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1.1 General

URS Dames & Moore was commissioned by Hindustan Lever Limited (HLL) to conduct an environmental site assessment and preliminary risk assessment for mercury at its thermometer manufacturing facility located at Kodaikanal in Tamil Nadu State. This followed publicity by Greenpeace and the Palani Hills Conservation Council after their discovery of glass scrap disposed from the manufacturing facility to a scrapyard in Kodaikanal townsite.

The site location plan is shown on Figure 1.

The glass scrap was recovered on 20 June 2001 and the site assessment was completed in several phases over the period March 2001 to February 2002.

1.2 History

The Kodaikanal thermometer factory came under the ownership of Hindustan Lever Limited (HLL) in September 1998 consequent to the merger with Ponds India Limited. It manufactured thermometers mainly for export to Europe, USA, South America, Australia and in recent years a small proportion were sold within India under permission from the Ministry of Commerce. Ponds (India) Limited had commenced its manufacturing operations in January 1984 using equipment relocated from a thermometer factory at Watertown, USA belonging to Chesebrough Ponds. Kodaikanal was chosen as the most suitable location in South India because of similar cool climatic conditions to those at Watertown. This was beneficial in terms of occupational health and safety, and the manufacturing processes. The plant ceased all manufacturing operations in March 2001.

1.3 Scope of Work

As part of the environmental investigations and the risk assessment for mercury, URS Dames & Moore has carried out a review of meteorology, topography, drainage, soils, geology and hydrogeology to assess sources and pathways for release of mercury onsite and offsite. The main sources are the Mercury Area, the distillation plant, the crushing plant, the industrial ETP and the onsite storage areas for glass scrap.

A comprehensive sampling programme has been undertaken involving the collection of 476 samples for total mercury analysis. These comprise 367 onsite samples and 109 offsite samples, and have included soil, sediment, water, bark and lichen samples. The breakdown of the various samples collected from on site and off site locations are provided in Table 1. Offsite sampling has been carried out north of the site up to and in Kodai Lake and south of the site on Levange Path, and around Pambar River as far as Kumbakarrai Falls. Selected samples have also been tested for methyl mercury. Extended sampling was also carried out within and around the Mercury Area drains inside the factory where the presence of mercury was observed. This material has been collected from the drains and is stored separately. A similar exercise has been conducted by HLL at the distillation and crusher rooms and beneath the floor of the old bakery resulting in the recovery of additional mercury, also stored on site.

Introduction

Analytical testing of the soil/sediment/lichen samples for total mercury has been primarily conducted at the MGT Environmental Laboratories in Melbourne, Australia. Testing has also been carried out at the Hindustan Lever Research Centre (HLRC) Laboratory in Mumbai, the TNO Laboratory in the Netherlands and Australian Laboratory Services (ALS) in Sydney. Selected samples tested at MGT have included testing in accordance with both the USEPA and Dutch Standards (NEN).

Samples of fish from Kodai Lake have also been tested for total mercury. These tests were carried out at Australian Government Analytical Laboratories (AGAL) in Sydney. AGAL is specialised to carry out analytical testing of fish tissues.

Testing for methyl mercury is highly specialised and has been conducted at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) laboratory in Sydney, Australia and the TNO Laboratory in the Netherlands.

The Hindustan Lever Research Centre (HLRC) Laboratory in Mumbai has a sample analysis turn around of only a few days compared to several weeks at the international laboratories which is important in a study of this nature. For total mercury concentrations of 10mg/kg and above, results for HLRC have shown acceptable correlation with the MGT results and have been useful in delineating areas with higher mercury concentrations.

Particular emphasis has been placed on following internationally accepted QA/QC protocols for collection and analysis of samples; eg., chain of custody and preservation procedures, duplicate samples and blanks, and storage times.

2.1 Topography

The HLL factory site is located at an elevation of approximately 2,180 m. The site (see Figure 1) is irregular in shape and occupies an area of approximately 85,000 square meters. The southern boundary of the site slopes steeply into the Pambar Shola Forest, a protected nature sanctuary of the Tamil Nadu Government.

Meteorological records are available for the six year period 1995 to 2000 and have been used to construct a monthly average rainfall chart (Figure 2) and wind rose (Figure 3). The dominant wind directions are northeast/north northeast, northwest/north northwest and southeast, consistent with the prevailing direction of the monsoon winds. Mercury vapour in air will therefore disperse initially in the direction of the air exhaust fan discharge and then predominantly to the northwest/north northwest, northeast/ north northeast and to the southeast. Topography and vegetation will also have an influence on mercury dispersion in air.

The access road to the site, St. Mary's Road, forms the drainage divide between the Pambar River subcatchment to the south, which includes the factory site, and the Kodai Lake catchment to the north. Drainage across the site is primarily via a small stream, termed the main stream, which originates at the northeastern corner of the site and flows in a southwest direction prior to discharging to the precipitous slopes which fall 1,300 m from the southern boundary to the Pambar River. There is a second smaller drainage termed the minor stream which traverses the western part of the site, and also a number of seepage areas. Details of the site features, facilities and access roads are illustrated on Figure 4. The topography of the site and its surroundings are provided on Figure 5.

The general land use to the north and east of the site is largely low density private residential properties along St Mary's Road. A few squatter cottages and St Mary's Church are located to the west. A large television broadcast antenna tower is located about 200 meters to the east of the site. The Pambar River (approximately 0.5 km to the south) is the nearest surface water body to the site within the factory site catchment, flowing in a southwest direction to the Kumbakarrai Falls about 7 km to the southeast, thence draining eastward across the Tamil Nadu Plain. Kodai Lake is 500m to the north of the site but within a different catchment area.

The whole site is underlain by shallow Archaean bedrock, mainly granite gneiss and charnockite, which is impermeable apart from limited fracture porosity related to vertical and subhorizontal joints and exfoliation joints in the uppermost weathering profile down to 5 or 6 m depth. Two shallow wells on site which are blasted into the rock, have limited supplies which decline markedly in the summer season. There is also a spring in the central/lower part of the site adjacent to the main stream, and this again becomes dry during summer. The soil profile is very thin, and comprise a few centimetres of predominantly sandy material in the upper part of the site grading down into densely vegetated peaty soils in the south. Maximum thickness of soil intersected across the site is approximately 1.5 m. A narrow access path, the Levange Path, is in the Forest Reserve immediately to the south of the site boundary and can be traversed on foot with the approval and presence of the Forestry Department in Kodaikanal. This path lies immediately above the precipitous slopes and is primarily on bedrock with only a thin veneer of

soil. Access to the slopes below the Levange Path and to the Pambar River as far as the Kumbakarrai Falls is extremely difficult and hazardous.

Several photographs taken at various locations of the site and its surrounds are provided in Plates 3 through 12 in the Plates section of the report.

2.2 Factory Layout and Operations

2.2.1 General

The thermometer manufacturing process in the factory had been divided into two main areas:

- Non Mercury Area; and
- Mercury Area.

Mercury was also handled in the crushing and distillation rooms and the glass scrap storage areas.

The Mercury and Non Mercury areas were physically separated by partitions and walls.

2.2.2 Non Mercury Area

This is where glass-forming operations were carried out before mercury was filled into thermometers and covered departments 1 and 2. Various processes that were carried out in this area included:

- Stem cutting;
- Bulb cutting;
- End opening;
- End cutting; and
- Bulb forming.

Glass scrap from this area is termed 1 & 2 scrap and does not contain mercury.

2.2.3 Mercury Area

This is where all operations from mercury fill through to final thermometer manufacturing operations were carried out and covered departments 3 and 4. Various processes that were carried out in this area included:

- Mercury filling;
- Top chambering;
- Annealing;
- Contracting;

- Airpassing;
- Test for shake;
- Scale setting;
- Grading; Screening;
- Baking;
- Top making;
- Final inspection;
- Quality assurance; and
- Packing.

Glass scrap from this area is termed 3 & 4 scrap and contains mercury.

Information on mercury in thermometers are presented in Appendix A.

2.3 Scrap Handling and Disposal

It should be noted that under Waste Category No. 4 of the Hazardous Waste (Management and Handling) Rules of 1989 any operation that generates more than 5 kg per year of mercury must ensure proper collection, reception, treatment, storage and disposal. The Hazardous Waste Rules were updated on 6 January 2000 (Rule 3i(b) of Schedule 2) and classifies mercury and mercury compounds as Hazardous Waste (Class A6) if the concentration exceeds 50 mg/kg.

Glass scrap from the Non Mercury Area 1 and 2 was packed in corrugated cartons and has either been disposed or is held in the Custom Bonded Storage area on site. Approximately 45 tonnes of mercury free scrap was also buried in four shallow pits on site.

The glass scrap from the Mercury Area contained residual mercury and since 1984 until 1990 was stored on site in the old bakery building. This non-treated scrap contains an estimated 5.97% of residual mercury by weight.

Mercury recovery commenced in 1990 using a crusher and twin recovery ovens, which operated until 1998. Approximately 68 tonnes of 3 and 4 glass have been processed during this period, however this operation was not considered particularly efficient as the grinder was unable to crush the glass to the desired level. After treatment the residual mercury in the scrap is estimated to be 1.04%.

At the beginning of 1999, a new crusher and vacuum activated mercury recovery plant was commissioned and continued in operation until March 2001. This new plant was able to process and recover mercury from 80-100 kg per day of scrap glass on a round the clock basis. Residual mercury in the scrap treated this way is estimated to be 0.15%.

Sale of glass scrap commenced in 1992. A total of 98.3 tonnes was sold during 1992-1999 and comprised 49.4 tonnes of 1 & 2 glass scrap, 43.6 tonnes of mercury-recovered 3 & 4 glass scrap (1.04 % residual

mercury) and 5.3 tonnes of enhanced mercury recovery 3 & 4 glass scrap (residual mercury 0.15%). Details of these sales including dates, purchaser names and material quantities are provided in Table 2.

The last sale in November 1999 of 5.3 tonnes of mercury recovered 3&4 glass scrap was made to a scrap dealer in Moonjikal area in Kodaikanal (which is the material referred to by Greenpeace) and this material lay in the dealer's yard (see Plates 1 and 2 in Plates section of report) until it was removed in June 2001 (see Appendix B for details). 7.4 tons

HLL has approached the Ministry of Environment, New Delhi for permission to send the accumulated glass scrap 3&4 and the retrieved glass scrap to Bethlehem Apparatus Company, a Mercury Recycler in the USA.

3.1 Regulatory Controls

A description of the Regulatory Controls in India which are pertinent to the Kodaikanal thermometer factory is given in Appendix C.

Of particular importance is the Indian Occupational Health and Safety Regulation (Tamil Nadu Factory Rules) for air quality in the workplace. This specifies a maximum time weighted average of 0.05 mg/m^3 of Hg. There are no regulations or guidelines for mercury emissions in air.

The factory operated under valid consent under section 21 of the Air (Prevention and control of Pollution) Act, 1981, as amended in 1987 and consent for discharge of Sewage and Trade Effluents granted by the Tamil Nadu Pollution Control Board (TNPCB). In addition, the factory had authorisation from the TNPCB for collection/storage of hazardous wastes under Rule 3(c) and 5(5) of The Collection/Storage of Hazardous Waste (Management and Handling) Rules 1989 enacted under the Environmental Protection Act 1986. This licence was for sludge derived from treatment of industrial effluent containing heavy metals and was renewed in April 2000 with a validity of two years. An application for extension of this licence was submitted to TNPCB in March 2002.

3.2 Indoor Air Monitoring

When the Plant was in operation, the mercury concentration in air area was monitored using a gold film mercury vapour analyser with a self-calibrating facility. Fifteen to twenty two air monitoring locations were spread across the Mercury Area, the Non Mercury Area, Distillation Room, Crushing Room and external to the workplace. The intention was for the mercury in the atmosphere to be controlled to less than 0.05 mg/m^3 of air by adopting the following measures:

- Total of 25 exhaust fans fitted along the southeastern wall of the Mercury Area to turnover the air in the 15,145 m^3 of open area every 45 minutes for 16 hrs per day, 310 days per year;
- Provision of vacuum cleaners equipped with water seals to collect broken thermometers when breakage occurred in the factory;
- Scrubbing and washing of the factory floor once a day with water to remove traces of mercury. This water was treated in the Effluent Treatment Plant (ETP) and reused for floor washing;
- Total of 6 exhaust fans along the northeastern wall of the mercury crusher building for an air change of the 288 m^3 of area every 5 minutes for 24 hrs per day, 310 days per year;
- Total of 5 exhaust fans along the southeastern wall of the mercury distillation building for an air change of the 166 m^3 of area every 4 minutes for 8 hrs per day, 310 days per year.

The following additional safety measures were also adopted:

- Natural ventilation was adopted in the Non Mercury Area;
- Mercury levels in urine were measured monthly for each employee (ie 5 to 10 employees per day); and
- Operators in the Mercury Area were provided with safety masks to filter out mercury vapours. This was backed by an emergency procedure when the mercury vapour exceeded 0.05 mg/m^3. This included opening all windows and cleaning the entire floor with water after which the water was brushed into the ETP.

Records of mercury vapour levels have been maintained for the period 1984 to 2001, measured daily at the 15 to 22 different locations within and adjacent to the Mercury and Non-Mercury Areas. During this time there have been some recorded exceedances of the 0.05 mg/m^3 criterion. The records for the period between 1994 and 1997 have not been sighted.

3.3 Medical Surveillance

In accordance with Company policy, medical surveillance comprised an annual medical checkup of all employees and monthly monitoring of mercury in urine. The annual medical check up consisted of physical examinations with special attention to mouth, gums, skin, teeth, hair and neurological symptoms such as tremors or unsteady gait. The medical tests comprised blood tests (haemoglobin estimation, total white blood cell counts, differential white blood cell counts) and routine urine examinations for albumen, red blood cells, casts, crystals and sugar. Records of these examinations for 130 employees are available from 1988. The medical records of 184 employees / casuals / contract workers who left the company and of others whose services were terminated in the recent past are also available. These results indicate that all levels monitored were within acceptable recommended WHO / ILO limits.

