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Subject : Global Mercury Assessment : Comments and inputs on draft assessment report.

Dear Dr. Willis

Please find my enclosed comments on the aforesaid draft report and additional information with particular reference to Indian context for your kind perusal. I will be happy to provide any other information, if desired.

THE REPORT HAS ALSO BEEN FAXED

Thanking you

Yours sincerely

Dr. R. C. Srivastava

Global Mercury Assessment

(Comments and inputs on Draft Assessment Report.)

SOURCE OF POLLUTION AND ITS EFFECT ON ENVIRONMENT AND HEALTH

1. SOURCES OF CONTAMINATION

India is one among the world's most active mercury industrial centres. Chloroalkali industries is still the major source of mercury release in atmosphere and surface water (Lenka et. al. 1992). Other industries, which contribute 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 of consumption of mercury (Mody, 2001).

In India about 73% of energy is obtained from thermal power plants, which use about 75 million tonnes of coal produced per year. Coal combustion as a source of energy is often sited as significant source of mercury emission. Mercury concentration more than 1ppm was reported in soil of high susceptible site (Pervez and Pondey, 1997). Mercury content in certain coal variety is even upto 0.080 μg/g, which is higher, compared to the acceptable level (ITRC, 1998).

Indoors air pollution by mercury vapour is mainly due to heating metallic mercury and mercury-containing objects at home like mercury droplets from broken mercury thermometers and use of vacuum cleaners after thermometer breakage. The dentists who use mercury for tooth filling (amalgamation) are also exposed to mercury vapour.

2. OCCUPATIONAL EXPOSURE

The mercury presents in the bronchial washout of different plant workers was found to be maximum in case of a steel industry (20-85 μg) followed by thermal power industry (16 – 56 μg) and 10-17 μg in case of cement plant industries. The mercury occurrence in bronchial tract in all cases was found to be increasing with increase in the age of the respective subjects. (Quraishi and Pondey, 1997).

A quantitative appraisal of environmental risks due to mercury in Singrauli, a major site of thermal power generation, in India, for 1200 subjects was carried out. Exposure to mercury was assessed by monitoring mercury level in hair and blood along with local food, vegetable, milk, fish, drinking and natural water. Mean mercury levels in blood (1055 exposed subjects was 21.39 ± 2.11 ng/ml compared to 1.75 ± 0.22 ng/ml in 191 control subjects) were significantly higher ($p<0.001$) in the subjects as compared to control subjects. More than 5 ng/ml in blood was found in 66.3% as compared to 10.5% in control. Mean mercury levels in hair (1183 exposed subjects was 1.90 ± 0.10 ug/g compared to 0.89 ± 0.10 ug/g in 196 control subjects) were significantly higher ($p<0.001$) in the subjects as compared to control subjects. More than 1 ug/g Hg in hair was found in 47.9% as compared to 24.5% in control [ITRC, 1998]. However correlation between hair mercury level and tremors/teeth problems could be established.

Report of a pilot study conducted in the cell houses of three chloroalkali plants reveals that the air borne mercury concentration were in the range from 0.05 – 0.42, 0.03 – 0.16 and 0.2 – 0.17, whereas urinary mercury levels (mg/lit) of the exposed worker of the respective plants ranged from 0.076 – 0.592, 0.015 – 0.220 and 0.013 to 0.275. The results shows a good correlation between environmental air and urinary mercury level. (Dangwal, 1993). Appropriate control measures to wipe out unattended mercury spillage on the floor and improper sealing of the lids of the end boxes of electrolysis cells led to the significant reduction in airborne mercury vapours the work environment of the cell house of the Chloroalkali plants. Significant correlations between occupational exposure to mercury and levels in the blood and urine of 642 workers have been reported in 21 chloroalkali facilities.

3. ENVIRONMENT

3.1 Ecosystem

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 ug/g wet wt. (Krishnakumar et. al. 1998). The environmental impact of chloroalkali industries in river basin in eastern India has also led to tremendous release of mercury 60 – 320 times beyond the permissible limit (0.01 mg/kg) in the river bodies. (Nanda, 1993).Mercury Emission from massive coal consumptions also enhances the level of mercury more than 1ppm in soil and more than 10 ppb in ground water and ponds. (Pervez and Pandey, 1997)

3.2 Indian Coastal System

India has a coastline of similar to 7000 km, rivers discharge similar to 1645 km super of fresh water annually of which 75% enters the Bay of Bengal (East Coast) and 25% the Arabian Sea

(West Coast). About 25% of the 700 million populations live in or near costal areas and are directly or indirectly, dependant on the sea of their living. (Sanzgiry et. al. 1988).

