Guidance and Awareness Raising Materials under new UNEP Mercury Programs
(Indian Scenario)

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Guidance Material Under New UNEP Mercury Programme

Mercury distribution in the environment has been a focus of scientific attention because of the potential health risks posed by mercury exposure. Never before in the history of mankind has there been such a vast multiplicity of environmental risk factors, nor there has been such an expression of concern regarding inherent danger of mercury and its likely impact on diverse aspects on human health. Further organic mercury, mostly methyl mercury (MeHg) the most toxic species is bioaccumulating in the biota and subsequently biomagnified in the aquatic food chain, especially in fish. Given the human health concern, it is critical and important that awareness programme is launched to educate the populations to the risk and impact of mercury exposure in humans especially potentially vulnerable population viz pregnant women, breast feeding women, the fetus new born and young childern residing in the hot spot area's of the country and also consequences of MeHg exposure through fish consumption.

There is a strong cultural pattern of fish consumption among coastal people (East, West and Southern coast of India) and among population residing in the plains around industrial sites. Therefore, their fish consumption pattern must be understood when their mercury exposure through fish consumption is to be evaluated. Certain species of fish are considered safe for consumption. Therefore it is important to account for the factors that may affect mercury exposure.

Based on the important research findings and key policy development having occurred over past few years there is sufficient evidence of significant global adverse impacts of mercury and its compounds to warrant national and international action to reduce the risk to human health and the environment. A consensus has emerged among national and international authorities to lower

the limits of MeHg exposure and / or stronger warning to help sensitive populations to avoid exposure, particularly for pregnant women, breast-feeding women, women who intent to become pregnant and children. These plans are being developed to raise national awareness of the critical need to sharply reduce human exposure to mercury.

Although it is well recognized that mercury is wide spread in the Indian environment and that exposure occurs primarily through consumption of fish, information about its distribution in blood system and hair mercury levels in general Indian population is lacking. Hence it has become difficult to fully evaluate the public health significance of mercury problem. Recent evidence has come to light that exposure to mercury is widespread and occurring at levels exceeding health based recommended value among Indian Population. Exposure information of women for childbearing age has also become urgently needed, since fetal exposure is known to be a critical window of exposure to the compound. Further the factors that may affect infant mercury levels due to in utero and / or lactation exposure is lacking. For such data analysis, mothers and their respective infants from the hot spots need to be interviewed (birth history) and biological samples (maternal and infant hair, and breast milk) need to be collected and analyzed. Mercury concentration in breast milk reflects mercury concentration in blood. In the hair, once mercury is bound, it remains there. Mercury concentration in breast milk therefore reflects most recent exposure, where as mercury concentration in hair is related to long term exposure.

In addition, questions have to be addressed to resolve the confounding factors that could affect mercury exposure and neurodevelopment outcome and cardiovascular disease in Indian population co-exposed to pesticides. WHO estimates that incidence of pesticide poisoning has doubled during the past ten years. It is alarming that developed countries accounted for only 15% of the worldwide use of pesticides. However over 50% of pesticides poisoning occurred in developing countries and mainly due to easier availability, misuse and

improper handling mainly because of lack of awareness. Interestingly no information is available on its role on the mercury exposure and its correlation with neurodevelopment changes. Other major confounding factors that may affect mercury absorption/accumulation in Indian context are infections and protein calorie malnutrition.

Several studies have shown that pesticide exposure in Indian population is much higher compared to Western World. In India pesticides (both organochlorine and organophosphates) are extensively used in spite of their restrictions. In a most recent study from the two cities of India (Bhopal and Lucknow) it was revealed that through breast milk infants consumed 8.6 times more of endosulfan and 4.1 times HCH more than the average daily intake (ADI) levels recommended by WHO. Among the various pesticides present in the breast milk, endosulfan concentration (0.363 ± 0.077 mg/lt.) exceeded HCH concentration by 3.5 fold, chloropyrifos by 1.5 folds and malathion by 8.4 folds. The high levels of pesticides in the breast milk is a reflection of consumption of food, drink, vegetables, fish etc. containing excessive levels of these pesticides (Human and Expt. Toxicol. 21, 1-6, 2002 and 22, 73-76, 2003). In another recent study it was estimated that 0.619 mg of endosulfan is the ADI per capita by humans through fish (Int. J. Ecol. Environ. Sci. 27, 117 – 120, 2001). Out of 422 vegetables samples tested, 79% were contaminated with endsoulfan, with 14% showing above MRL (All India Coordinated Res. Project on Pesticide Residue, pp 178, 1999). It is unfortunate that pesticide contamination has been detected even in bottled water and soft drink several fold higher than EC and American norms. (Press Release; Times of India, Feb 4, 2003 and Aug 6, 2003). As a result, Bureau of Indian Standard (BIS) equivalent to EPA, adopted strict EC norms of pesticides levels in water (0.0001 mg/lit for individual of pesticides levels in 0.0005 mg/lit, the limit of total pesticide residue). It is expected that new levels would be effective from January 2004. These informations may help to take action to reduce mercury as well as pesticide exposure, develop awareness of mercury and pesticide exposure, management of mercury exposure and to

develop advisories to prevent exposure to critical doses of mercury and pesticides during awareness programme as per recommendations of the UNEP, Governing Council Meeting held in Nairobi, Kenya, in Feb. 2003,

The first phase of awareness programme would be four days Brain Storming Session on “Nature and Magnitude of Mercury Problem in India” around March 2004 with the objectives of (i) Projecting the **nature and magnitude of the mercury problem in India** (ii) Tools and strategies to mitigate mercury pollution that has an impact on human health and environment and (iii) To suggest immediate and long term national action as appropriate to reduce man made mercury release. (iv) To develop information network to communicate to public the risk and impact of mercury exposure in humans especially vulnerable population and (v) To adopt policies to prevent illegal trafficking of mercury. The invitees would include representatives from Government (Min. of Environment and Min. of Health), Member of Industries, Non-Government Organizations, WHO, World Bank, UNEP, etc.

Subsequently, we would develop training materials, guidance document and tool kit on the following topics to organize regional / sub – regional awareness raising workshop sometimes in July 2004 at various hot spots in India in promoting measures to reduce man made mercury release that have adverse impact on human health and environment:

1. Nature and Magnitude of the Mercury problem in India.
2. Identifying and evaluation of populations at risk.
3. Risk communication and outreach to populations at risk
4. Developing inventories of mercury uses and release
5. Potential pollution prevention measures, control technologies and strategies for reducing mercury uses and releases

6. Increasing awareness and promotion of mercury free products, technologies and processes, or responsible use of mercury, where appropriate.
7. Deleterious impact on human health and the environment attributed to mercury and its global capacity for transport and cycling
8. Initiative to protect human health and environment through measures that will reduce or eliminate release of mercury and its compounds to the environment and establishing national implementation programme.