The monthly urine examinations of all employees were done for mercury and compared to the maximum regulated level (WHO recommended acceptable upper limit) of 100 micrograms of mercury per litre (µg/L) of urine. Employees whose mercury levels exceeded 100 µg/L level were deployed from the Mercury Area. In all such cases mercury levels of the re-deployed staff reduced to acceptable levels (less than 100 µg/L) in one to two months. The urine monitoring results are available with HLL.

Group mean mercury levels in urine for employees over the period 1988 to 2001 are provided in Table 4. They show an annual range between about 13 and 32 µg/L. WHO recommends that on a group basis the mercury level in urine should not exceed 50 µg/L.

Results of the most recent urine examinations conducted in March 2001 indicate that the mercury concentrations in the urine of all employees, ex-employees and scrap dealers are well below the WHO recommended acceptable upper limit of 100 µg/l. Of the 255 included in the survey, 3% of those surveyed had between 40 and 60 µg/l of mercury in urine, another 3% between 30 and 40 µg/l and the remaining 94% had mercury levels of less than 30 µg/l of urine. A further survey was undertaken in May 2001 and the results of the study are presented in Appendix D. Medical records comprising the urine

analysis results, annual medical surveillance and comprehensive occupational health surveillance done in March/May 2001 have been given to the individual employees.

This comprehensive occupational health surveillance done in March/May 2001 (clinical protocol, biological monitoring, results and conclusions) has been reviewed and validated by Dr Tom van Teunenbroek of TNO, Netherlands and his report is provided in Appendix E. Independent reviews carried out by the All India Institution of Medical Sciences and Indian Association of Occupational Health are also provided in Appendix E.

A mercury balance has been prepared in order to estimate the total unaccounted losses of mercury over the 18 years life of the operation. These unaccounted losses comprise dispersion of airborne mercury and accumulation in soil, lichen and vegetation both onsite and offsite, mercury in soil and sediment hotspots derived from accidental spillages, mercury recovered from drains and other areas of mercury accumulation adjacent to Mercury Processing Areas, and mercury discharging offsite with suspended sediment southwards to Pambar Shola.

Several of the key components of the mercury balance have been subjected to detailed review and audit as part of the risk assessment. These components are described below:

- Thermometers in the factory were manufactured from imported glass and imported mercury. The mercury used in thermometers was triple distilled (99.999%) and its importation required clearances from the Ministries of Commerce and Finance of the Government of India. Entry of glass or mercury on to site and dispatch off site of finished products and wastes have been carried out under certification by the customs official posted at the Factory and recorded in the Annual Bond Account. A proportion (12%) of the imported mercury was sourced from other Indian importers from 1993 to 1998 and this has been recorded in the Daily Materials Receipts Register at the time of purchase. A detailed description of this important component of the balance is given in Appendix A and indicates that a total of 165,178,795 thermometers were exported from site containing an aggregate of 119,067 kg mercury.

- The calculated weight of mercury expelled to air from the Mercury Area (operated from 1984 to 2001), the Crusher Building (constructed in 1990) and the Distillation Building (mercury purification from 1984 to 1986 then distillation until 2001) can be estimated using the frequency of air changes nominated for each area, the period of operation and an average (conservative) mercury concentration in air of 0.03 mg/m^3. The total aggregate is 64 kg as follows:

  Mercury Area = 54 kg, Crusher Building = 8 kg, Distillation Building = 2 kg.

- It is recognised (refer Encyclopaedia of Occupational Health and Safety, International Labour Office, Geneva, 1998) that mercury in urine bears a reasonably constant relationship to mercury in air. The correlation factor between mercury in air, measured as mg/m^3 to mercury in urine measured as µg/L is 1.2 to 2.0 x 10^3. The NIOSH time weighted average mercury concentration in air of 0.05 mg/m^3 therefore equates to between 60 and 100 µg/L in urine. An average urine concentration of 32 µg/L, the maximum average annual value recorded, therefore equates to an air concentration of between 0.026 and 0.016 mg/m^3. This lends credibility to the adoption of a mean air concentration of 0.03 mg/m^3 for estimation of mercury emissions to air. The above data for monitoring carried out at the HLL Plant is provided in Table 3 and illustrated on the associated chart.

- Scrap handling has been discussed in Section 2.3 of the report. In summary, glass scrap from the Mercury Area (3&4) scrap is in three forms – unrecovered with approximately 5.97% of mercury; partially recovered with an estimated 1.04% of mercury; and enhanced recovery with approximately 0.15% of mercury. Glass scrap which was sold off site and has either been repurchased by HLL or had been recycled has also been tabulated and considered to contain between 0.15% and 1.04% of mercury.

The elements of the mercury balance are:

MI = TE + GSS + GSO + ETP + ST + WIP + ΔU, where,

MI: Mercury imported to site in containers directly from the USA and Spain or via Indian importers. The customs bond and local purchase registers record a total of 136,486 kg.

TE: Mercury exported from site in thermometers. HLL has made an exhaustive review and collation of the recorded numbers and types of thermometers dispatched from site and their contained mercury. The total number of thermometers was 165,178,795 with a total mercury content of 119,067 kg.

GSS and GSO: This represents glass scrap stored onsite (GSS) and glass scrap disposed offsite (GSO). GSS has been calculated from tabulated records of unrecovered 3 & 4 glass (160,051 kg @ 5.97% residual mercury), 3 & 4 partially recovered (9,858 kg @1.04% mercury), and 3 & 4 enhanced recovery (58,511 kg @ 0.15% mercury). These amounts have been assessed by sampling each batch of unrecovered glass scrap in GSS and measuring mercury recovery. GSO is based on the glass scrap disposed offsite (43,577 kg @1.04% and 5,327 kg @ 0.15%).

ETP Mercury in stored sludge (17,542 kg) from the industrial ETP, estimated to be 593 kg. This figure is based on analysis of total mercury in fifteen composite samples drawn from 145 drums containing ETP sludge and analysing them in the TNPCB Laboratory. The average concentration of fifteen composite samples is 3.38%, which translates into 593 kg.

ST and WIP: Mercury in stock (ST) and work in progress (WIP) are based on audited inventories.

ΔU: Unaccounted Losses.

Based on the above information the mercury balance can be expressed as follows:

MI	=	TE	+	GSS	+	GSO	+	ST	+	WIP	+	ETP	+	ΔU
136,486	=	119,067	+	9,746	+	461	+	2,983	+	1,605	+	593	+	ΔU

Unaccounted losses, ΔU, therefore total 2,031 kg.

Mercury imported - 2001 = 125,676 kg
Mercury imported - 2002 = 136,486 kg.

The unaccounted mercury losses can also be expressed as the following equation:

$$\Delta U = SSR + LLD + MPA + PS$$

where:

SSR = Mercury contained in soil and sediment which will be remediated ie at concentrations in excess of 10 mg/kg, namely Areas A, B, C (C1 and C2). SSR is estimated to be 291 kg (Table 9). This has been based on the mercury concentration contours derived from the results of the sampling program (and assuming a soil density of 1800 kg/m^3).

LLD = Low level dispersion at concentrations of between 0.1 and 10 mg/kg in soil and sediment both onsite and offsite. The onsite component of this is estimated to be 75 kg. The offsite component is estimated to be approximately 30 kg.

MPA = Mercury recovered from the Mercury Area Drains (see Figure 4) inside the factory (76 kg), the Vacuum Distillation Unit (16 kg), the Bakery Floor (52 kg with soil) and the Distillation Room Sump (138 kg with soil). Sampling of the main drain predominantly along the south wall of the Mercury Area and two shorter sections of drains perpendicular to the main drain revealed the presence of free mercury. This prompted the investigation of other areas adjacent to mercury processing areas as summarised above.

PS = Discharge offsite to the south to Pambar Shola.

PS	=	ΔU	-	SSR	-	LLD	-	MPA
		2,031	-	291	-	105	-	282
	=	1353 kg						

Therefore, estimated offsite discharge to the Pambar Shola is approximately 1,350 kg. This estimate will be further refined after site remediation has been completed and the volume of mercury contained in the ETP sludge is subject to detailed analysis as well as actual content of mercury in GSS and GSO, to be advised after recycling is completed.

This estimate indicates unaccounted losses of about 75 kg annually over the 18 year life of the operation equivalent to 200 g/day or approximately 15 mL/day.

The elements of the mercury balance are:

MI = TE + GSS + GSO + ETP + ST + WIP + ΔU, where,

MI: Mercury imported to site in containers directly from the USA and Spain or via Indian importers. The customs bond and local purchase registers record a total of 136,486 kg.

TE: Mercury exported from site in thermometers. HLL has made an exhaustive review and collation of the recorded numbers and types of thermometers dispatched from site and their contained mercury. The total number of thermometers was 165,178,795 with a total mercury content of 119,067 kg.

GSS and GSO: This represents glass scrap stored onsite (GSS) and glass scrap disposed offsite (GSO). GSS has been calculated from tabulated records of unrecovered 3 & 4 glass (160,051 kg @ 5.97% residual mercury), 3 & 4 partially recovered (9,858 kg @1.04% mercury), and 3 & 4 enhanced recovery (58,511 kg @ 0.15% mercury). These amounts have been assessed by sampling each batch of unrecovered glass scrap in GSS and measuring mercury recovery. GSO is based on the glass scrap disposed offsite (43,577 kg @1.04% and 5,327 kg @ 0.15%).

160051
9858
58511
228420

68 Tons

ETP Mercury in stored sludge (17,542 kg) from the industrial ETP, estimated to be 593 kg. This figure is based on analysis of total mercury in fifteen composite samples drawn from 145 drums containing ETP sludge and analysing them in the TNPCB Laboratory. The average concentration of fifteen composite samples is 3.38%, which translates into 593 kg.

ST and WIP: Mercury in stock (ST) and work in progress (WIP) are based on audited inventories.

ΔU: Unaccounted Losses.

Based on the above information the mercury balance can be expressed as follows:

MI	=	TE	+	GSS	+	GSO	+	ST	+	WIP	+	ETP	+	ΔU
136,486	=	119,067	+	9,746	+	461	+	2,983	+	1,605	+	593	+	ΔU

2 3

Unaccounted losses, ΔU, therefore total 2,031 kg.

15388

5.3 Mercury Distribution Offsite

An estimated 30kg of mercury is considered to have deposited offsite to the north and south with lesser offsite deposition to east and west. This has been based on an average concentration of 0.5mg/kg 500m to the north and the south of the site boundary, and a concentration of 0.1 mg/kg beyond and up to the Kodai Lake in the north and down to and immediately beyond Pambar river in the south. The primary source of this low level dispersion both onsite and offsite is from air discharged from the mercury working areas and from revolatilisation of mercury already deposited in sediments or discharged from the working areas as metallic mercury.

5.3.1 Soil

Mercury levels in the soil immediately north of the site were found to be between 0.70 and 2.2 mg/kg at locations CM2 and CM respectively (see Figure 6 and Table 7). Mercury levels in the soils along Upper Shola and Lower Shola Roads located about 400m to 500m north of the site (samples prefixed by US and LS respectively as shown on Figure 6 and Table 7) were found to be less than the detection limit of 0.1 mg/kg. Soil samples collected from the southern periphery of the Kodai Lake, 800 m to the northeast (sample locations LK1, LK2 and LK3 are shown on Figure 6 and the results provided in Table 7) also contained mercury levels of less than the detection limit.

To the south of the site mercury levels of the surface soils along the Levange Path immediately south of the boundary fence were measured to be between 0.63 mg/kg at location LP7 and 6.0 mg/kg at LP2 (see Table 8 and Figure 6). The elevated level at LP2 is related to sediment discharge from the minor stream on the western side of the site. Elevated level in sediment at LP5 is due to the main stream outfall at this location. The main stream discharging from the site forms a waterfall which, over time, has eroded a scoop pool (ie a small shallow basin in the rock) along the Levange Path. The sediments in this pool location DFE, returned total mercury concentrations ranging between 26 and 110 mg/kg (see Table 8 and Figure 6); the pool contains at most about 50 kg of sediment which at a mercury concentration of 100 mg/kg equates to approximately 5 gm of mercury washed down from the factory site. There is also some offsite seepage of water and sediment from the soil/rock contact and possibly exfoliation joints which has been sampled at location DFNE close to location DFE. These locations are shown on Figure 6.

Several small pockets of sediment with elevated mercury concentrations have also been detected below the Levange Path as far as the Pambar River. For example, elevated levels of mercury have been found in sediments at locations (DS1A, DS2, DS2A) along the course of the main stream from the site (Table 8, Figure 5). However, the mercury concentration at location DS1B immediately downstream of the junction between the stream and the river (located less than 50 m from DS1 along Pambar River) was found to be very low (0.52 and 0.56 mg/kg).

Sediment samples (K series locations on Figure 5) were also collected and tested from the Pambar River as far as the Kumbakarrai Falls and then to the junction with the Varaganuthi River in Periukulam (PDR), 7 km below the Falls. All samples tested by MGT and TNO contained mercury concentrations of less than the detection limit (Table 8).

5.3.2 Lichen and Bark

Elevated mercury levels were detected in lichen and bark samples (albeit to a much lesser level in the latter) collected immediately north and south of the site.

Offsite concentrations in lichen immediately north of the site are generally between 2.2 to 9 mg/kg with the exception of locations CM-53 and MH-51 which had maximum levels of 26 and 68 mg/kg respectively (see Figure 6 and Table 7). The mercury levels in lichen further north of the site reduce to a level of 0.2 mg/kg as detected at location KDLL on the banks of Kodai Lake.

To the south of the site, the mercury concentration of one of the lichen samples (DS3A) collected immediately south of the site boundary (Table 8 and Figure 5) recorded a value of 80 mg/kg. The concentration reduced to 44 mg/kg (maximum) 100 m further south (DS2A) and to 2.3 mg/kg further south again (DS1A). These mercury levels in the lichen are attributable to dispersion of metallic mercury vapour in air from the Mercury Area exhaust fans, the mercury distillation and crusher room exhaust fans together with the revolatilisation of metallic mercury discharged from site either in elemental form or in sediment.