High concentrations of mercury were found in the coastal waters which are influenced by the coastal industries in the area of Kalpakkam, Chennai, Tamil Nadu.(Selvaraj, 1999). The number of chemical, fertilizer, aquaculture industries are growing along the coastal areas in TamilNadu covering a coastal stretch of 1026 Km and the population about 55 million. They have become a source of health hazard to humans as well as aquatic life (Gupta, 1997, Mishra and Nanda, 1997; Pahan et. al. 1996). Also the distribution pattern of mercury in Ennore Estuary, Chennai, TamilNadu was 0.0763 µg/ lit in water, 0.0428 µg/ lit in sediment and 0.013 µg/ lit to 0.40 µg/g in fish due to the discharge of industrial effluents. (Rajathy, 1997). High concentrations of mercury was observed in the environment near the vicinity of a caustic soda plant at Binage, Karwar, Karnata coast (west coast of India) indicating mercury pollution. Total mercury concentration in the tissue of oysters sampled from a contaminated stream from the above site, exceeded the safe limit of 0.5 µg/g wet weight. (Krishnakumar et. al. 1998). High concentrations of mercury was also reported in water, sediment and biomaterials collected from the southern Kerala coast (Ouseph. 1997). The distribution pattern of mercury in seawater along the west coast of India ranged upto 0.116 µg / lit during the year (Kaladharan et. al.1999).

3.3 Marine Food

Similar situation is reported for the high concentration of total mercury and methyl mercury in marine food chain in Thane creek, Mumbai, 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 (mean 189 ng/gm). Daily intake of total mercury and methyl mercury from sea food by Mumbai population is estimated at 0.8 µg and 0.5 µg. (Pandit et. al. 1997).

Baseline study of the level of concentration of mercury in the food fishes of Bay of Bengal, Arabian 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 µg/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 spp. found in the Mediterranean, Atlantic and Pacific Ocean (Ramamurthy, 1979).

3.4 Food and Vegetables

Monitoring and assessment 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. (Lenka et. al. 1992). Similarly high concentrations of mercury were observed in wheat and rice and leafy vegetables grown in the southern part of India (Sri Kumar, 1993).

Aquatic and terrestrial 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. (Lenka et. al., 1992). Similar observations have earlier been reported in the pattern of distribution of mercury around chloralkali industry. (Shaw and Panigrahi, 1986 and 1987).

4. BIOMONITORING

Many efforts are being made to use organisms sensitive to ambient environment as bio-indicators in monitoring mercury pollution. This being developed to provide baseline data for future environmental quality program. (Sarkar et. al. 1999)

Efforts are also being made to use certain species of fish as bio-indicators for monitoring mercury in aquatic environment especially from industrial belts including chloroalkali plants. The penaeid prawn species collected from Rushikulya Estuary, Orissa exhibited much higher concentration of mercury (much above the permissible limit of 0.5 ppm) located near a chloralkali factory (Das et. al. 2001). High mercury concentrations in 29 fish and three shell fish samples from commercial landing in Madras coast has earlier been reported. (Joseph and Srivastava, 1993).

Nostoc calcicola cells exposed to mercuric chloride, methyl mercuric chloride and fungicide ceresin (phenyl mercuric acetate) showed that methyl mercury was more mobile with higher bio-concentration factor compared to the other two (Pant, 2000).

5. MITIGATION

Efforts are underway to reduce mercury levels from wastes using various technologies.

5.1 Absorbent

Efforts are underway to reduce mercury levels from wastewater using various absorbents due to its simplicity and cheapness. Among the various carbon materials, activated coconut charcoal revealed highest degree of absorption (64 mg/gm of absorbent) compared to wood charcoal having the absorption capacity of 24 mg/gm of absorbent. (Sait et. al. 2000)

Successful efforts have made to reduce the mercury level in water using chitosam as an absorbent from prawn waste of different particle size. (Nair and Madhavan, 1984).