Awareness Raising Materials Under the New UNEP Mercury Programme

India May Become 'Hot Spot for Mercury Poisoning

Asia is the biggest villain in polluting the atmosphere with new mercury emissions, impacting the health of people as well as wildlife, a new UN report says. In even worse news for India, the first global study on this hazardous heavy metal says Indian could be one of a dozen hot spots after an upsurge in gold-mining over three decades.

Source : Chandrika Mago, Times of India, February 4, 2003

India's population was unaware of mercury hazards for last few dacades. Due to global scenario, the awareness regarding hazards caused by mercury pollution is increasing among Indians. Chloralkali industries are still the major source of mercury release in atmosphere and surface water. Other industries, which contributes to mercury pollution in India, are Coal fired plants viz. thermal power plants, steel industries and cement plants. Plastic industry (mercury is used as a catalyst), pulp and paper industry, medical instruments and electrical appliances, certain pharmaceutical and agricultural product accounting for additional consumption of mercury. India consumes 75 million tones of coal every year in various thermal power plants. Coal contains mercury and its combustion as a source of energy is often sited as significant source of mercury emission. Mercury levels are reported to be extremely high in the working environment of these industrial processes including thermometer factories, and even medical practices such as dental clinics. The effect of mercury on human health and the working environment in the industry has not been taken seriously by Management. The hazardous working conditions and dangerous waste management practice is still continuing in several industries related to mercury (Figure 1).

The document enumerates the enormity of mercury problem in India as compared to Global scenario, and its amelioration by using various technologies and regulations. The major points addressed are:

1. **National threat Vs local concern**
2. **Main contributors to mercury emissions in India**
3. **Mercury free alternatives**
4. **Mercury laws**
5. **Technologies and practices**
6. **Strategies to reduce mercury exposures**

National Threat *versus* Local Concern (Human & Environment)

- Mercury contamination in water in India is verging on alarming situation due to discharge of industrial effluents containing mercury ranging from (0.058-0.268 mg/l) against 0.001mg/l. as per WHO and Indian standards.

- About 0.20 kg of mercury is lost per ton of caustic produced thereby creating serious pollution causing adverse effect to biological system.

- Mercury levels in water near caustic chlorine industry has been reported as high as 0.176 $\pm$ 0.0003 mg/l. in water and 596.67 $\pm$ 25.17 mg/kg dry wt. soil against the prescribed limit of 0.001 mg/l. in water and 0.05 mg/kg in soil.

- Environmental Mercury concentration in Chambur, Mumbai is almost three times higher during the dust storm when compared to normal conditions of 0.93 $\pm$ 0.66 mg cm^3. Most Hg was present in gaseous form. In certain areas the average precipitation of Hg was 82 μg/l.

- The iron and steel industry, the single largest source of huge quantities of particulates was reported to contain as high as 56 ppm Hg in dust fall out and 40-72 ppm in surface soils

- The fallout of elemental mercury over the soil-horizon in the vicinity of a steel plant was reported to be in the range of 60.36 to 836.18 g/km^2/month

- High concentration of the gaseous mercury present in the ambient air closer to the chloroalkali industries may lead to long-range transport of mercury.

- The concentration of mercury in blood and hair of human population has been reported as high as 100 μg/dl and 8 μg/g respectively at industrial site compared to 5 μg/dl. and 1 μg/g, respectively in unexposed population.

- Based on the studies of occupationally exposed Indian adult population several fold higher concentration of mercury in blood (5 μg/dl.) and hair (0.15 – 8.4 μg/g) was observed compared to control population.

- The occurrence of mercury in bronchial wash out of plant workers from coal-fired industries was 20 – 85.2 μg, 16 – 56 μg, 10 – 17.5 μg/ml from Steel industry, Thermal power industry and Cement industry, respectively.

- The concentration of mercury in fish in other sea food consumed in certain costal areas reported in range of 0.03-10.82 μg/g compared to the permissible limit of 0.5 μg/g

- There is a potential risk to human health and environment due to the entry of mercury in food chain in and around chloralkali plant. The basket fruits and vegetables contain several folds higher concentration mercury in certain industrial area against prescribed Indian standards.

MERCURY SPILL

- The most lethal fallout from the September 15,earthquake that rocked the Andaman archipelago has been a 50 kilogrammme leakage of lethal mercury from east island lighthouse in North Andman. This spill is posing a health hazards to the local people as well as to the fragile ecology of the entire region. Environmental organizations have expressed apprehension over the resultant toxicity that can threaten the flora and fauna and the amount of mercury that enter the food chain.

- Regular monitoring of mercury pollution located in the eastern part of the country revealed that the different vegetables grown in the contaminated kitchen garden, particularly the leafy vegetables were found to be bio-concentrate mercury at statistically significant level. High concentration of mercury was also found in wheat and rice and leafy vegetables grown in the southern part of the India.

- Aquatic and terrestial plants including a few vegetables and crops growing in heavily mercury contaminated soil in and around chloralkali plant at Ganjam,east coast revealed a significant correlation between soil and plant mercury level.

- Similar situation is reported for the high concentration of total mercury and methyl mercury in marine food in Thane creek,west coast. The methyl mercury concentration ranges from 20.4 to 344.4 ng/g dry weight and maximum concentration has been found in crabs and prawns. The overall total mercury concentration ranged from 62.5 to 548 ng/gm (189 ng/gm). Daily intake of total mercury and methyl mercury from sea food by Mumbai population is estimated at 0.8 **μg/g** and 0.5 **μg/g** (1997).

- Baseline study of the level of concentration of mercury in the food fishes of bay of Bengal,Aarabian Sea and Indian Ocean reports reveals that mercury levels in 18 groups of fish and other sea food had the mean average values ranged from 5-65 microgram/kg. Levels of the mercury concentration in some known food fish of the Indian Ocean,Bay of Bengal

and Arabian Sea were compared with similar species found in the Mediterranean,Atlantic and Pacific Ocean(1979).

- Large numbers of cases had reported during last ten years regarding metals pollution especially mercury in fishes and through them to human beings. High concentrations of mercury in the environment were observed in vicinity of caustic soda plant,indicating high mercury contamination. The total mercury concentration in the fish sample from a contaminated stream from the above sight exceeded the safe limit of 0.5 **μg/g** wet weight. The environment impact of chloralkali industries in river basin in eastern India has also led to tremendous releases of mercury 60-320 times beyond the permissible limit(0.01mg/kg) in the river bodies. Mercury emissions from massive coal consimption also enhances the level of mercury more than 1 ppm in soil and more than 10 ppb in ground water and ponds.

Risk due to Mercury Amalgam dental fillings

- Mercury amalgam in dental filling poses a real threat of chronic mercury poisoning.
- Blood mercury levels have reported as high as 20 μg/dl. in humans with dental amalgam filling.
- The alternatives are not yet deemed fully capable of substituting amalgam in all types of dental filling.
- Lack of awareness of health hazards of mercury amalgam dental fillings in pregnant women and their precautionary measures.
- The base silver alloy is mostly imported from USA, Switzerland, France, UK and Australia and is cheaper compared to other permanent restorative materials.