5.3.3 Water

A water sample collected in Kodai Lake (LKW) and from a small stream on Upper Shola Road (USW1) returned mercury concentrations less than the detection limit of 0.0003 mg/l (Figure 6 and Table 7).

Samples of water discharging from on site streams or as seepages to the Levange Path below the factory site (DFE, DFEW, DFNE, DW), from the Levange Path to the Pambar River (DS series), from the Pambar River to the Kumbakarrai Falls (K series) and then a further 7 km to the junction with the Varaganuthi River (PDR) all returned mercury concentrations below the detection limit (Figure 5 and Table 8).

5.4 Mercury Distribution On Site

5.4.1 Soil

Locations of sampling which have been carried out for this study are shown on Figure 4. Results of the analytical testing of the samples are provided in Table 5.

Based on these results three areas with significantly elevated total mercury concentrations in soil have been located within the site. All these areas are situated well within the site boundaries and are identified as Area A, Area B and Area C (Areas C1 and C2) on Figure 8. Mercury concentration contours are also shown on Figure 8.

Area A surrounds the old bakery building where 3 & 4 glass scrap was stored and also where some glass/steel mercury containers were discarded. This area is approximately 1800 m^2 of which about 40% contains mercury concentrations of between 10 and 30 mg/kg.

Area B is located southeast of Area A and immediately south of Ponds Path. This area is approximately 3040 m^2, 60% of which has a concentration range of between 10 and 30 mg/kg. A small area of approximately 25 m^2 of Area B has elevated levels in excess of 500 mg/kg.

Area C consisting of Areas C1 and C2 is located south of the factory building and extends south to the Ponds Path. Area C also contains the mercury distillation unit. This area is 8590 m^2 of which approximately 60% contains mercury concentrations of between 10 and 30 mg/kg.

Details of these impacted areas are provided in Table 9.

An estimated 75kg of mercury (Area D in Table 9) at low levels of concentration between 0.1 and 10 mg/kg is distributed across the site (outside Areas A, B and C).

5.4.2 Lichen and Bark

Elevated total mercury concentrations were measured in lichen samples (ranging between 18.3 mg/kg in sample L4 to 87 mg/kg in sample L3) and bark samples (ranging between 1.24 mg/kg in sample B5 to 20.4 mg/kg in sample B1) taken from trees located within the site (see Figure 4 and Table 6). The highest concentrations are closest to the air exhaust fans from the mercury processing areas. The approximate locations of the air exhaust fans in the main factory, the distillation room and in the crusher plant are shown on Figure 4.

5.4.3 Water

Water samples were collected from the main stream, the minor stream and the on site springs. Two surface runoff water samples collected during a heavy storm returned elevated readings, 0.085 mg/l in BRW and 0.031 mg/l in MDRW (Table 5). Both these samples contained silt and were analysed unfiltered which accounts for the anomalous readings. All remaining samples were below detection limit.

5.5 Methyl Mercury Results

The methyl mercury results of the samples tested are provided in Table 10. The samples tested for methyl mercury included mainly those with higher than average total mercury concentrations for on site samples. Also samples from off site locations such as those from the banks of Kodai Lake, the sediments at the main stream discharge on to the Levange Path, the sediments of Kumbakarrai Falls and lichen samples from the Charlemont Property, directly north of the site, and the Pambar Shola Forest adjacent to the main stream downslope of the Levange Path.

The methyl mercury levels in the samples tested from within the site are well below levels of concern (see Section 5.2 for USEPA Guideline Levels). The ratio of methyl mercury to total mercury in these samples ranged between 0.0007% and 0.15% (Table 10). The lichen samples (locations L1, L2, L3, L4, L5 on Figure 4 and Table 10) from the site which had elevated total mercury concentrations, all contained less than the detection limit of 0.10 mg/kg of methyl mercury except for sample L1 which had a methyl

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Area A surrounds the old bakery building where 3 & 4 glass scrap was stored and also where some glass/steel mercury containers were discarded. This area is approximately 1800 m^2 of which about 40% contains mercury concentrations of between 10 and 30 mg/kg.

Review of the literature indicates that mercury deposition to lichen may be enhanced where fog or misty conditions are prevalent (cf the Pambar Shola below the factory site) and that the mercury concentrations in lichen decline exponentially with distance from source.

The distribution of mercury in lichen within and adjacent to the factory site clearly indicates a correlation with mercury vapour emission sources and wind patterns. Superimposed on this pattern is an area of elevated mercury in lichen along the course of the main stream which discharges from site across the Levange Path and down to the Pambar River. This is considered to represent vaporisation, remobilisation and deposition of mercury vapour from the mercury contained in the main stream as it cascaded down the offsite precipice.

The levels of methyl mercury are very low compared to metallic mercury concentrations and are not considered to be a hazard. A study on mercury in lichen at the Theodore Roosevelt National Park in the U.S. showed a 30% decrease in mercury concentration over the 16 year period of the study. It is expected that mercury levels in lichen at the HLL site will also show a progressive decline now that the factory has been closed and mercury emissions to atmosphere terminated.

5.7 Mercury Levels in Sediments and Fish in Kodai Lake

Four samples of edible fish were purchased from fishermen at Kodai Lake at the time of catch and the muscle tissue analysed for mercury. All four fish returned a mercury concentration of 0.04 mg/kg as wet weight. These results are provided in Table 11. This is at the lower range of mercury in fish concentrations reported from uncontaminated freshwater lakes and below the international health advisory limits for human fish consumption. Lake bed sediments, lake water and near shore soils also returned levels of mercury either below detection limit or representative of low level background concentrations. These sampling locations are shown on Figure 6 and the results are provided in Table 7.

These results confirm that there has been no measurable impact on Kodai Lake from mercury discharges at the mercury thermometer factory. They further suggest that the recognised main pathway for mercury entering the food chain via consumption of fish is not present in this area.

A detailed discussion of these findings is given in Appendix G.

6.1 Mercury in the Environment

All chemical compounds of Hg are toxic to humans although Hg° (elemental mercury) may have to be oxidised to ionic forms to show toxic effects. Organomercurials, in particular methyl mercury appear to show strong teratogenic effects, and carcinogenic and mutagenic activity have also been implied.

Occupational Health and Safety Guidelines applicable to mercury in the workplace are therefore very stringent. The most applicable guidelines are those published by the US Department of Health and Human Services, National Institute for Occupational Safety and Health (NIOSH). The Kodaikanal Thermometer Factory closely followed the NIOSH guidelines for mercury vapour which include a maximum time weighted average mercury concentration of $0.05 mg/m^3$ in air and regular monitoring of mercury levels in urine of all employees.

An estimate of the global atmospheric repository of mercury (Fitzgerald 1994) is 5 million kg. Nriagu (1979) also estimated that ocean sediments contain about 10^{14} kg of mercury, ocean waters about 10^{10} kg, soils and freshwater sediments 10^{10} kg, the biosphere 10^{8} kg and freshwater 10^{4} kg ; his estimate of 10^{5} kg for the atmosphere is 50 times lower than Fitzgeralds subsequent calculation.

Basic processes involved in the atmospheric fate and transportation of mercury include; emissions to the atmosphere; transformation and transport in the atmosphere; deposition from the air and then re-emission to the atmosphere. Current natural global emissions arise from mercury were present as part of the pre-industrial equilibrium and subsequently as mercury which has been mobilised from geologic deposits and added to the global cycle by human activity.

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

- Burning of fossil fuels, mainly coal;
- Consumption related discharges, including waste incineration
- Industrial production processes, in particular the mercury cell chlor-alkali process for production of chlorine and caustic soda;
- Mining and smelting of copper and zinc ores;
- Use of agricultural fertilisers, fungicides and seed disinfectants.

Annual estimates of mercury release in the United States (U.S. EPA 1997) give the following breakdown:

–	Coal fired power stations	46.9 t
–	Incinerators	65.3 t
–	Other combustion sources	10.8 t
–	Chlor Alkali production	6.5 t
–	Lead and copper smelting	0.16 t
–	Other sources	12.1 t

About half of total anthropogenic mercury emissions eventually enter the global atmospheric cycle. Due to its low solubility in water metallic mercury has an average residence time in the atmosphere of about one year and is thus distributed fairly evenly in the troposphere. Current background concentrations of Hg in the atmosphere in remote oceanic regions is 1.6 ng/m^3. During pre-industrial times the natural level was 0.5 ng/m^3. The basic processes involved in the atmospheric fate and transport of mercury include emissions to the atmosphere, transformation and transport in the atmosphere.

An understanding of the global mercury cycle as briefly summarised above is important in understanding the fate and distribution of mercury derived from the Kodaikanal site. The measured concentrations of mercury in soils, waters, lake bed sediments and fish, for example, can be compared against published background levels in other parts of the world.

6.2 Kodaikanal

The volatilisation and re-emission of metallic mercury to the atmosphere and either local re-deposition in soils, bark, lichen etc or transfer to the global cycle is therefore seen to be an important part of the Kodaikanal mercury balance. The principal pathway for unaccounted mercury discharges offsite is via the stream which traverses the site and discharges southwards to the Pambar Shola. The volatilisation of mercury during its turbulent flow down to the Pambar River and subsequent air dispersion is seen to be a major mechanism for promoting the wider distribution of very low levels of mercury to the local and regional environments.

6.3 Potential Exposure Pathways – Human Health

Human exposure to mercury in the environment external to the mercury working areas in the factory may have occurred via the following mechanisms or pathways:

- Incidental ingestion of soil through hand to mouth contact;
- Inhalation of dusts;
- Inhalation of vapours;
- Ingestion of water; and
- Consumption of food grown in contaminated soil, or exposed to mercury vapours, or fish from mercury contaminated waterbodies.

In relation to the site, the following issues are relevant to the assessment of exposure pathways.

- The area, including the site, is heavily vegetated and therefore there exists limited opportunity for the generation of dust through wind erosion.
- The prime source of mercury vapours is via emissions from the factory extractor fans. When in operation, the site workers would represent the population most at risk from inhalation of vapours due to their proximity to the source. The mercury intake of workers has been assessed through a medical monitoring program.

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–	Other sources	12.1 t

The mercury balance which, has been derived in order to estimate the amount of mercury discharged to the Pambar Shola indicates a total in the order of 1350 kg over the 18 year life of thermometer production operation.

The results of soil, sediment, water and lichen samples which have been collected and tested from below the Levange Path and from the Pambar River upstream of Kumbakarrai Falls, confirm that it is extremely unlikely that the flora and fauna of the Pambar Shola and Pambar River have been at risk or currently at risk from the estimated mercury discharges from the site. Considering that the plant has ceased operations, the low levels of mercury currently found would be expected to further disperse and reduce with time. The silt traps which have been installed at the site will also greatly reduce the off site discharge of sediments in the main stream.

Kodai Lake is on a separate drainage catchment to the Factory and has been confirmed so by the results of the sampling and testing of soils on the lake banks and lake bed sediments. These results together with the results of the mercury testing in fish caught from the lake confirm that the site operations have not impacted the Kodai Lake. All soil and water samples taken from and around Kodai Lake contained total mercury concentrations below detection level. As described in Section 4.7, the sediment concentration which averaged 0.15mg/l and the fish samples which contained 0.04mg/kg (wet weight) are well below background concentrations found in freshwater lakes elsewhere in the world.

7.1 Clean Up Criteria

Risk Based Corrective Action (RBCA) is a USEPA accepted system for determining appropriate clean-up levels in soil based on assessment of sources, pathways, receptors and evaluation of health and ecological risk. The Tier 1 RBCA uses Risk Based Screening Levels (RBSLs) derived from published data and the Dutch criteria, which are acknowledged to be conservative, are commonly used internationally for this purpose.

The Dutch Intervention value of 10 mg/kg is based on multi-functional use of land over a shallow drinking water aquifer and is therefore very conservative for most sites. It is accepted that if the Intervention Value is exceeded a risk assessment should be undertaken to calculate a site specific value, and at the Kodaikanal Site this would be expected to be significantly higher than 10 mg/kg.

However, an alternative approach to the management of the Kodaikanal site is to adopt the conservative Dutch Intervention Value of 10 mg/kg total mercury as the remediation criteria. This approach would ensure that the site is suitable for any beneficial end use including residential without a requirement for further assessments and possible additional remediation work in the future.

7.2 Conclusions

Mercury impacted soil has been identified at the HLL Plant site in Kodaikanal. The total estimated volume of impacted soil requiring remediation to a level of 10 mg/kg is in the order of 4,100 m^3 equivalent to about 7,400 tonnes of soil containing approximately 291kg of mercury.

In addition, it has been estimated that additional mercury at concentrations between 0.1 and 10 mg/kg has been deposited at shallow depth across the site (75 kg) and to the north and south of the site (30 kg) primarily from airborne mercury emitted from the factory. This does not require remediation and levels will decrease naturally over time. There has also been offsite transfer of mercury by runoff to the south via the main stream which traverses the site, crosses the Levange Path and falls 1,300 m down to the Pambar River.

Based on mercury balance calculations the maximum discharge from site to the Pambar River catchment may be of the order of 1,350 kg of mercury over a period of 18 years or an average of about 75 kg/year.

These figures will be revised when mercury recycling of glass scrap and site remediation has been completed.

Despite extensive sampling on site and offsite there is little evidence of the ultimate receptor of this mercury. There are slightly elevated mercury concentrations in soil, lichen and bark extending a short distance from the factory boundary.

Sampling along the course of the main stream down the precipice below the site to the south indicates the presence of some isolated pockets of residual mercury in sediment commencing at the small depression on the Levange Path where the main stream exits the factory site and attenuating at the Pambar River.

Sampling at the Pambar River and for a considerable distance downstream have not revealed any indications of mercury accumulations in water, soil or vegetation with all samples being below detection limits.