Granulated slag of steel plant was found to remove mercuric ion from the effluent of chlor alkali plant. One gram of slag was reported to remove about 70 mg of the mercuric ion (Loomba and Pandey, 1992).

Suitable Bioreactors are being developed through which the chloroalkali waste waters are passed for purification. Some of the bioreactors were found to be 97% efficient for the neutralized chloroalkali electrolysis waste water with a mercury concentration of 3-10 mg/L within 10 hrs. of inoculation.

5.2 Reclamation by Bacteria

Broad spectrums mercury resistant bacterial strains are being developed to decrease the toxicity of the industrial waste particularly from the chloroalkali industries. The blue green algae accumulated substantial amount of mercury from the medium while the mercury resistant bacterial strain volatilized more than 90% of inorganic and organic mercury (Mishra and Nanda, 1997; Pahan et. al. 1996). Thermophilic Streptomyces, can stimulate reduction of concentration inorganic mercury in water (Dey and Patke, 2000).

5.3 MINAS

Implementation of the standard control measures stipulated in MINAS has brought down the total mercury discharge from 27 units of Chloroalkali industries from 822 kg/yr to 35 kg/yr. The efforts are being made to further reduce the discharge of mercury. (IAWPC, 1985).

6. DEVELOPMENT IN TECHNOLOGY:

Electrolytic cells other than mercury electrode are being encouraged as substitute for mercury cells in chloroalkali plants. The diaphragm cells are being replaced for mercury cells and are cost effective.

The use of titanium substrate insoluble anode (TSIA) developed by CECRI, Karaikudi, Chennai, India is thought to be a revolutionary change in the technology of the production of caustic chlorine and is welcome by the chloroalkali Industries. The technology includes low energy consumption / ton of caustic produced with more yield from same area of anode and from mercury pollution. (Komerwar et. al. 1978)

7. APPLICATIONS

India has the largest production plant of Clinical thermometers. Besides mercury finds use in medical instruments like blood pressure measuring equipments, fluorescence lamps, metal switches, electrical thermostat, batteries, pesticides, traditional Indian drugs and certain pharmaceutical and agricultural products.

8. PROBLEMS, RECCOMENDATIONS AND LEGISLATIONS

8.1 Problems

At a time uses of mercury in developed countries are being phased out, US have continued to export the toxic metal to the third world countries (The Hindustan Times, 2001). Several tonnes of mercury are being shifted to India for use in medical instruments and in other manufacturing processes. Hindustan Lever thermometer factory in Kodaikanal, Tamil Nadu has major ties to U. S. companies, including Cheseborough Ponds, Baxter, Medline and Bethlehem Apparatus at the factory, mercury-bearing waste are stored haphazardly in open with contents spilled onto the workspace. Reports gathered from workers indicate serious health effects including variety of neural disorders, tremors, infertility and loss of appetite (Mody, 2001). US has exported 85 metric tonnes of mercury to India in the year 1999 and much more have been done in the succeeding years. US claim that shipment of mercury is a commercial transaction in developing business is legal under Indian law. It is a proven environmental problem and steps need to be taken to reduce to export from developing countries to third world countries [USGS, 1999].

8.2 Recommendations

Developed countries should take initiative to prevent the export of the toxic mercury to the third world countries with less stringent environmental standards than US. People awareness about the release of such hazardous wastes is most important measures of environmental pollution control. Due to peoples awareness it becomes national issue so that the Federal Government feels its responsibility to solve pollution problem.

Ever stricter environmental regulations and the development of new technologies are expected to be the primary factors in reducing the demand for mercury in commercial products.

Govt. of India is reviewing the occupational exposure standards of 0.1 mg/m^3 of air, set up by Occupational Safety and Health Administration, USA for its implementation in our country, although EPA claim that 0.3 ug/m3 (of air) of mercury is a no – effect level for chronic inhalation exposure. There is a need to reduce mercury air emissions from coal-fired power plants.

The maximum allowed concentration of total mercury in fish is 0.50 ppm in India (Ministry of Commerce, India 1995). The WHO guideline set for mercury intake by fish is 0.47 mg/kg/day, while the limit set by EPA is 0.1 mg / kg /day, which is one fifth to that of WHO. The values are being studied for setting a guideline for India to promote, save fish consumption advisors.