Global Threat *versus* National Concern

- Import of mercury is legal under Indian law. However, it is a proven environmental toxin.
- India bound mercury shipment causing a concern to environment, health and security of Urban and Rural Population.
- It is possible to manage and use mercury safely in the developed countries to safe guard the public and environment, but least of all in developing countries lacking in regulatory infrastructure and resources.

- India advocates to World Bank for installation of safe waste disposal technologies for medical waste.

- Scientists in a US estimated that 30 – 70% of Mercury deposition comes from long-range environmental transport of mercury emissions from other countries causing increase concentration in water and biota specially fishes.

Summary Table: Mercury Pollution In India: Year and place of study

Serial no.	Date,Source of publication (author)	Mercury Pollution Detail	When was this studied
	14th December,1997 **The Week**	After the Gwalior Rayons Factory was set up in Mavoor in Kozhikode district, the river turned dark, dead fish floated on the surface and the air smelled foul. The villagers attributed the high incidence of cancer and respiratory and skin diseases in the villages to the factory. After conducting test, it was found that contamination due to **mercury** was the main reason.	Calicut University West Bengal 1974
	31st August,1999 **Down to Earth**	The DTE/IIT test conducted on a water sample from a handpump in Mehak district of Andhra Pradesh showed that the level of **mercury** was 115 times the permissible limit. Arsenic and nickel concentration level were also too high. People of this area complained of the plethora diseases such as epilepsy,skin and throat problem,respiratory diseases ,cancer and paraplegia,while pregnant women are giving birth to still-born children.	IIT & DTE New Delhi
	10th Februaray,2000 **Indian Express**	Study conducted in the Thane Bay area revealed that due to **mercury peroxide**,an effluent from a nearby paint factory caused serious health problem especially to children. **Neurological disabilities** developed in childrens. The mercury peroxide settled in the muscles of these children and rendered them **permanently disabled.**	Dr. Rashmi Mayur,an advisor to the United Nations on Environmental Issues, 1991
	15th July, 2001 **Down to Earth**	The Tamil Nadu Pollution Control Borad (TNPCB) has confirmed that mercury-contaminated glass pieces were dumped at various locations in Kodaikanal by a thermometer factory of Unilever,a multinational company. The waste described as scrapyard contains more than 50 milligramme per kilogramme (mg/kg) which means mercury is approximately 1% of the total waste which works out to be 10,000 mg/kg. This clearly an offence under the Hazardous waste Management act.	Green Peace, New Delhi March, 2001
	September,2001 **www.indiatogether.com**	Paryavaran Suraksha Samiti in an exhaustive investigation In Ankhleshwar	December 2000,

		(Gujarat) industrial estate, tested 120 ground water sources , affecting 100,000 people, were highly contaminated. Latter studies conducted by DTE found high quantities of mercury, lead and zinc. As an effect of this pollution people are suffering skin ailments, respiratory problems, headaches and many others which have not been noticed.	

Status of Mercury in Ground Water in the Major States of India

The bureau of India standards (BIS) has laid down safety limits for drinking water at 0.001 mg of mercury per liter. A number of samples of groundwater in some industrial belts have shown concentrations of mercury higher than safe standards.

States	**Hg in ground water (Permissible limit 0.001mg/l)**
1)MAHARASHTRA	
Mumbai Chembur 1) Near Ashis theatre 2) Mahul Village 3) Gaon Pada 4) Malkar Industrial area 5) Thana Road No.2 6) Acharya Complex Arnapurna Farm Top Bottom 1) Ulhas River	 $0.0007 * 10^{-6}$ $0.0005 * 10^{-6}$ $0.0003 * 10^{-6}$ $0.0024 * 10^{-6}$ $0.0014 * 10^{-6}$ $0.0176 * 10^{-6}$
2)ORISSA	
Central Orissa Banarpal Kandsar Balaramprasad Gurujangali Godibandhra Kaniha Chhelia Angul Talcher Rushikulya Estuary Estuary Head (2-3 km upstream the discharge) Estuary Head(Near Chlor alkali unit,Ms JayaShree Chmeicals) Agricultural soil (nearby estuary)	 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.001ppm **0.0723**ppm

3)HARYANA	
Panipat	
Industrial Area	0.268
Barsai Road	0.074
4)GUJARAT	
Vatva	0.211
Vapi	0.096
1) Kachigam	0.001
2) Morai	0.001
3) Balitha	0.002
4) Namdha	0.002
5) Chandoor	0.001
Ankeshwar	
(a) Sarangpur	0.118
(b) Bapunagar	0.176
Vadodara ECP	--
Nandesari ECP	1.3
5)ANDHRA PRADESH	
Patancheru	0.058
6)JHARKHAND	
Dhanbad	
1) Puja Cinema	0.003
2) Income Tax Office	0.008
3) Golf Ground	
4) Jharia	0.001
5) Sri Jain Bhawan School	0.001
	0.002
7)MADHYA PRADESH	
Ratlam-Nagda Belt	
1) New Ratlam	ND
2) Dosigaon	ND
3) Ghatla	ND
4) Bhatani	ND
5) Bhajan Kheda	ND
6) Jadwasa	ND
7) Kurel Dam	ND
8) Takar wada	ND
9) Parmar Kheda	ND
10) Old Nagda	ND
Bhopal(Near union carbide)	ND

8)DELHI	
Yamuna River Najafgarh Inderlok Ashok vihar Moti Nagar Mukherjee Nagar Timarpur Wazir Pur Azadpur	 ND ND ND ND ND ND ND ND
9)WEST BENGAL	
Durgapur 1) Mayabazar 2) Ashis nagar 3) Sagarbhanga 4) Gangatantra 5) Palashdiha Howrah 1) Point 1 2) Point 2 3) Point 3 4) Point 4 5) Point 5 (Howrah name not mentioned)	 0.005 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.006 0.005
10)PUNJAB	
Gobindgarh(5 sites) These areas are near steel rollong mill, fabrication mill	ND
12)HIMACHAL PRADESH	
Parwanoo(6 sites) Kala Amb(6 sites)	ND ND
13)RAJASTHAN	
Pali (6 sites) Jodhpur(6 sites)	ND
ND:Not detectable	