The cascading of mercury in water southwards from the site down the steep precipice leading to the Pambar River is postulated to have resulted in volatilisation of almost all mercury and release to atmosphere before reaching the river. As such, a large proportion would have entered the global atmospheric mercury cycle and become very widely distributed at very low concentrations.

The sampling and testing of water and sediment in Kodai Lake, which lies within a separate hydrological catchment to the factory site confirms that there has not been any mercury accumulation or impact on ecology of the lake.

Slightly elevated mercury levels were found in the lichen immediately north of the site, but similar to all other locations where elevated mercury levels have been observed, the methyl mercury concentrations are low, generally less than detection limit. Lichen further away from the site on the bank of Kodai Lake contains less than the detection limit of 0.2 mg/kg of total mercury.

The available soil and water data and the medical surveillance data suggest that the risks to human health during the operation of the plant have been insignificant and negligible. The available data and the mechanisms by which mercury is believed to have migrated beyond the site and the relatively small area of forest affected, also suggest an extremely low potential for adverse effects on the environment. Mercury does not accumulate in lichen and bark by uptake from contaminated soils and the elevated concentrations, where observed are related to absorption from atmospheric discharges during the operation of the Plant.

The elevated levels of total mercury detected in some lichen samples are not considered to be of major concern due to the following reasons:

- The organic mercury (methyl mercury) component in all the lichens tested was either mostly below detection limits or at extremely low concentration;
- The mercury levels in lichen at limited distances from the site, namely at Pambar River in the south and Kodai lake in the north, are either below detection limits or close to background levels when detected;
- The mercury concentrations in the bark tested were generally found to be less than the detection limit suggesting that the elevated levels in the lichen have no impact on the trees nor their fruit and leaves which are the more likely routes to the food chain;
- The plant is now shutdown and the levels of mercury in the lichen which are currently present will further disperse in the environment and reduce over time through growth and decay;
- Cattle, monkeys, birds and insects which may come into contact with the areas containing lichen with elevated mercury concentrations will do so infrequently, if at all. There is no evidence or literature to suggest that this is a potential pathway for mercury accumulation in animals. This is further supported by the very low levels of methyl mercury which are reported.

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Based on mercury balance calculations the maximum discharge from site to the Pambar River catchment may be of the order of 1,350 kg of mercury over a period of 18 years or an average of about 75 kg/year.

These figures will be revised when mercury recycling of glass scrap and site remediation has been completed.

Despite extensive sampling on site and offsite there is little evidence of the ultimate receptor of this mercury. There are slightly elevated mercury concentrations in soil, lichen and bark extending a short distance from the factory boundary.

Sampling along the course of the main stream down the precipice below the site to the south indicates the presence of some isolated pockets of residual mercury in sediment commencing at the small depression on the Levange Path where the main stream exits the factory site and attenuating at the Pambar River.

Excavation of the soils is planned to be carried out by a combination of small excavation equipment (similar to a backhoe or bobcat) and manual excavation. In steeply sloping areas such as Area B, access to machinery will be limited and therefore manual excavation methods are likely to be adopted.

7.4.1 Remediation Action Plan

URS Dames & Moore has prepared a Remedial Action Plan (RAP) incorporating various protocols which will include environmental controls to be implemented during the remediation work. The RAP will address issues related to stormwater runoff control including various measures that would be required to prevent stormwater runoff from clean areas entering the remediation areas. The RAP will also detail measures to divert water collected in disturbed areas through silt traps/sediment fences, etc prior to leaving the areas being remediated. All disturbed areas will also be protected from erosion by suitable means until such time there is sufficient vegetation.

The excavated material will be packed in polythene bags, sealed and placed in drums (equivalent to 44 gallon drums). These drums containing the impacted material will be sealed with lids and clamps, stacked and stored temporarily in the factory premises until an appropriate site for disposal or intermediate storage pending final disposal is identified by the TNPCB.

The RAP also describes the site validation program that should be implemented once the soils with elevated mercury (>10 mg/kg) in Areas A, B and C (C1 and C2) are excavated out. The RAP will cover the following issues:

- Procedure for Excavation of Impacted Materials, Transport & Storage;
- General Site Management;
- Noise Control;
- Erosion Sediment and Stormwater Control;
- Air Quality Control;
- Machinery and Equipment;
- Contingency Planning and Emergency Procedures; and
- Validation.

7.4.2 Health & Safety Plan

URS has prepared a detailed Health & Safety Plan (H&S Plan) to be strictly implemented during all phases of the site remediation activities. The H&S Plan will address the following as a minimum:

- Description of work activities and the associated physical hazards;
- Personal Protective Equipment to be worn by all persons involved in the site remediation activities;
- Role of the Site Health & Safety Officer;

- Description of Chemical Hazards and Air Monitoring Requirements and Action Levels including Control Measures;
- Definition of Exclusion Zones;
- Personnel and Equipment Decontaminants; and
- Emergency Response Plan.

A medical surveillance program will also be implemented where mercury levels in urine of all persons involved will be measured on all workers before and after the remediation works are completed. Urine tests will also be done on all workers at the beginning of each working day.

7.4.3 Offsite Disposal

HLL's intention is to temporarily store the excavated soil from Areas A, B and C (C1 and C2) and the building rubble from the demolished buildings (if found to contain elevated levels of mercury) within the factory premises until an appropriate site for disposal or intermediate storage pending disposal is identified by the TNPCB. Once a suitable disposal site has been obtained, the drums will be loaded into trucks and transported.

Discussions are currently underway between HLL, Indian Regulatory Authorities and Bethlehem Apparatus Company in the USA with regard to obtaining consent to export the glass scrap for processing and recovery of mercury. The stored ETP sludge is also proposed to be exported to Bethlehem Apparatus Company.

Respectfully submitted
URS DAMES & MOORE

Dr Damika Wickremesinghe
Principal Remediation Engineer

Dr Martin Howell
Senior Principal Chemist

Paul Whincup
Senior Consultant to URS Dames & Moore

Table 1
Summary: Samples Tested for Total Mercury

	ONSITE	OFFSITE	TOTAL
Soil	346	18	364
Sediment	2	22	24
Water	5	16	21
Lichen	7	28	35
Bark	7	25	32
TOTAL	367	109	476

Table 2

Details of Sales of Scrap Glass Cullets

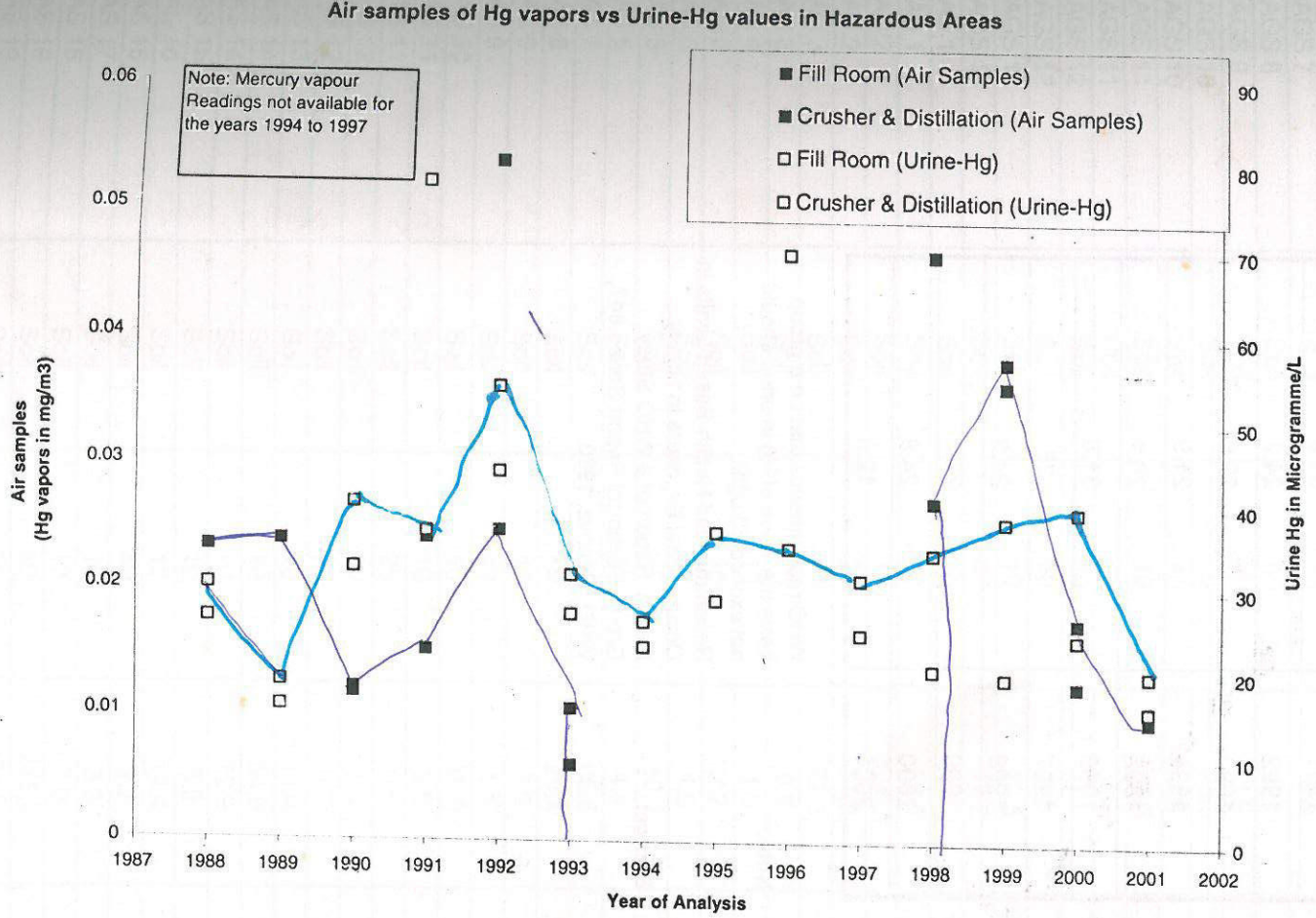
Date	Name of the Party	1 & 2 (kg)	3 & 4 Recovery (kg)	3 & 4 Enhanced Recovery (kg)
28-04-92	MLC Industries Limited, Mysore	2000		
21-11-93	MLC Industries Limited, Mysore	8000		
22-12-93	MLC Industries Limited, Mysore	8000		
5-04-94	MLC Industries Limited, Mysore	6000		
26-10-94	MLC Industries Limited, Mysore		7044.6	
26-10-94	MLC Industries Limited, Mysore		6955.4	
22-12-95	Raj Agencies, Anna Nagar, Chennai		9000	
27-12-95	Raj Agencies, Anna Nagar, Chennai		9000	
9-05-97	Thirupathi Udyog, Coimbatore	9660		
21-08-97	Thirupathi Udyog, Coimbatore	4617		
4-04-98	M. Jakir Hussain, Theni	5929		
27-09-98	PPS & Co., Coimbatore		5550	
27-09-98	PPS & Co., Coimbatore		6027.1	
24-05-99	Thirupathi Udyog, Coimbatore	5152.5		
11-11-99	Mr. Ramesh (Thiraviyam), Kodaikanal			2743
19-11-99	Mr. Ramesh (Thiraviyam), Kodaikanal			2584
	Total 98263.	49358.5	43577.1	5327

Notes:

1. Raj Agencies in Chennai has consumed all the materials in glass marble manufacture, except 4.8 tonnes of glass scrap with mud, which has been retrieved by HLL.
2. Thirupathi Udyog in Coimbatore has confirmed that all the materials have been consumed except for 30 kg, which has been retrieved by HLL.
3. Mr Jakir Hussain has sold the scrap to a glass manufacturer who has consumed all the materials.
4. PPS & Co., in Coimbatore has sold 8.0 tonnes to Philips India Limited and 3.6 tonnes was sold to glass marble manufacturers. From the marble manufacturer, about 1.3 tonnes (including mud) has been retrieved by HLL in Bangalore.

43577 / 5327 / 48904

Table 3
Air Monitoring Data



	Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Fill Room	Air Samples (mg/m3)	0.023	0.024	0.012	0.015	0.025	0.010					0.046	0.038	0.012	0.010
Crusher & Distillation Room	Air Samples (mg/m3)			0.012	0.024	0.054	0.006					0.027	0.036	0.017	0.010
Fill Room	Urine-Hg (microgrammes/L)	30.15	18.700	40.100	78.050	54.000	31.507	25.923	28.540	69.663	31.125	34.280	38.158	39.479	19.975
Crusher & Distillation Room	Urine-Hg (microgrammes/L)	26.2	15.829	32.270	36.700	43.890	26.777	22.934	36.737	34.869	24.585	20.403	19.521	24.144	15.821

Table 4

Medical Surveillance Data

Mean Urinary Mercury Values of Current and Ex-Employees (1988-2001)

Year	Group Mean Values of Hg in Urine in ug/lit
1988	22.7
1989	16.4
1990	26.4
1991	31.9
1992	24.2
1993	22.6
1994	21.9
1995	26.1
1996	31.8
1997	26
1998	24.3
1999	21.3
2000	24.8
2001	12.9

Note: WHO recommends that on a group basis the value of Hg in urine should not exceed 50 ug/lit.

Source: Recommended Health-Based Limits in Occupational Exposure to Heavy Metals. Report of a WHO Study Group. Technical Report Series 647, WHO, Geneva, 1980.