The dumping of the solid waste from mercury polluting chloroalkali industries be contained in subsurface masonry retained structures, jutting above ground water to avoid contacts with the ground water. (Bhatnagar and Oza,1982).

To prevent or offset mercury damage in humans, recommendations have been made to follow a high fiber diet, eat more garlic and onions, drink distilled water and supplement with high doses of beta carotene, vitamin A, vitamin C, selenium, vitamin E, aloe vera juice, green drinks like barley green, chlorella, spirulina, blue green algae and high sulfur containing amino acids like cysteine, methionine, N-acetyl-cysteine and glutathione. This regimen is also acceptable as a way of preventing free radical damage to the body by toxic heavy metal including mercury.

8.3 Legislations

In 1994, the U.S. govt. sold 625,000 pounds of mercury to China, India and South Africa at an average cost of $1.00 per pound. Critics contend that it does not make any sense to remove mercury from incinerator emissions at a cost of thousands of dollars per pound, while selling mercury to developing countries at $1.0 per pound (USGS, 1999).

The controversy highlights the peculiar state of mercury, a naturally occurring metal that can behave as a neurotoxin in certain forms, and can harm fetuses if pregnant women ingest it. However, it remains legal to buy, sell or use in industry. Despite the controversy India is getting shipment, even environmentalist says refusing entry could cause problems because mercury is not illegal and so many industries use the material.

Government of India is trying to bring legislation for phased elimination of mercury from consumer products including thermometer, fluorescent tube, batteries, electrical thermostat and switches, medical instruments, certain pharmaceutical and agricultural products with an exemption for essential products (MoEF, 2000)

Government of India is trying to ensure that potentially harmful mercury wastes are recycled or disposed off under strict standards to prevent the emission into the environment.

Tolerance Guidelines*

Title	Details
Max. permissible limit in water	1 μg/l
Max. concentration in compost	0.15 mg/kg dry basis
Max. concentration in treated leacheate	10 μg/l in land, surface water and public sewers
Max. allowed / recommended levels of mercury in fish	0.5 ppm total mercury
Mercury concentration in fish	Please see table – 2
National data on consumption	NA
Mercury applications and current use	Kindly see the text under the head **“Sources of Contamination”**
Bans or restrictions on uses of mercury	Kindly see the text under the head **“Legislation”**

***Ministry of Commerce, Govt. of India. 1995**
***Ministry of Environment and Forest, Govt. of India. 2000**

Table – 1

Reported Concentration of total mercury in biota from different coastal parts of peninsular India

Location	Hg Concentration	Organisms
Sagar Island, east coast	0.06-2,24 ug/gm dry	Bivalves
Madras, southeast coast	BDL-100 ng/gm	Fishes
Madras, southeast coast	0.08-0,14 ppm/wet wt	Fishes
Karwar, west coast	0.03-0.003 ug/gm wet wt	Fishes
Bombay, west coast	0.13-10.82 ug/gm dry wt	Bivalves
Bombay, west coast	0.03-0.82 ug/gm dry wt	Fishes
Bombay, west coast	1.05-3.60 ug/gm dry wt	Gastropods
Bombay, west coast	1.42-4.94 ug/gm dry wt	Crabs
Arabian Sea and Bay Of Bengal	Below Detection -0.210 ppm	Fishes
Indian Ocean	0.02-0.065 ppm wet wt <0.004-0.021 ppm wet wt <0.004-0.36 ppm wet wt	Bivalves Crabs Fishes

Bhattacharya B; Sarkar S. K. Chemosphere, Vol. 33, 147-158, 1996

Table – 2

Pollution sources and control techniques

Air pollution sources	**Control measures**	**Water pollution**	**Control measures**	**Soil pollution**	**Control measures**
Mercury					
Hg mining and smelting	Conditioning of Hg vapour in refrigeration unit followed by EP	Chlor-alkali industry	Process-change/pro-perly designed tailings disposal sys.	Use as herbicide and insecticide	Restriction in use in agriculture
Mercury battery cell	EP/baghouse	Mining and semlting / battery	Ion exchange/neutralization and sedimentation with /without ppt	Airborned Hg particulate deposition	Air pollution control
Chlor-alkali industry	Process – change/use of ventury scrubber	Pulp and paper	Process – change / restriction in use of Hg	Solid waste dumping	Restriction without pretreatment like recycling/sanitary – land fill, etc.

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