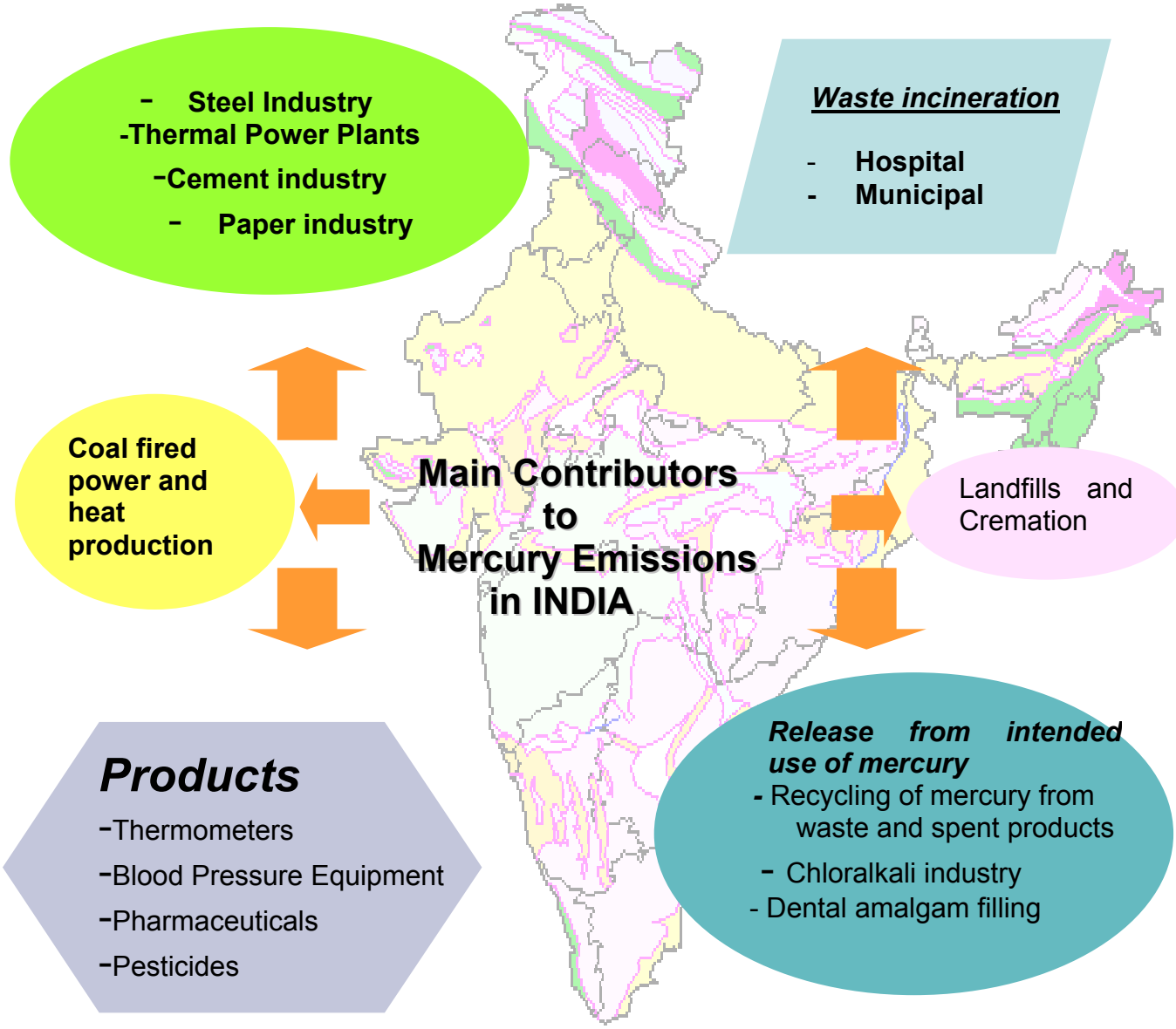
Sources: Groundwater Quality in Problem Areas –A status report (Part V),Dec 1995

LEVEL OF MERCURY(mg/l) in Industrial Effluents

Permissible limit(industrial effluent)……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


- Steel Industry
-Thermal Power Plants
-Cement industry
- Paper industry
Waste incineration
- Hospital
- Municipal
Coal fired power and heat production
Main Contributors to Mercury Emissions in INDIA
Landfills and Cremation
Products
-Thermometers
-Blood Pressure Equipment
-Pharmaceuticals
-Pesticides
Release from intended use of mercury
- Recycling of mercury from waste and spent products
- Chloralkali industry
- Dental amalgam filling

Risk due to mercury release by the Indian caustic-chlorine sector

The mercury consumption in Indian companies are at least 50 times higher than the global best companies. They alone contribute to about 40 per cent of the total mercury pollution in the country.

As much as 44 per cent of mercury consumed by mercury cell companies are released into environment through unknown sources.

On an average, 47 gm mercury is lost in the production of 1 tonne of caustic soda in the Indian caustic-chlorine industry. This mercury loss is based on the total caustic soda production, irrespective of the production process.

The average specific mercury loss from mercury cell plants in India is about 142 gm/MT NaOH produced.

On the average, between 1997 – 1998, 1999 – 2000, about 79 tonnes of mercury was released into atmosphere by the caustic chlorine industry.

The vulnerability and dangers of mercury losses during the production process and leakage of chlorine during process and from storage is a constant nightmare to both the industry and the environmentalists.

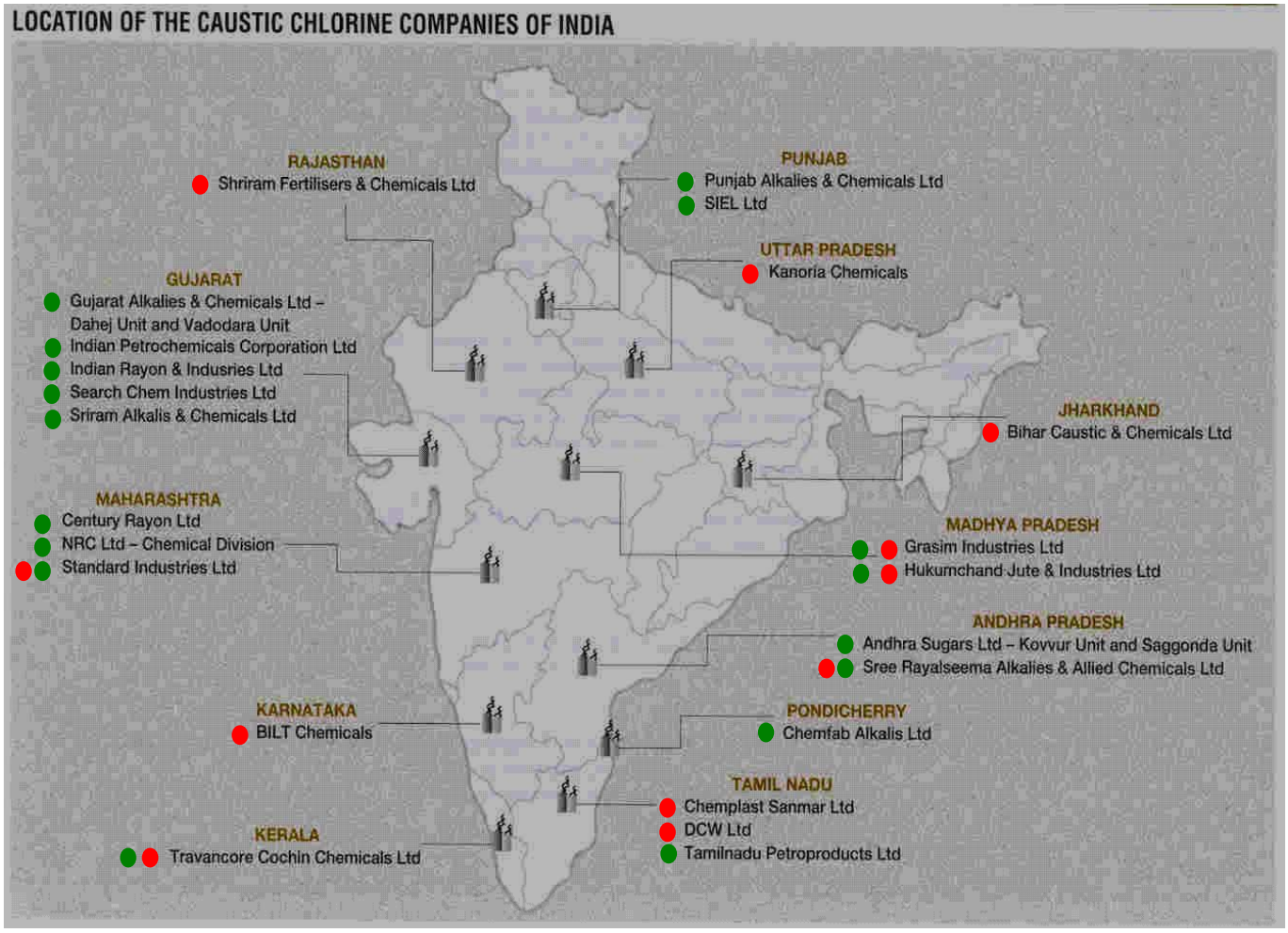
A serious effort is needed by Indian caustic chlorine sector in moving towards membrane cell technology. However, pollution and contamination arising due to emissions of mercury into air, water and land are several fold higher compared to western countries.