Table 5

Total Mercury Concentrations in Soil/Sediment/Water Samples from On Site Locations

Sample Location	Type of Sample	Sample Depth (cm)	Hg in mg/kg	
			HLRC	MGT
AGS 1	Soil	40	6.7	-
AGS 2	Soil	30	3.1	-
AGS 3	Soil	20	79.4	-
AGS 3	Soil	50	50.60	-
AGS 4	Soil	40	12.5	-
AGS 5	Soil	40	22.3	-
AGS 6	Soil	20	15.9	-
AGS 7	Soil	20	8.6	-
AGS 8	Soil	40	6.1	-
AGS 9	Soil	40	3.5	-
AGS 10	Soil	10	28.5	-
AGS 10	Soil	40	0.9	-
AGS 11	Soil	10	10.3	-
AGS 11	Soil	40	2.9	-
AGS 12	Soil	10	6.4	-
AGS 12	Soil	40	2.6	-
AGS 13	Soil	10	22.5	-
AGS 13	Soil	40	19.2	-
AS 1	Soil	10	177.3	-
AS 1	Soil	40	22.6	-
AS 2	Soil	10	136.3	-
AS 2	Soil	25	77.8	-
AS 3	Soil	10	72.3	-
AS 3	Soil	20	6.7	-
AS 4	Soil	10	1.5	-
AS 5	Soil	10	2.2	-
AS 5	Soil	25	1.5	-
AS 6	Soil	10	10.1	-
AS 6	Soil	15	4.4	-
AS 7	Soil	10	85.5	-
AS 8	Soil	10	25.4	-
AS 9	Soil	10	9.5	-
AS 9	Soil	40	1.1	-
AS 10	Soil	10	16.0	-
AS 11	Soil	10	3.5	-
AS 11	Soil	25	0.5	-
AS 12	Soil	10	5.8	-
AS 12	Soil	25	0.7	-
AS 13	Soil	10	11.4	-
AS 14	Soil	10	54.6	-
AS 14	Soil	20	22.9	-
AS 15	Soil	10	6.0	-
AS 16	Soil	10	14.4	-
AS 16	Soil	40	2.2	-
AS 17	Soil	10	3.3	-
AS 18	Soil	10	7.9	-
AS 19	Soil	10	215.7	-
AS 19	Soil	25	21.7	-
AS 20	Soil	10	37.5	-
AS 20	Soil	30	37.5	-

Table 5
Total Mercury Concentrations in Soil/Sediment/Water Samples from On Site Locations

Sample Location	Type of Sample	Sample Depth (cm)	Hg in mg/kg	
			HLRC	MGT
AS 21	Soil	10	0.8	-
AS 21	Soil	20	21.6	-
AS 22	Soil	10	5286.0	-
AS 22	Soil	40	32.8	-
AS 23	Soil	10	37.2	-
AS 23	Soil	40	2.1	-
AS 24	Soil	10	5.4	-
AS 24	Soil	20	12.3	-
AS 25	Soil	5	3.2	-
AS 26 (not sampled)	-	-	-	-
AS 27	Soil	10	71.1	-
AS 28	Soil	10	36.0	-
AS 28	Soil	20	49.4	-
AS 29	Soil	10	9.0	-
AS 30	Soil	10	3.1	-
AS 30	Soil	20	4.4	-
AS 31	Soil	10	6.2	-
AS 31	Soil	25	0.6	-
AS 32	Soil	10	0.7	-
AS 32	Soil	35	2.4	-
AS 33	Soil	10	27.3	-
AS 33	Soil	20	32.0	-
AS 34	Soil	10	151.4	-
AS 34	Soil	35	4.3	-
AS 35	Soil	10	66.6	-
AS 35	Soil	35	38.0	-
AS 36	Soil	10	21.4	-
AS 36	Soil	35	0.6	-
AS 37	Soil	10	5.1	-
AS 38	Soil	10	1.2	-
AS 38	Soil	30	0.8	-
BE	Soil	5	65.2	59
BE 1	Soil	10	2.5	0.51, 0.50
BE 2	Soil	10	1.6	0.13
BE 3	Soil	10	2.0	0.26
BGE	Soil	5	4.5	22, 24
BGW	Soil	5	2.5	2.5
BN 1	Soil	10	33.3	35
BN 1	Soil	40	8.4	6.7
BRW*	Water**	-	24.0	0.085 (mg/L)
BS 1	Soil	10	0.6	0.14
BS 2	Soil	10	1.1	< 0.1
BS 3	Soil	10	9.9	6.2
BS 4	Soil	10	2.3	2.7
BS 5	Soil	10	1.2	0.99
BW	Soil	5	34.3	9.4
CCT 1	Soil	10	18.3	-
CCT 1	Soil	40	26.6	-
CCT 2	Soil	10	25.6	-
CCT 2	Soil	40	3.1	-

Table 5
Total Mercury Concentrations in Soil/Sediment/Water Samples from On Site Locations

Sample Location	Type of Sample	Sample Depth (cm)	Hg in mg/kg	
			HLRC	MGT
CD	Soil	5	67.8	14
CD	Soil	50	60.8	71
CT 1	Soil	10	108.0	330
CT 1	Soil	80	5.9	47
CT 1	Soil	130	3.7	14
DD	Sediment	Stream bed	73.0	270
DD	Soil	40	9.1	25
DP	Soil	5	123	40
DP	Soil	50	30	20
DP 1	Soil	10	18.8	36
DP 1	Soil	40	31.0	155
DP 2	Soil	10	5.3	5.9
DP 3	Soil	10	1.4	3.2
DP 4	Soil	10	1.4	5.9
DP 4	Soil	50	2.4	3.8
DP 5	Soil	10	-	40
DP 6	Soil	10	-	20
ES	Water **	-	-	<0.0003 (mg/L)
FC 1	Soil	10	1.6	1.7
FC 2	Soil	10	1.3	1.3
FC 3	Soil	10	1.5	1.7
FC 4	Soil	10	8.9	16
FC 5	Soil	10	1.8	3.2
FN 1	Soil	10	0.9	2.5
FN 2	Soil	10	0.8	1.0
FN 3	Soil	10	0.6	0.75
FN 4	Soil	10	62.8	60
FN 4	Soil	80	4.0	10
FN 5	Soil	10	171.0	240
FS 1	Soil	10	68.5	-
FS 1	Soil	40	7.7	-
FS 2	Soil	10	7.7	-
FS 2	Soil	40	27.6	-
FS 2	Soil	70	25.4	-
FS 2	Soil	100	57.5	-
FS 3	Soil	40	2.3	-
FS 4	Soil	40	43.7	-
FS 5	Soil	40	15.9	-
FS 5	Soil	85	315.1	-
FS 5	Soil	70	74.9	-
FS 6	Soil	40	76.7	-
FS 6	Soil	70	83.5	-
FS 6	Soil	100	19.8	-
FS 7	Soil	40	7.8	-
FS 8	Soil	40	118.4	-
FS 8	Soil	70	46.1	-
FS 8	Soil	100	1011	-
FS 9	Soil	10	114.9	-
FS 9	Soil	40	2.1	-
FS 10	Soil	10	68.5	-

Table 5
Total Mercury Concentrations in Soil/Sediment/Water Samples from On Site Locations

Sample Location	Type of Sample	Sample Depth (cm)	Hg in mg/kg	
			HLRC	MGT
FS 10	Soil	40	28.1	-
FS 11	Soil	10	12.6	-
FS 11	Soil	40	1.0	-
FS 12	Soil	10	5.4	-
FS 12	Soil	40	2.4	-
FS 13	Soil	10	6.9	-
FS 13	Soil	40	2.3	-
FS 14	Soil	10	3	-
FS 14	Soil	40	2.8	-
FS 15	Soil	10	9.3	-
FS 15	Soil	40	3.7	-
FS 16	Soil	10	95.6	-
FS 16	Soil	40	67.9	-
FS 17	Soil	10	204	-
FS 17	Soil	40	68.3	-
FS 18	Soil	10	80.2	-
FS 18	Soil	40	74.9	-
FS 19	Soil	10	19.5	-
FS 19	Soil	40	2.4	-
FS 20	Soil	10	16.6	-
FS 20	Soil	40	2.3	-
FS 21	Soil	10	5.8	-
FS 21	Soil	40	4.4	-
FS 23	Soil	20	-	10, 10
FS 24	Soil	20	-	0.64
FS 25	Soil	20	-	81, 85
FS 26	Soil	10	-	650
FS 26	Soil	30	-	34
FS 27	Soil	20	-	150
FS 28	Soil	20	-	5.3
FS 29	Soil	20	-	51
FS 30	Soil	20	-	3.1
FS 31	Soil	20	-	16
GS 0	Soil	40	14.6	-
GS 0	Soil	50	440.6	-
GS 1	Soil	40	107.4	-
GS 1	Soil	70	144.5	-
GS 2	Soil	10	118.3	-
GS 2	Soil	40	10.0	-
GS 3	Soil	20	7.6	34
GS 4	Soil	40	7.2	-
GS 5	Soil	40	11.9	-
GS 6	Soil	30	8.2	-
GS 7	Soil	40	7.9	-
GS 8	Soil	40	3.3	-
GS 9	Soil	40	5.0	-
GS 10	Soil	30	14.7	-
GS 10	Soil	40	5.8	-
GS 11	Soil	30	21.2	-
GS 12	Soil	30	21.2	-

amples from

ng/kg

MGT
-
-
-
-
-
-
-
-
-
-
-
-
-
-
-
-
-
-
-
-
-
10, 10
0.64
81, 85
650
34
150
5.3
51
3.1
16
-
-
-
-
-
-
34
-
-

Table 5
Total Mercury Concentrations in Soil/Sediment/Water Samples from On Site Locations

Sample Location	Type of Sample	Sample Depth (cm)	Hg in mg/kg	
			HLRC	MGT
GS 12	Soil	70	59.2	-
GS 13	Soil	30	8.5	-
GS 14	Soil	10	20.9	-
GS 14	Soil	20	32.1	-
GS 14	Soil	40	107.4	-
GS 15	Soil	10	33	-
GS 15	Soil	40	7.9	-
GS 16	Soil	10	11.1	-
GS 16	Soil	40	19.9	-
GS 17	Soil	10	4.5	-
GS 17	Soil	40	5	-
GS 18	Soil	10	59.3	-
GS 18	Soil	40	22.2	-
GS 19	Soil	10	2.4	-
GS 19	Soil	40	1.8	-
GS 20	Soil	40	56.3	-
GS 21	Soil	10	87.8	-
GS 21	Soil	40	3.8	-
GS 22 (not sampled)	-	-	-	-
GS 23	Soil	20	-	23
GS 23	Soil	40	10.0	-
GS 24	Soil	20	-	120
GS 25	Soil	30	-	60
GS 26	Soil	30	-	2800
GS 26	Soil	40	-	75, 71
GS 26	Soil	60	-	31
GS 27	Soil	10	-	410
GS 28	Soil	20	-	74
GS 29	Soil	20	-	100
GS 30	Soil	20	7.6	34
GS 31	Soil	30	-	35
HL 1	Soil	10	8.3	7.3
HL 1	Soil	80	1.6	2.9
IF 1A (not sampled)	-	-	-	
IF 2A	Soil	30	-	2.0, 2.2
IF 2A	Soil	60	-	1.1
IF 2B	Soil	30	-	3.5
IF 3A	Soil	30	-	0.81
IF 3A	Soil	50	-	0.48
IF 4A	Soil	30	-	3.1
IF 4A	Soil	60	-	0.78
IF 5A	Soil	30	-	5.0
IF 5A	Soil	60	-	0.58
IF 5B	Soil	20	-	1.2
IF 5B	Soil	40	-	0.80
IF 7A	Soil	30	-	0.70
IF 8A	Soil	30	-	0.68, 0.7
IF 8A	Soil	50	-	0.63
IF 8B	Soil	30	-	0.73
IF 8B	Soil	50	-	0.73

Table 5
Total Mercury Concentrations in Soil/Sediment/Water Samples from On Site Locations

Sample Location	Type of Sample	Sample Depth (cm)	Hg in mg/kg	
			HLRC	MGT
IF 9A	Soil	20	-	0.70
IF 10A	Soil	30	-	0.53
IF 10A	Soil	50	-	0.55
IF 10B	Soil	30	-	0.74
IF 10B	Soil	50	-	0.43
IF 13A	Soil	30	-	23
IF 13A	Soil	50	-	0.91
IF 13B	Soil	30	-	0.58
IF 13B	Soil	50	-	0.51
IF 14A	Soil	30	-	0.53
IF 14A	Soil	50	-	3.6
IF 14A	Soil	60	-	2.4
MD	Soil	5	1.0	20
MD	Soil	50	3.1	11
MDRW*	Water **		-	0.031(mg/L)
NS	Soil	5	3.0	4.5
OFN 1	Soil	5		23
OFN 1	Soil	30		1.9, 2.3
OFN 2	Soil	5		14
OFN 2	Soil	30		0.3
OFN 3	Soil	5		16
OFN 3	Soil	30		0.44
P 1	Soil	5	9.7	20
P 1S	Soil	10	2.2	1.9
P 1S	Soil	40	1.2	0.59
P 2	Soil	5	21.0	62
P 2S	Soil	10	3.5	4.1
P 2S	Soil	40	17.1	5.3
P 3	Soil	10	13.0	25
P 3S	Soil	10	0.8	4.7
P 3S	Soil	30	3.4	5.7, 5.7
P 4	Soil	5	10.1	9.4
P 4E	Soil	10	11.9	20
P 4E	Soil	80	1.5	5.0
P 4S	Soil	10	22.9	31
P 4SE	Soil	10	6.2	10
PPE	Soil	5	2.2	4.6
PPS	Soil	10	3.7	32
PPS 1	Soil	10	2.7	6.7
PPS 2	Soil	10	2.8	0.35
PPS 3	Soil	10	3.0	3.0
PPW	Soil	5	5.8	13, 13
S 1	Soil	10	4.1	-
S 1	Soil	40	10.2	-
S 2	Soil	10	16.2	-
S 2	Soil	40	2.8	-
S 3	Soil	10	2.0	-
S 3	Soil	30	0.8	-
S 4	Soil	10	0.9	-

Table 5
Total Mercury Concentrations in Soil/Sediment/Water Samples from On Site Locations

