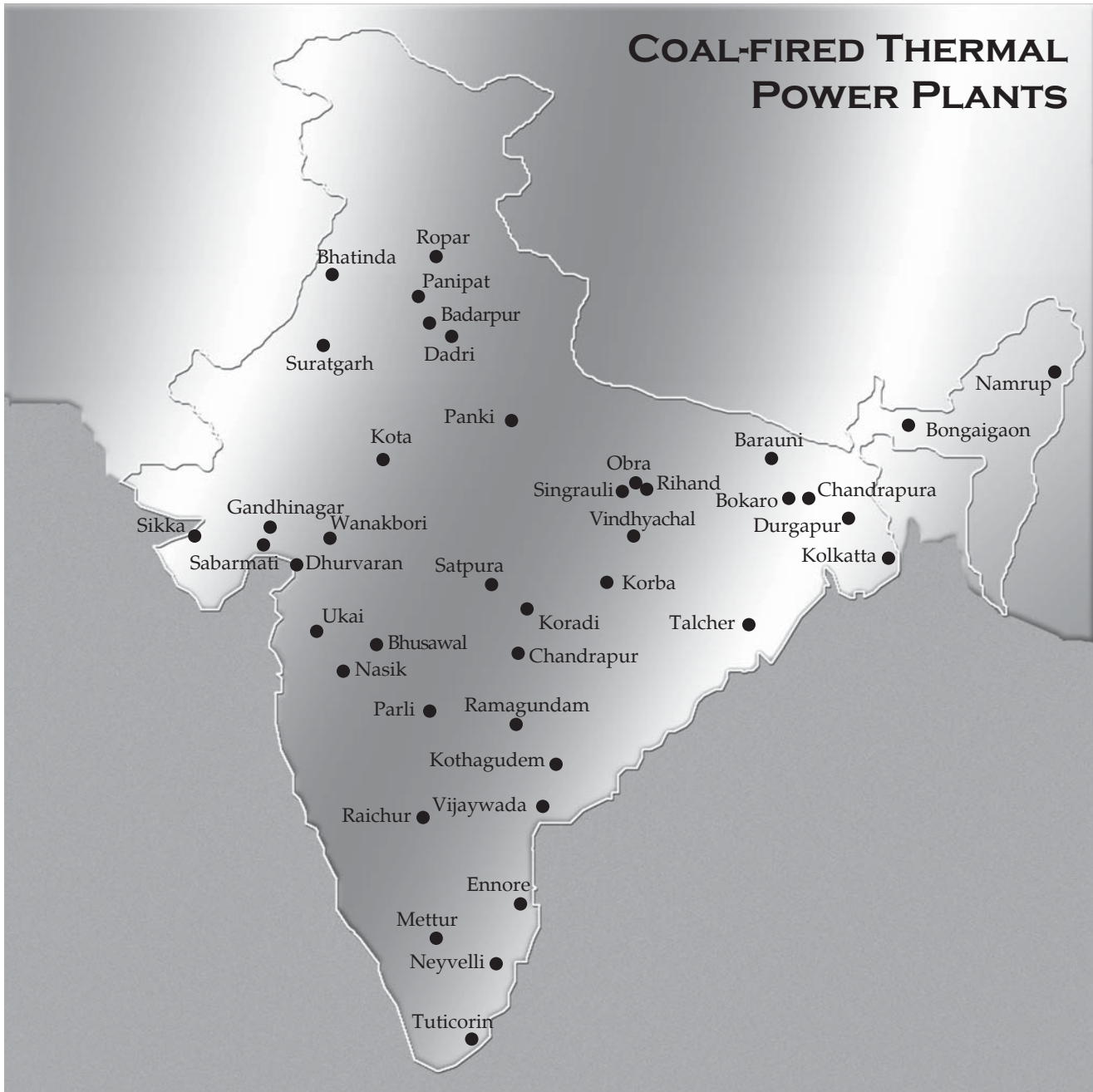
Emissions from Coal Burning: The smokestacks of thermal power plants spew a broad range of toxic substances into the air. These vapours include known carcinogens such as mercury, heavy metals, dioxins, furans and PCBs. During combustion, many of these metals like Fe, Al, Mn, Co, Ni, Cd, Hg, Pb, Zn, Cd, 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-





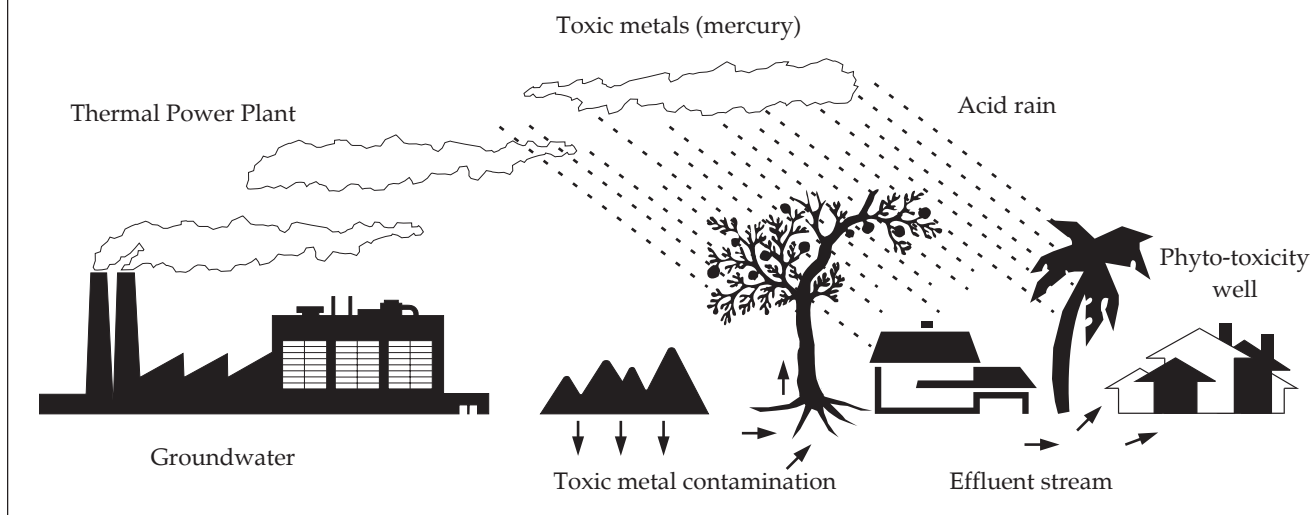
system 8x million grams of the metal.

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 possibil-

MERCURY IN INDIA

ity 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 docu-

ment, 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 ($\mu\text{g/ml}$)		
	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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