Although local conditions may effect mercury exposure in certain populations, most people are also exposed to elemental mercury vapours due to occupational activities.

Exposure studies from diverse geographic areas indicate that a significant portions of humans are exposed to methyl mecury at levels of concern, primarily due to consumption of contaminated fish.

Other populations are of great concern such as pregnant women, children and indigenous populations exposed to methyl mercury through consumption of contaminated fish.

LOCATION OF CAUSTIC CHLORINE COMPANIES IN INDIA



ANNUAL MERCURY EMISSIONS

Years	Caustic soda[1] production	Average mercury loss	Average annual mercury
1997 – 1998	676474.0	142.0	96.1
1998 – 1999	514852.0	142.0	73.1
1999 – 2000	475603.0	142.0	67.5
Average of	555643.0	142.0	78.9

Source : Analysis of the data collected by GRP from caustic-chlorine companies, CSR, 2002

1. Annual Report, AMAI, 1997 – 1998, 1998-1999, 1999-2000

Benchmarking The Performance Of Indian Companies In Mercury Consumption.

	INDIAN PERFORMANCE[1] (average release by Indian plants)	GLOBAL PERFORMANCE[2] (least release globally)	INDIA'S BEST PERFORMANCE[1] (least release in India)
Mercury cell	142 gm/ MT NaOH	0.2-2.5 gm/MT NaOH	69 gm/MT NaOH (Bihar caustic)

Considering an average loss 0f 142 gm per tonne of NaOH, the caustic-chlorine sector emitted around 78.9 MT of mercury per annum

Even the best Indian company has about 25 times more specific mercury loss than the global best figure.

More than 1,000 tonnes of mercury remains in the inventory of industry and 8 – 10 per cent is the annual replenishment.

For producing 0.5 million tonnes caustic soda, the total annual consumption of mercury in Indian caustic-chlorine industry is about 70 -100 tonnes.

In Europe, for producing the same amount of product, the mercury consumption is 750 kgs.

Risk due to Mercury Emissions from Thermal Power Plants, Singhrauli, Madhya Pradesh (A major site of Thermal Power Generation in India)

The Singhrauli area is a major site of thermal power generation in the country at Present. Govind Ballabh Paant Sagar lake is surrounded by the super thermal powerPlants(STPP) namely Singhrauli STPP, Vindhayachal SSTP, Rihand STPP, Anpara A & B STPP, Renusagar STPP. Besides Hindalco, High Tech Carbon and Kanoria Chemical Industrial Units, which contribute towards thermal, chemical and industrial effluents alongwith airborne pollutants. In a comprehensive environmental impact assessment survey made of for National Thermal Power Plant(NTPC) by M/s. Electricite de France International , high levels of mercury in certain environmental compartments at some locations in the area were indicated. This necessitated the study of the health status of the local population in respect of mercury related health problems occurring today or likely to occur in future.

Industrial Toxicology Research Centre, Lucknow, undertook a project for quantitative appraisal of environmental risks due to mercury in Singrauli area. Over 1200 persons residing in the area have been clinically examined land their exposure to mercury assessed through analysis of hair and blood, along with local food land water samples collected from the area. The present scientific study is unique as it is the first major environmental epidemiological study done in the country. Some of the major findings are described below:

- **Mean mercury levels in blood (1055 subject) were significantly higher ($P<0.001$) in the subject as compared to that in controls. Percentage of Subjects from Singauli having more than 5 ng/ml in blood was found to be 66.3% as compared to 10.5% in controls**

- **Mean values of mercury in hair (1183 subject) of the Singrauli subjects were also significantly higher ($p<0.001$) as compared to that in control subjects. Percentage of subjects having more than 1 ug/mg mercury in hair from Singrauli was found to be 47.9 compared to 24.5 in control subjects.**

- **The prevalence of oral signs was among 28.7 % of Singrauli population. The problems pertaining to gums were observed in 16.8% of the subjects while the signs pertaining to mouth (halitosis, excess salivation etc.) were detected in 11.9% of the subjects.**

- **Prevalence of tremors in the study populations was 8.0% while its prevalence in the controls was 7.6 % and tremors were predominantly of fine type. Sensory disturbances were present in 2.3 %.**

- **Clinical findings in 120 children attending the pediatric clinics at the hospital revealed respiratory problems (n=46), diarrhea and abdominal pain in (n=50), worm infestation (n=80) and pica (n=5) cases. Hyper pigmentation of lower limbs, blue gum lining, lower IQ were also found in some of the examined cases.**

- **Women (n=100) attending the gynecology clinic revealed headache and still**
  births, menstrual irregularities, sterility, numbness land tingling of the lower extremities. Hyperpigmentation, anaemia, black line over gums, high B.P. and the fine tremors were also seen in some of the cases. The existence of these psychological alterations, more in the women of child-bearing are, are likely to enhance the gravity of the situation. A Mercury being cumulative toxicant, and in case its exposure continues, its level further unit increase. Detailed investigation involving much larger population, comprising of varied age groups, exposure period and socioeconomic conditions, is warranted to gauge the depth of the problem.