Sample Location	Type of Sample	Sample Depth (cm)	Hg in mg/kg	
			HLRC	MGT
S 5	Soil	5	8.4	-
S 6	Soil	10	44.6	-
S 6	Soil	40	1.0	-
S 7	Soil	10	7.9	-
S 7	Soil	40	2.0	-
S 8	Soil	10	16.8	-
S 9	Soil	10	178.8	-
S 9	Soil	20	51.8	-
S 10	Soil	10	2.6	-
S 10	Soil	15	2.9	-
S 11	Soil	10	5.7	-
S 11	Soil	25	0.7	-
S 12	Soil	5	8.0	-
S 13	Soil	10	1.5	-
S 13	Soil	40	0.6	-
S 14	Soil	10	6.5	-
S 14	Soil	15	4.0	-
S 14	Soil	25	4.0	-
S 15	Soil	10	2.4	-
S 16	Soil	10	1.2	-
S 17	Soil	10	1.2	-
S 18	Soil	10	4.4	-
S 19	Soil	10	5.1	-
S 20	Soil	10	3.0	-
S 21	Soil	10	0.7	-
SA 1	Soil	10	22.0	-
SA 2	Soil	10	28.8	-
SA 2	Soil	40	153.7	-
SA 3	Soil	10	30.8	-
SA 4	Soil	10	57.6	-
SA 4	Soil	25	2.6	-
SA 5	Soil	10	4.0	-
SA 5	Soil	25	0.3	-
SA 6	Soil	10	12.8	-
SA 7	Soil	10	20.9	-
SA 7	Soil	40	2.9	-
SA 8	Soil	10	5.9	-
SA 8	Soil	35	0.9	-
SA 9	Soil	10	3.9	-
SA 10	Soil	10	42.8	-
SA 10	Soil	40	0.6	-
SA 11	Soil	10	2.8	-
SA 11	Soil	40	0.5	-
SA 12	Soil	10	4.3	-
SA 12	Soil	25	13.0	-
SA 13	Soil	10	236.1	-
SA 14	Soil	10	1.2	-
SA 14	Soil	25	0.4	-
SS	Soil	5	2.0	6.6
SS 1	Soil	10		3.5

Table 5
Total Mercury Concentrations in Soil/Sediment/Water Samples from On Site Locations

Sample Location	Type of Sample	Sample Depth (cm)	Hg in mg/kg	
			HLRC	MGT
SS 2	Soil	10		2.6
SW	Water **	-	-	<0.0003 (mg/L)
TB	Soil	5	12.5	31
TBD	Sediment	Stream Bed	41.9	110
VE 1	Soil	10		1.1
WS	Water **	-	-	<0.0003 (mg/L), <0.0003 (mg/L)

Note: **All water samples are unfiltered when tested in the laboratory.

* Sample of surface runoff water collected during heavy storm

1. Mercury globules observed in sample.

amples from

g/kg
MGT
2.6
0.0003 (mg/L)
31
110
1.1
.0003 (mg/L),
.0003 (mg/L)

Table 6

Total Mercury Concentrations in Bark/Lichen Samples from On Site Locations

Sample Location	Type of Sample	Hg in mg/kg		
		TNO (NEN)	MGT (NEN)	MGT (USEPA)
B1	Bark	20.4		
B2	Bark	13		
B3	Bark	4.1		
B4	Bark	2.6		
B5	Bark	1.24		
B6	Bark		<0.2, <0.2	
B7	Bark		<0.2	
L1	Lichen	60		
L2	Lichen	63		
L3	Lichen	87		
L4	Lichen	18.3		
L5	Lichen	15.4		
L6	Lichen		29	21
L7	Lichen		16	14, 16

Table 7

Total Mercury Concentrations in Soil/Sediment/Lichen/Water Samples North Site including Kodai Lake

Sample Location	Type of Sample	Sample Description	Hg in mg/kg	
			MGT (USEPA)	MGT (N
CC-1 (Carlton Compound)	Soil	5 cm bgl	1.1	-
CM (Charlemont Property)	Soil	5 cm bgl	2.2	-
CM-1 (Charlemont Property)	Soil	5 cm bgl	1.3, 1.2	-
CM-2 (Charlemont Property)	Soil	5 cm bgl	0.70	-
CML (Charlemont Property)	Lichen	From tree trunk	4.5	-
CML-2 (Charlemont Property)	Lichen	From tree trunk	4.8	-
CM-51(Charlemont Property)	Lichen	From tree trunk	-	7
CM-51(Charlemont Property)	Bark	From tree trunk	-	5
CM-52 (Charlemont Property)	Lichen	From tree trunk	2.2(a)	-
CM-52 (Charlemont Property)	Bark	From tree trunk	-	6.5
CM-53 (Charlemont Property)	Lichen	From tree trunk	26	25, 33
CM-53 (Charlemont Property)	Bark	From tree trunk	-	9
CM-54 (Charlemont Property)	Lichen	From tree trunk	-	6.5
CM-54 (Charlemont Property)	Bark	From tree trunk	-	1.8
CM-55 (Charlemont Property)	Lichen	From tree trunk	-	8.5
CM-55 (Charlemont Property)	Bark	From tree trunk	-	3.4, 3.0
KDLK-51(Kodai Lake)	Sediment	Lake Bed	0.08, 0.07	<0.2
KDLK-52 (Kodai Lake)	Sediment	Lake Bed	0.05, 0.10	<0.2
KDLK-53 (Kodai Lake)	Sediment	Lake Bed	0.13	<0.2
KDLK-54 (Kodai Lake)	Sediment	Lake Bed	0.20, 0.18	<0.2
KDLL (Kodai Lake Bank)	Lichen	From tree trunk	-	<0.2
LK1 (Kodai Lake Bank)	Soil	5 cm bgl	<0.1	-
LK2 (Kodai Lake Bank)	Soil	5 cm bgl	<0.1	-
LK3 (Kodai Lake Bank)	Soil	5 cm bgl	<0.1	-
LKW (Kodai Lake)	Water	From Lake	<0.0003(mg/L)	-
LSL (Lower Shola Road)	Lichen	From tree trunk	5.0, 2.8(a)	3.1
LSL (Lower Shola Road)	Bark	From tree trunk	-	<0.2
MH-51(Malhotra Property)	Lichen	From tree trunk	48	55, 68
MH-51 (Malhotra Property)	Bark	From tree trunk	-	4.7
MH-52 (Malhotra Property)	Lichen	From tree trunk	-	11
MH-52 (Malhotra Property)	Bark	From tree trunk	-	1.8
US1 (Upper Shola Road)	Soil	5 cm bgl	<0.1, <0.1	-
US2 (Upper Shola Road)	Soil	5 cm bgl	<0.1	-
US3 (Upper Shola Road)	Soil	5 cm bgl	<0.1	-
US4 (Upper Shola Road)	Soil	5 cm bgl	<0.1, <0.1	-
US5 (Upper Shola Road)	Soil	5 cm bgl	<0.1	-
US6 (Upper Shola Road)	Soil	5 cm bgl	<0.1	-
USW 1 (Upper Shola Road)	Water	Stream	<0.0003 (mg/L)	-

Notes: (a) = ALS-USEPA Method; bgl = below ground level
All water samples are unifiltered when tested in laboratory

Table 8

Total Mercury Concentrations in Soil/Sediment/Lichen/Bark/Water Samples South of Site (Levange Path, Shola Forest, Pambar River, Kumbakarrai Falls)

Sample No.	Sample Type	Sample Depth	Total Hg, dry basis in mg/kg				Sampling Location Description
			HLRC	MGT (USEPA)	TNO (NEN)	MGT (NEN)	
DFE	Water	-	-	<0.0003	-	-	Main Stream Outfall
DFE	Sediment	Surface	41 ✓	85 ✓	-	-	Levange Path
DFE 1	Sediment	Surface	26	110 ✓	-	-	Main Stream Outfall on Levange Path
DFE 51	Sediment	-	-	61, 59 ✓	-	60 ✓	Main Stream Outfall on Levange Path
DFE W	Water	-	-	<0.0003	-	-	Main Stream Outfall
DFNE	Water	-	-	<0.0003	-	-	Levange Path
DFNE	Sediment	Surface	5	6	-	-	Levange Path
DS 1	Sediment	-	-	0.55	<1	-	On Main Stream immediately upstream of Pambar River
DS 1	Water	-	-	<0.0003	-	-	On Main Stream immediately upstream of Pambar River
DS 1	Bark	-	-	<0.1, <0.1	<2	-	On Main Stream immediately upstream of Pambar River
DS 1	Lichen	-	-	0.62	<5	-	On Main Stream immediately upstream of Pambar River
DS 1 A	Lichen	-	-	-	-	2.3	On Main Stream immediately upstream of Pambar River
DS 1 A	Bark	-	-	0.05	-	<0.2	On Main Stream immediately upstream of Pambar River
DS 1 A	Sediment	-	-	10,12	-	8.0	On Main Stream immediately upstream of Pambar River
DS 1 B	Lichen	-	-	-	-	1.2	On River immediately downstream of junction of mainstream and River
DS 1 B	Bark	-	-	-	-	<0.2	On River immediately downstream of junction of mainstream and River
DS 1 B	Sediment	-	-	0.56	-	0.52	On River immediately downstream of junction of mainstream and River
DS 2	Sediment	-	-	5.5	5.7	-	Location approximately 100 m south of DS3
DS 2	Water	-	-	<0.0003	0.45	-	Location approximately 100 m south of DS3
DS 2	Bark	-	-	0.22	<2	-	Location approximately 100 m south of DS3
DS 2	Lichen	-	-	1.3	10.4	-	Location approximately 100 m south of DS3
DS 2 A	Sediment	-	-	41,39 ✓	-	60	Location approximately 100 m south of DS3
DS 2 A	Lichen	-	-	30,19.5 (a) ✓	-	44, 36 ✓	Location approximately 100 m south of DS3
DS 2 A	Bark	-	-	2.6, 1.2(a)	-	3.3	Location approximately 100 m south of DS3
DS 2 N	Lichen	-	-	-	-	3.9	Location approximately 50m north and 50m west of DS2
DS 2 N	Bark	-	-	-	-	33	Location approximately 50m north and 50m west of DS2
DS 2 W	Lichen	-	-	-	-	4.4	Location approximately 50m west of DS2
DS 2 W	Bark	-	-	-	-	<0.2	Location approximately 50m west of DS2

Table 8

Total Mercury Concentrations in Soil/Sediment/Lichen/Bark/Water Samples South of Site (Levange Path, Shola Forest, Pambar River, Kumbakarrai Falls)

Sample No.	Sample Type	Sample Depth	Total Hg, dry basis in mg/kg				Sampling Location Description
			HLRC	MGT (USEPA)	TNO (NEN)	MGT (NEN)	
DS 3	Sediment	-	-	23, 28 ✓	51 ✓	-	Down-stream of Levange path (closer to site)
DS 3	Water	-	-	<0.0003	-	-	Down stream of Levange path (closer to site)
DS 3	Bark	-	-	0.55	3.1	-	Down-stream of Levange path (closest to site)
DS 3	Lichen	-	-	5.7, 5.8	34.4	-	Down-stream of Levange path (closer to site)
DS 3 A	LIchen	-	-	80, 35.6(a)✓	-	45	Down-stream of Levange path (closest to site)
DS 3 A	Bark	-	-	1.7, 4.1(a)	-	3.6	Down-stream of Levange path (closer to site)
DSW 1	Lichen	-	-	-	-	3.3	On Levange Path immediately south of southeast corner of HLL site
DSW 1	Bark	-	-	-	-	<0.2	On Levange Path immediately south of southeast corner of HLL site
DSW 2	Lichen	-	-	-	-	3.1	On Levange Path approximately 130m east of DSW1
DSW 2	Bark	-	-	-	-	5.5	On Levange Path approximately 130m east of DSW1
DW	Water	-	-	<0.0003	<0.002	-	Main Stream Outfall
KDU	Bark	-	0.1	<0.1	<2	-	Pambar River on the way 5 km to Kumbakarrai (Broken Bridge)
KDU	Lichen	-	0.5	<0.1	<2	-	Pambar River on the way 5 km to Kumbakarrai (Broken Bridge)
KDU	Sediment	Surface	0.3	<0.1	<1	-	Pambar River on the way 5 km to Kumbakarrai (Broken Bridge)
KDU	Water	-	<0.0003	<0.0003	<0.004	-	Pambar River on the way 5 km to Kumbakarrai (Broken Bridge)
KK	Bark	-	0.2	<0.1, <0.1	<2	-	Pambar River in Kumbakarrai - approx 100 stream
KK	Lichen	-	0.2	<0.1	<5	-	Pambar River in Kumbakarrai - approx 100 stream
KK	Sediment	Surface	1.1	<0.1	<1	-	Pambar River in Kumbakarrai - approx 100 stream
KK	Water	-	<0.0003	<0.0003	0.005	-	Pambar River in Kumbakarrai - approx 100 stream
KR	Sediment	Surface	-	<0.1	-	-	Just upstream of Kumbakarrai Falls opposite Temple
KR	Water	-	-	<0.0003	-	-	Just upstream of Kumbakarrai Falls opposite Temple
KUB	Bark	-	1.4	<0.1	<2	-	Upstream of Kumbakarrai approx 1 hr walk through Pambar River
KUB	Lichen	-	0.1	<0.1	<2	-	Upstream of Kumbakarrai approx 1 hr walk through Pambar River
KUB	Sediment	Surface	0.2	<0.1, <0.1	<1	-	Upstream of Kumbakarrai approx 1 hr walk through Pambar River
KUB	Water	-	-	<0.0003	<0.004	-	Upstream of Kumbakarrai approx 1 hr walk through Pambar River
KUM	Bark	-	0.2	<0.1	<2	-	Upstream of Kumbakarrai approx 2 hrs walk through Pambar River
KUM	Lichen	-	0.1	<0.1	<2	-	Upstream of Kumbakarrai approx 2 hrs walk through Pambar River
KUM	Sediment	-	0.6	<0.1	<1	-	Upstream of Kumbakarrai approx 2 hrs walk through Pambar River