- **Out of total 100 vegetable samples.23% samples had mercury levels higher than permissible limit**

- **Mean mercury level; were significantly higher (p<. 001) food crops obtained from Singhrauli region than mean levels of the samples collected from the control areas.**

- **Out of forty samples of drinking water collected from Singhrauli region, Six samples showed higher values than the permissible level of 1 ug/l.**

- **The mean mercury values of (30 samples) of mercury in fish collected from Singhrauli region were significantly higher (p<. 001) than the mean values of fish collected from control areas.**

- **19 milk samples out of 22 samples collected from the Singhrauli region had mercury levels higher than the permissible levels of 3ug/l.Mean values were also found to be significantly higher (p>0.05)**

Risk due to Mercury Emissions from Other Industrial Processes

No exhaustive work has been done on the effect of release of mercury from different industrial units in our country. Isolated studies have been carried out in different parts of the country to investigate the release of mercury in various compartment of the environment by steel, plants, paper and cement industries.

Mercury in dust fall out from a steel plant near Raipur showed that the fallout of elemental mercury over the soil horizon were in the range from 60.36 to 836.18g/km/month depending on the distance, wind direction and location of the area with respect to the domestic environment in the vicinity of a steel plant contained mercury in the large of 2.3 to 56.8ppm.

Comparative study of the presence of mercury in the air dust particulates from paper mill of two metropolitan cities of India revealed that mercury in the ambient air dust in the paper mill was 20.5 +0.8 ug/g compared to 0.08 to 0.91 ug/g in cities .In anther study suspended particulate matter from a metro city had mercury levels from 0.79 to 0.99 ng/cubic meter. Precipitate analysis of the same areas reveal mercury levels to be 6.0to 82..0 ug/l

Daily mercury emissions from a cement factory were found to be 343g/day mainly resulting from burning of coal and limestone. Mercury emission and ambient mercury levels were observed in range of 1.13-4.00ug/m and 0.055-6.17 ug/cubic meter respectively.

Mercury Threat at Thermometer Factory

The former employees of Hindustan lever Limited's (HLL) thermometer factory in Kodaikanal, Tamil Nadu, are protesting against the company regarding hazardous working conditions and dangerous mercury waste management practices.

The workers were exposed to unacceptable mercury vapor levels since they were working without proper safety measures and without regular medical check-ups.

In fact, many of the workers, symptoms, which clearly indicated reaction to mercury, were often not even recoded during medical examinations.

In the last few years, several ex-workers have died of either renal failure or multiple complications, which could easily be established to mercury exposure.

Many more are suffering and at various stages of critically with problems ranging from neurological, nephrological, reproductive and endocrinal disorders

Mercury Free Alternatives

Most of the mercury that enters the environment comes from human use. It has been used in thousands of industrial, agricultural, medical and household applications. Major uses of mercury include dental amalgam, tilt switches, thermometers, lamps, pigments, batteries, reagents and barometers. The good news is that the majority of products that use mercury purposefully have acceptable alternatives. The following list of alternatives should not be assumed to be complete. These are provided only as examples of mercury-free alternatives that are currently available for use in health care facilities.

Health Sector

Alternatives for Mercury-containing Thermometers

Electronic (digital)
Infrared
Chemical Strip
Glass filled with gallium, indium or tin

Alternatives for Mercury-containing Sphygmomanometers

Aneroid
Electronic

Alternatives for Mercury-containing Gastrointestinal Tubes

Bougie tubes (tungsten)
Cantor Tubes (tungsten)
Miller Abbott tubes (tungsten)
Feeding tubes (tungsten)

Alternatives for Mercury-containing Laboratory Chemicals

The mercury compound in a chemical formulation may be an active ingredient, a preservative, or a contaminant introduced during manufacturing. Identify why mercury is present and a replacement may be able to be identified. Hospital purchasing agents should contact suppliers and request mercury-free reagents.

Alternatives for Mercury-containing Pharmaceutical Products

In many cases mercury-free preservatives are available. Purchasers should request that suppliers provide mercury-free alternatives whenever possible.

Dental Amalgum

Metal ceramic crown glass inomer synthetic polymer gold alloy etc. these alternatives are however available but they are beyond the reach of common people.

Electrical Applications

Mercury is used in temperature-sensitive switches and in mechanical switches. These are used in products like thermostats and silent switches. Mercury tilt switches have been used in thermostats for more than 40

years. A small electrical switch may contain 3,500 milligrams of mercury; industrial switches may contain as much as eight pounds of mercury.
Now,there are numbers of alternatives available to these products such aselectronic thermostats,float control,temperature sensitive switches. The plunger or displacement displacement relay is used in high current,high voltage applications that could include lighting resistanceheating or power supply switching.

Mercury Switches in Electrical Applications

Switch	Quantity of mercury	Available
Tilt Switch		
Thermostats	3000-6000mg	Electronic type and snap switch
Float Control(septic tank and sump pumps	2000mg	Magnetic dry reed switch,optic sensor or mechanical switch
Freezer Light	2000mg	Mechanical Switch
Washing Machine	2000mg	Mechanical Switch
Silent Switches(light switches prior to 1991	2600mg	Mechanical Switch
Thermo-Electrical Applications		
Accustat("mercury in glass thermostat" a calibrated device resembling a thermometer is used to provide precise temperature control for specialized applications)	~1000mg	?
Flame Sensor(used in residential and commercial gas ranges,mercury is in capillary tube when heated mercuyr vaporizes and opens gas valve or operates switch. Used for both electrical or mechanical output	2,500mg	Hot surface ignition system for devices or products that have electrical connections

Automobile Sector

MERCURY USE IN AUTOMOBILES AND ALTERNATIVES

Products Known toContain Mercury	Quantity of Mercury (if known)	Known/Possible Use	Available Alternative
Airbag sensors	Not confirmed ,	confirmed on models listed below1,	mercury-free versions,
Anti-lock braking systems (ABS)	~ 3,000 mg ,	apparently have been used on some four wheel drive vehicles; use on other ABS vehicles unknown2	
Headlamps	0.5 - 1 mg	used in high intensity discharge (HID) lamps by one importing manufacturer in the 90's & by one domestic anufacturer as an option in one 1995 model3	standard halogen or tungsten filament for car headlights
Radios	?	rechargeable batteries for radios; in use by one or more importing manufacturer	mercury-free versions
Ride control	~ 1,000 mg	in use by one or more manufacturer	

Remote transmitters	?	mercury oxide batteries	mercury-free versions (zinc air)
Light switches	1,000 mg	known: used to activate convenience lighting in trunk, under hood	various electro-mechanical switches being explored
Speedometer systems	< 40 mg	In use by one or more importing manufacturers	

Mercury – Containing Chemicals

Chemical reagents used with regularity in a wide range of laboratory testing are likely sources of mercury contaminations. After concern shown by several environmental organizations, these mercury reagents are substituted with other chemical alternatives.

Mercury Containing Chemicals and Alternatives

Chemical	**Alternatives**
Mercury(II) Oxide	Copper catalyst
Mercury Chloride	None identified
Mercury(II) Chloride	Magnesium Chloride/Sulfuric Acid or Zinc,Freeze drying
Mercury Nitrate(for corrosion of copper alloys) for antifungal use	Ammonia/copper sulfate,Mycin
Mercury Iodide	Phenate method
Sulfuric Acid(commercial grade mercury as impurity)	Sulfuric acid from a cleaner source
Zenker's Solution	Zinc Formalin
Mercury(II) Sulfate	Silver Nitrate/Potassium/Chromium(III Sulfate)

	September 2001, **www.indiatogether.com**	Paryavaran Suraksha Samiti conducted a similar study in Vapi(Gujarat), finding 60 polluted water sources affecting a population of over 30,000 people.	April 2001
	January 12th ,2002 **www.indiatogether.com**	The study conducted by Bhopal fact finding mission indicated contamination of breast milk as well as soil,water and vegetables by HCH, **mercury**, lead and nickel. It gives rise to possibilities of inter-generational effects being transfer generation of the survivors who are themselves coping with health effects suffered from several years ago.	A fact finding mission was set up in 1999 to investigate various aspects of Bhopal tragedy and its ongoing impact
	15th June, 2002 **Down to Earth** (Monali Sharma)	During 1988 alone US generated 5-7 million tones of e-waste and that 50-80 percent of it was exported to developing countries like India E-waste is toxic in nature contamination. Lead, beryllium, mercury and cadmium. The recycling methods adopted in countries like India include open burning of circuits boards or using acid strips, which are potentially harmful.	Now it is 2003, the quantity of e-waste generated might be many folds. Another alarming situation.

	15th October,2002 **Down to Earth**	There was a 50 kg leakage of lethal mercury from east island lighthouse in North Andaman due to severe earthquake on 15th September,.2002. The spill is posing threat to health hazards to the local people and the fragile economy of the entire region, The resultant toxicity is threatening the flora and fauna and chances of enter the food chain.	
	20th October, 2002 **Deccan Herald**	In the Thane creek, Bombay mercury has been recorded at a depth of 57 mm in the ooze, yet industrial activity was steeped up, not reduced. Apart from damage to marine environments from pollutions, the seas are being reduced to virtual sterility across vast patches on account of 'wall of death' fishing practices employed by boats from Japan, Taiwan and South Korea.	
	September, 2002 www.infochageindia.org (Nitin Jugran Bahuguna)	The caustic-chlorine industry in Indian releases a staggering 60-70 tonnes of mercury every year into our environment. This figure is 75 times the amount of mercury that triggered the Minamata tragedy. With alarming new data that reveals the dangers of mercury poisoning, a well known Delhi based environment NGO-Centre for Science and Environment (CSE) – holds the caustic chlorine sector responsible for 40 pe3rcent of the mercury pollution in the country. What is particularly disquieting about these emissions is that the Indian companies have no idea.about their mercury is lost or whe3re it vanishes, CSE claims.	Discovered by CSE during their rating of chlor-alkali industry
	March,2003 **Toxics Link**	Findings revealed high level of heavy metals including Mercury.	

Mercury Laws

Indian Vs. European Countries

Products	India	Norway	Sweden	Switzerland
Mercury in product	The government of India is trying to bring legislation for phased elimination of mercury from consumer products.	A lot of products containing mercury are prohibited in Norway. The products that still are allowed are considered not to be a problem when in use. As they become waste they are to be separately collected and treated as hazardous waste.		Since 1986 a ban has been existed on the use of mercury in all products. A list of exemptions is given,alomg with gradual reduction of mercury in the product according to technical possibilities.
Ammunition				Mercury-containing ammunition is no longer used by the Army.
Dental amalgam		Dental amalgam is not prohibited but the release of mercury from the product is prevented through legislation prescribing the dental clinics to separately collect amalgam in the solid waste stream and use of amalgam separators in the wastewater.	Use has still not been totally banned,as the alternatives are not yet deemed capable of substituting mercury in all types of dental fillings	Because of increasingly popular non-mercury alternatives,use of amalgam tooth cements is strongly reduced. There is also increasing use of mercury separators in dentist offices.
Electrical equipment	The government of India is trying to bring legislation for phased elimination of mercury products such as electrical thermostat and switches.	Use of mercury in lighting and electrical equipment is not prohibited but when these products becomes waste, the legislation prescribes to separately collect them and treat them as hazardous waste.	Professional manufacture,import and sale of thermometers, level switches,pressure switches,thermostats,relays,electrical contacts and other measuring instruments has been banned since 1993.Some exemptions,mainly for spare parts,still exist.	Almost complete elimination of mercury from switches etc.
Paints		There are prohibitions against production,import,export,sale and use of mercury in non-fouling paints used on boats,underwater		Use of mercury in paints has been forbidden.

		installations and equipment.		
Pesticides		Mercury in pesticides (seed dressing) is prohibited.	The use of mercury-containing seed dressings is banned since 1979. import, sale, transfer and use of mercury and mercury compounds as biocides are not approved	Use of mercury as a seed dressing has been forbidden since 1991.
Pharmaceuticals		Use of mercury in pharmaceuticals is not prohibited. When the pharmaceuticals products becomes waste the legislation prescribes to separately collect them and treat them as hazardous waste.		There is increased use of alternatives to mercury-containing bactericidal and wound treatment products.
Thermometers		There are prohibitions against production, import, export and sale of thermometers containing mercury. Old thermometers in use are considered hazardous waste and they are to be delivered to authorized facilities for hazardous waste.	The import, professional manufacture and sale of clinical mercury thermometers were prohibited from 1 January 1992. professional manufacture, import and sale of thermometers, level switches, pressure switches, thermostats, relays, electrical contacts and other measuring instruments has been banned since 1993.Ssome exemptions, mainly for spare parts, still exist.	There is still significant use of mercury-containing thermometers. Otherwise, almost complete disappearance of mercury from laboratory instruments.
Batteries		Batteries containing more than 5ppm mercury are prohibited. Button cell formats are exempted from the prohibition if the mercury content amounts to less than 2 weight %.	According to an amendment the batteries with mercury content in excess of 0.0005% by weight are defined as dangerous for the environment. Button cell with a mercury content of no more than 2% by weight are exempted from this prohibition. The new rule mean that mercury oxide may no longer be sold.	Limited the mercury and cadmium contents of batteries sold in articles of any kind to <0.001%(w/w)
Lighting			There is at present no commercially available, mercury free alternatives to linear fluorescent lamps and compact fluorescent lamps. In order to minimize the environmental impacts from the use of mercury in these products, maximum permitted mercury contents should preferably be established.	There is still very significant use of mercury-containing fluorescent lamps, however, there are also an increased recycling rate.