KUB	Water	-	0.2	<0.1, <0.1	<1	-	Upstream of Kumbakarrai approx 1 hr walk through Pambar River
KUM	Bark	-	-	<0.0003	<0.004	-	Upstream of Kumbakarrai approx 1 hr walk through Pambar River
KUM	Lichen	-	0.2	<0.1	<2	-	Upstream of Kumbakarrai approx 1 hr walk through Pambar River
KUM	Sediment	-	0.1	<0.1	<2	-	Upstream of Kumbakarrai approx 2 hrs walk through Pambar River
			0.6	<0.1	<1	-	Upstream of Kumbakarrai approx 2 hrs walk through Pambar River
							Upstream of Kumbakarrai approx 2 hrs walk through Pambar River

Table 8

Total Mercury Concentrations in Soil/Sediment/Lichen/Bark/Water Samples South of Site (Levange Path, Shola Forest, Pambar River, Kumbakarrai Falls)

Sample No.	Sample Type	Sample Depth	Total Hg, dry basis in mg/kg				Sampling Location Description
			HLRC	MGT (USEPA)	TNO (NEN)	MGT (NEN)	
KUM	Water	-	<0.0003	<0.0003	-	-	Upstream of Kumbakarrai approx 2 hrs walk through Pambar River
KUT	Bark	-	0.2	<0.1	<2	-	Upstream of Kumbakarrai approx 3 hrs walk through Pambar River
KUT	Lichen	-	0.1	<0.1	<2	-	Upstream of Kumbakarrai approx 3 hrs walk through Pambar River
KUT	Sediment	-	0.2	<0.1	<1	-	Upstream of Kumbakarrai approx 3 hrs walk through Pambar River
KUT	Water	-	<0.0003	<0.0003	-	-	Upstream of Kumbakarrai approx 3 hrs walk through Pambar River
LP 1	(not sampled)	-	-	-	-	-	
LP 2	Soil	10	-	6.0	-	-	Levange Path
LP 3	Soil	10	-	2.4	-	-	Levange Path
LP 4	Soil	10	-	1.4	-	-	Levange Path
LP 5	Sediment	Surface	126 ✓	55 ✓	-	-	Levange Path
LP 6	Soil	10	0.8	1.1	-	-	Levange Path
LP 7	Soil	10	-	0.63	-	-	Levange Path
PDR	Bark	-	2.5	<0.1	<2	-	Pambar River joining Varaganathi in Periakulam
PDR	Lichen	-	0.1	<0.1	<2	-	Pambar River joining Varaganathi in Periakulam
PDR	Sediment	Surface	0.6	<0.1	<1	-	Pambar River joining Varaganathi in Periakulam
PDR	Water	-	<0.0003	<0.0003	-	-	Pambar River joining Varaganathi in Periakulam

Notes:
All water samples are unfiltered when tested in laboratory
Mercury concentration in water in mg/L
(a) = ALS-USEPA Method

Table 9

On Site Mercury Distribution and Details of Remediation Areas

Area	Concentration Range	Size of Area	Average Concentration (mg/kg)	Soil Volume with Mercury (m^3)	Weight of Mercury in Soil (kg)
A: Around Old Bakery	10 - 30 ppm	715 m^2	17.4	214	7
	30 - 50 ppm	735 m^2	33.3	220	13
	50 - 100 ppm	350 m^2	62	105	12
AREA A TOTAL		**1,800 m^2**		**539**	**32**
B: South of Ponds Path	10 - 30 ppm	1,810 m^2	20.7	543	20
	30 - 50 ppm	755 m^2	36.9	227	15
	50 - 100 ppm	210 m^2	64.4	63	7
	100 -500 ppm	240 m^2	156	72	20
	> 500ppm	25 m^2	529	8	8
AREA B TOTAL		**3,040 m^2**		**913**	**70**
C: North of Ponds Path (Area C1 & Area C2)	10 - 30 ppm	4,955 m^2	15.3	1486	41
	30 - 50 ppm	1,725 m^2	37.1	577	39
	50 - 100 ppm	920 m^2	72.1	276	36
	> 100 ppm	990 m^2	136.5	297	73
AREA C TOTAL		**8,590 m^2**		**2,636**	**189**
TOTAL OF AREA A, AREA B, AREA C				**4,088**	**291**
D: (All areas except A, B & C)					
North West Sector	<10 ppm	21,842 m^2	1.2	4,368	9
North East Sector	<10 ppm	24,822 m^2	4.3	4,964	38
South West Sector	<10 ppm	13,710 m^2	2.9	2,742	14
South East Sector	<10 ppm	12,090 m^2	3.2	2,418	14
TOTAL		**72,462 m^2**		**14,492**	**75**
TOTAL in AREAS A, B, C AND D					**366**

Note: Weight has been based on a soil density of 1,800 kg/m^3

Table 10

Methyl Mercury Concentrations in Soil/Sediment/Lichen Samples Tested

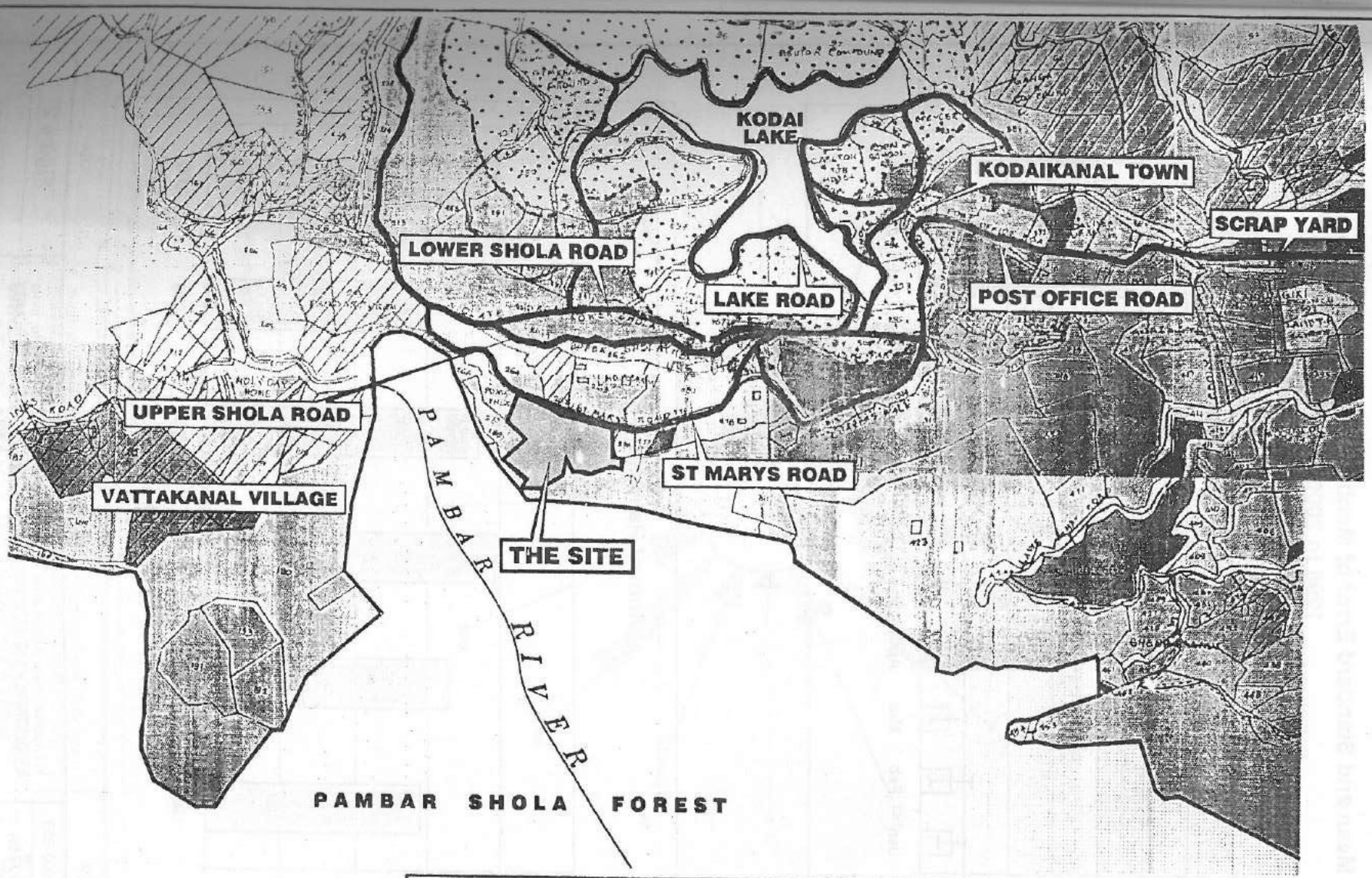
Sample Location	Sample Depth (cm) & Type	Methyl Mercury (mg/kg)	Total Hg (mg/kg)	Ratio Methyl Mercury to Total Mercury
ON SITE LOCATIONS				
CT1	10 (Soil)	0.0029	330	8.7×10^{-6}
CT1	80 (Soil)	<0.0001	47	$<2.1 \times 10^{-6}$
CT1	130 (Soil)	0.0001	14	7.1×10^{-6}
DD	Surface Sediments	0.0026	240	1.1×10^{-5}
DP1	10 (Soil)	0.0002	36	5.6×10^{-6}
DP1	40 (Soil)	<.00005	155	0.3×10^{-6}
DP5	10 (Soil)	0.0094	40	0.0002
FN4	10 (Soil)	0.0049	60	8.1×10^{-5}
FN5	10 (Soil)	0.0026	240	10.8×10^{-6}
MD	5 (Soil)	0.0014	20	7.0×10^{-5}
MD	50 (Soil)	0.0005	11	4.5×10^{-5}
TBD	Surface Sediments	0.003	110	2.7×10^{-5}
L-1	Lichen from tree trunk	0.11 (TNO)	60	0.0018
L-2	Lichen from tree trunk	<0.10 (TNO)	63	<.0016
L-3	Lichen from tree trunk	<0.10 (TNO)	87	<.0015
L-4	Lichen from tree trunk	<0.10 (TNO)	18.3	<.0055
L-5	Lichen from tree trunk	<0.10 (TNO)	15.4	<.0065
OFF SITE LOCATIONS				
CM (Charlemont Property)	5 (Soil)	0.0011	2.2	0.0005
CML (Charlemont Property)	Lichen from tree trunk	0.0019	4.5	0.0004
CML2 (Charlemont Property)	Lichen from tree trunk	0.0019	4.8	0.0004
DFE (Levange Path)	Surface Sediments	0.126	85	0.0015
DFE1(Levange Path)	Surface Sediments	0.06	110	0.0005
DFNE (Levange Path)	5 (Soil)	0.0008	6	0.00013
LK1 (Kodai Lake)	10 (Soil)	0.0008	<0.1	<.008
LK3 (Kodai Lake)	10 (Soil)	0.0002	<0.1	<.002
LP5	Surface Sediments	0.0062	55	<.0001
SRA (Kumbakarrai Falls)	Surface Sediments	0.0001	<0.1	<.001
DS1 (along main stream downstream of Levange Path)	Lichen from tree trunk	<0.03 (TNO)	<5	<.0060
DS1 (along main stream downstream of Levange Path)	Surface Sediments	<0.003 (TNO)	<1	<.0030
DS2 (along main stream downstream of Levange Path)	Lichen from tree trunk	<0.03 (TNO)	10.4	<.0027
DS2 (along main stream downstream of Levange Path)	Surface Sediments	0.004 (TNO)	5.7	0.0007
DS3 (along main stream downstream of Levange Path)	Lichen from tree trunk	0.094 (TNO)	34.4	0.0027
DS3 (along main stream downstream of Levange Path)	Surface Sediments	0.008 (TNO)	51	0.0002

Note: All methyl mercury tests conducted at CSIRO (Melbourne, Australia) except for the labelled (TNO) indicating those performed at TNO (Netherlands).