Indian Vs. Asian Countries

Products	India	Japan	Thailand	China
Batteries		Production of mercuric oxide batteries stopped completely by the end of 1995. Production of mercuric oxide batteries for hearing aid application, has already stopped in March,1994)	Mercury has been generally used in battery manufacturing, but the battery organization reported that there is no mercury used in the process.	• 0.025% by weight (upto end of 2004) • 0.0001% for alkaline manganese batteries by weight (from Jan. 1,2005)
Cosmetics			The Food and Drug Administration in Thailand reported that there is no use of mercury in pharmaceutical and cosmetics products.	1mg/kg
Pesticides		No pesticides containing mercury, including pesticides for seed dressing has been registered since 1973.		No pesticides containing mercury including pesticide for seed dressing has been registered since 1973.
Household products		Law for the control of household products containing harmful substances. Organic mercury compounds: must not be detected.		Law for the control of household products containing harmful substances. Organic mercury compounds must not be detected.
Paints		Household paint must not contain organomercury compounds; this has been regulated in 1973/74	Less than 25% of the factories in Thailand still use mercury as an additive in the process and in quantity not more than 0.5% by total weight. However, some paint industries have no mercury involved in processes since 1991. the factory is certified green label as no mercury used in the process.	

Technologies and Practices and Their Effectiveness Including the Use of Suitable Substitutes

As discussed earlier, in India, the chloralkali plants using mercury cell as the electrolytic cell are the main cause of mercury pollution. The mercury cell chloroalkali plant is reported to discharge mercury in wastewater in the range of 0.08-2mg/l. Other industries discharging mercury-contaminated wastewaters include mining, smelting, tars and asphalt, coke ovens, textiles and those manufacturing cements, catalysts, paints, pesticides, pharmaceuticals, and batteries. The maximum limits for the presence of mercury in the industrial effluents, as per Indian Standards, is 0.001 mg/l. The pollution can be substantially reduced either by the use of some other metal electrodes and electrolytic cell in the chloralkali plants or by the effective treatment of the effluents from these polluting industries.

DIFFERENT TYPES OF ELECTROLYTIC CELLS

Electrolytic cells having other than mercury electrodes are reported as substitutes for mercury cells in chloralkali plants. The diaphragm cells are well know substitute of the mercury cells. They are cost effective and comparable in caustic yield to the mercury cells. Asahi Chemicals Industry Co. Ltd., Japan is successfully running a diaphagm cell with the most modern technique, with the capacity of 10,070 MT per year electrolyses by using ion-exchange membrane as diaphragm and metal anodes. The adoption of this modern technique in the place of mercury cell technology will help in abating the mercury pollution from chloralkali plants to almost nil.

The other metal electrodes are also known for the cost-effective substitution of mercury electrodes in the mercury cell of chloralkali plants. The use of titanium

substrate insoluble anodes (TSIA) is reported by central Electrochemical Research Institute, Karaikudi, India. These are titanium substrate activated coated electrodes, which are practically insoluble and are used as anode in the electrolytic cell. Development of TSIA is welcomed by the chloralkali industries as it is thought to be a revolutionary change in the technology of the production of caustic-chlorine. The major advantage of using TSIA besides that of no mercury pollution, includes low energy consumption per ton of caustic production with more yields from the same area of anodes.

Other that TSIA, graphite is another well-known replacement of mercury electrodes in most of the chloralkali industries. The drawback is the loss of graphite at higher current density. Hence, a frequent cleaning of the cell and replacement of the graphite electrode is required. However, in well-maintained plants, one set of graphite anodes had a life of 10-12 months and the cleaning of the ell may also be minimized with moderate current density.

TREATMENT OF CHORALKALI ELECROLYSIS WASTE WATER

1. Micro-organism bases Technology

Microbial mercury removal is a potential biological treatment for chloralkali electrolysis wastewater. The enzymatic reduction of Hg (II) to water insoluble Hg (0) by mercury resistance bacteria can be used for the removal of mercury from wastewater on technical scale. Suitable bioreactor may be developed through which the chloralkali wastewater may be passed for purification. Some bioreactors based on pure cultures of mercury resistance strains of Pseudomonas are reported for the conversion of Hg (II) to insoluble Hg (0). The bioreactors was found to be 97% efficient for the neutralized chloralkali electrolysis wastewater with a mercury concentration of 3 –10 mg/l. within 10 hours of inoculation. Some other bioreactor based on resistance bacterial strain,

Pseudomonas putrid Spi3, isolated from polluted river sediments, has also been developed. These bioreactors having biofilms of P.putida Spi3 grown on porous carrier materials, when continuously fed with chloralkali wastewater having mercury concentration up to 7mg/liter, gave a mercury retention efficiency between 90 and 98 %. Thus, simple, effective, and robust biotechnology for remediation of mercury polluted wastewater can be developed.

2. Use of low cost Resins

The low cost resins based on functionalized polymers may be developed to adsorb the dissolved Hg (II) from the industrial effluents. The polymers having suitable functional groups like Carboxylates and thiols, can be used as a resins or sorbent material for Hg (II). The regeneration can be achieved by simple acid wash. Carboxylate functionalized polymer – grafted coconut husk (PGCH-COOH) is reported to exhibit a very high absorption potential for Hg (II). The sorption of Hg (II) was found to be dependent on the contact time, concentration, pH, and temperature. Maximum removal of 99.4 % with 2 g/l. of the solvent was observed at 125 μ mol/l Hg (II) concentration of pH 6.0. Adsorbed metal ions were removed and the sorbent was restored to its original state by acid regeneration.

Other Methods

Various other methods for the removal of mercury are reported. These included precipitation of mercury by a more reactive metal, such as Al, Fe, Cu, Zn etc., and also as mercuric sulphide using sulphide reagents. Granulated slag of a steel plant is also effective in removing the mercuric ions as mercuric sulphide because of the presence of sulphide in the slag matter. The Hg (II) can be reduced to elemental mercury by electrochemical means in the presence of reactive metals. One gram of the slag was found to remove about 70 mg of the mercuric ions in a 7 days period using electrochemical method.

Strategies to Reduce Mercury Exposure to Humans & Environment

- **Awareness programs for general public on potential adverse effects of mercury.**
- **Restrict release and sale of Indian herbal medicine containing mercury for human consumption without toxicological data / profile.**
- **Stringent legislation to reduce industrial mercury emission to safe guard human and environment.**
- **To establish task force to coordinate and implement the mercury action plan on the long-range trans boundary air pollution and to resolve some of the uncertainties involving various mercury issues.**
- **Steps to reduce the international demand and supply of mercury and its derivatives.**
- **Development of low cost and safe technology to absorb and release of mercury from industrial effluents.**
- **Regular monitoring of mercury levels in drinking water resources.**
- **To collect information on environmental burden of mercury with time.**
- **Identification of vulnerable human populations who may be at risk of mercury poisoning based on their blood and hair values (Increasing risk : 20 – 100 ppb in blood, 6 - 30 ppm in hair. At risk > 100 ppb in blood and > 30 ppm in hair) as reported by Canadian studies .**
- **Establish regional poison information / control centres in the country to provide round the clock information on the signs, symptoms and antidote for mercury poisoning.**
- **Nutritional supplementation of Vitamin 'E', selenium and omega 3 fatty acids, and Garlic (a source of selenium, a common item in India, used in preparation of fish in India) in the amelioration of mercury toxicity.**
- **Use of 2.3 – dimercaptopropane-1-sulfonate (DMPS) and meso-2,3-dimercaptosuccinic acid (DMSA) are becoming most commonly used metal chelator as antidotes for mercury**