Table 11

Mercury Levels in Kodai Lake Fish Samples

Sample No.	Description	Total Mercury in mg/kg
B1	Tissue from 500 g fish	0.04
A1	Tissue from 4 kg full grown fish	0.04
A2	Tissue from 4 kg fuli grown fish	0.04
A3	Tissue from 4 kg full grown fish	0.04



LEGEND

ROADS

CLIENT
HINDUSTAN LEVER KODAIKANAL THERMOMETER FACTORY, TAMIL NADU, INDIA

PROJECT
ENVIRONMENTAL SITE AND RISK ASSESSMENT FOR MERCURY

TITLE
SITE LOCATION PLAN

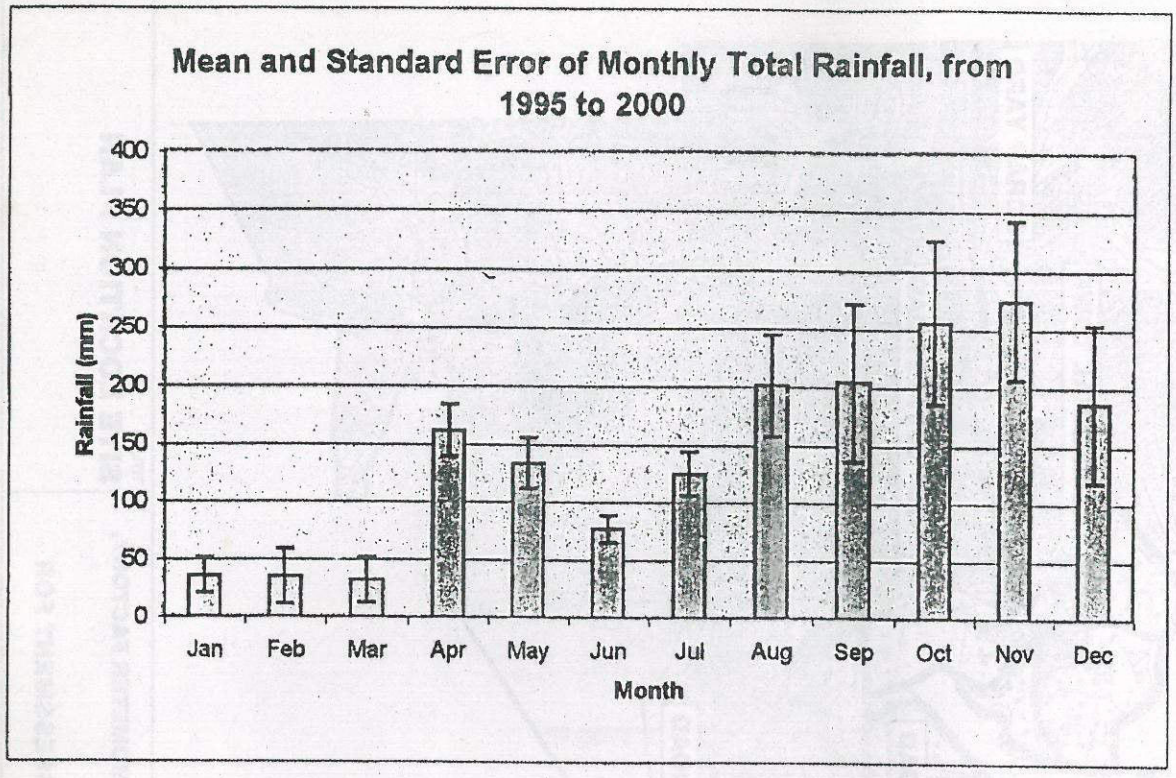
A4

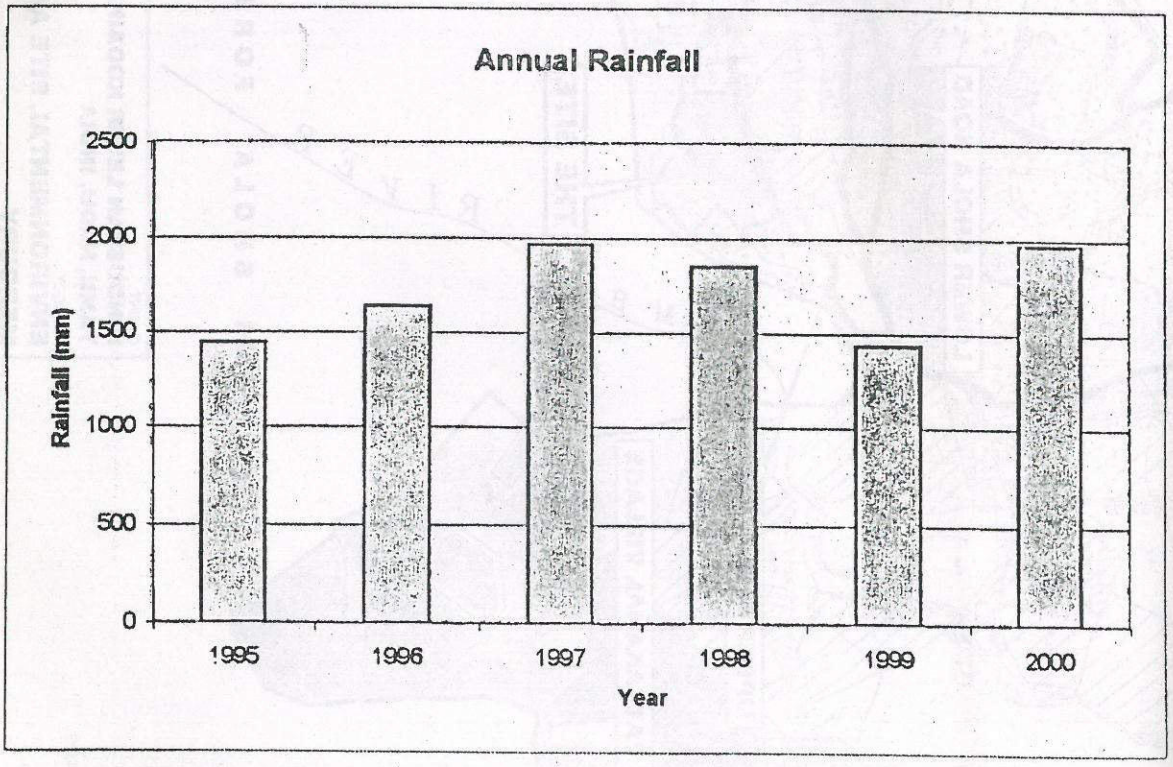
0 100 200 300 400 500
motros (approx)

DESIGNED:	DSW	APPROVED:	DSW	PROJECT:	49032_002_353
DRAWN:	HC	DATE:	02/05/02	CAD FILE:	001.DWG
CHECKED:	DSW	STATUS:	FINAL	REVISION:	A

URS

FIGURE 1





Job No.	49032-002-353	
Prep. By	PW	22 May 01
Chk'd By		
Office	Perth, Western Australia Phone: +61 8 9221 1630	

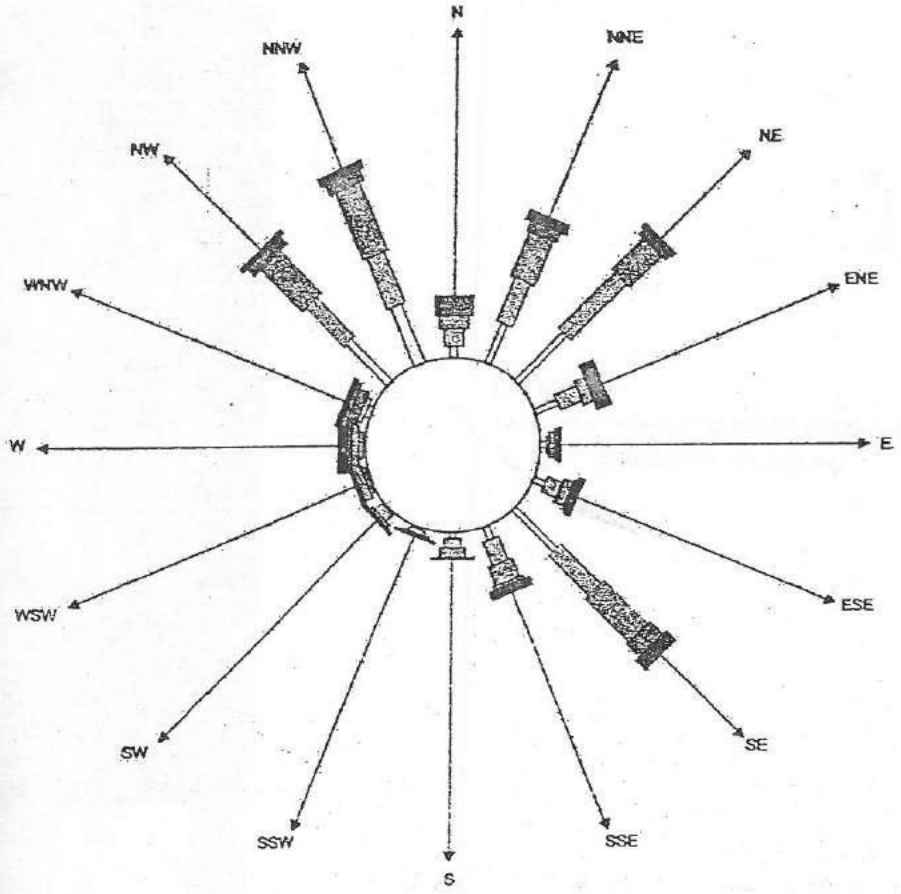
Hindustan Lever Kodaikanal Thermometer Factory, Tamil Nadu, India
ENVIRONMENTAL SITE AND RISK ASSESSMENT FOR MERCURY

RAINFALL RECORDED AT KODAIKANAL WEATHER STATION

Figure 2

URS

WIND ROSE for 1995 - 2000



Wind Speeds (meter/second)

<7 7-11 11-18 18-22 >22

Note : The middle circle shows calm wind, is not in the right scale

Job No.	49032-002-353	Hindustan Lever Kodaikanal Thermometer Factory, Tamil Nadu, India ENVIRONMENTAL SITE AND RISK ASSESSMENT FOR MERCURY	Figure 3
Prep. By	PW 22 May 01		
Chk'd By		WIND DIRECTIONS AND SPEED RECORDED AT KODAIKANAL WEATHER STATION	URS
Office	Perth, Western Australia Phone +61 8 9221 1820		

Thermometer Grading and Mercury Content

Mercury-in-glass clinical thermometers are classified into three types; Regular, Subnormal and Ovulation. Regular thermometers (which comprises 99.4% of all thermometers shipped) are further sub-divided into Wart [short bulb with wider diameter] and Cylinder type [long bulb with smaller diameter]. These thermometers were manufactured at Kodaikanal variously using seven different types of glasses; Corning [5], Corning [6], Schott, B-D, Toshiba, China and TGI each with different properties and bore dimensions.

The weight of mercury in a thermometer is dependent on the volume of the bulb and the area of the capillary stem glass which are reflected in process variation and glass type used.

Manufactured thermometers are segregated into nine "Grades" viz. F, G, H, J, K, L, M, N and P depending on the length of expansion of mercury. Using the grading details from the process quality control and knowing the glass and thermometer type, it is possible to calculate the expansion volume and therefore original volume of mercury in each thermometer shipped.

The quantity of various grades of thermometers dispatched is determined from the grading distribution details documented in the annual Central Exercise and Customs records, giving the various types of thermometers (warts, cylinders, scale type, etc.).

The total quantity of mercury exported in thermometers has been compiled over the period 1984 to 2001 using the number of thermometers in each grade and glass type multiplied by the corresponding weight of the mercury per thermometer.

The information presented in this Appendix shows the distribution of glass type, the grading and the weight of mercury in each thermometer per grade/glass type (using regular thermometers as the reference).

Based on this information, the calculated total weight of mercury exported in a total of 16,5178,795 thermometers over the period of operation of the factory is 119,067 kg.

Quanity of thermometers shipped and weight of mercury.

Grade	Thermometers Shipped	Total Qty of Mercury - Kg.
F	4721397	2896
G	14081376	9404
H	24116975	16746
J	32345822	22550
K	42173668	30281
L	32176002	24327
M	11773506	9492
N	3183087	2798
P	606961	574
Total	165178795	119067

Glass	Total no. of Thermometers (pieces)	Total Qty of mercury (kg)
Corning[5]	105210944	73958
Corning[6]	2076319	1783
Schott	52268092	39079
TGI	2888629	2058
China	933920	865
Toshiba	137056	101
BD-Accu	1663834	1223
	165178794	119067

Year	Therm. shipped (pieces)	Total Kg.
1984	2836516	1922
1985	7451632	5049
1986	11018808	7629
1987	13768144	9761
1988	14211072	10102
1989	9782489	6943
1990	11430450	8109
1991	7979172	5668
1992	7975372	5641
1993	8915603	6480
1994	11052182	8823
1995	8116194	6349
1996	11541572	8565
1997	12323595	8664
1998	11061148	8098
1999	7925250	5756
2000	7054645	5000
2001	734951	508
	165178795	119067

BD-Accu	1663834	1223
	165178794	**119067**

Glass	Total no. of Thermometers (pieces)	Total Qty of mercury (kg)
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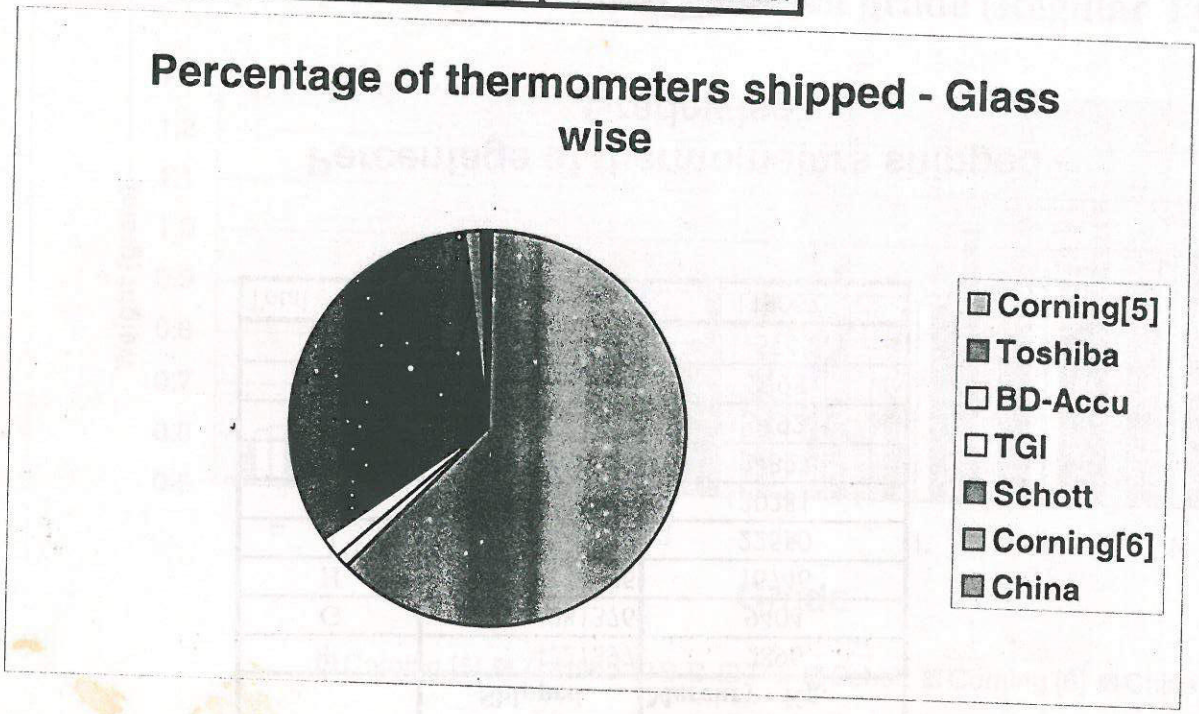

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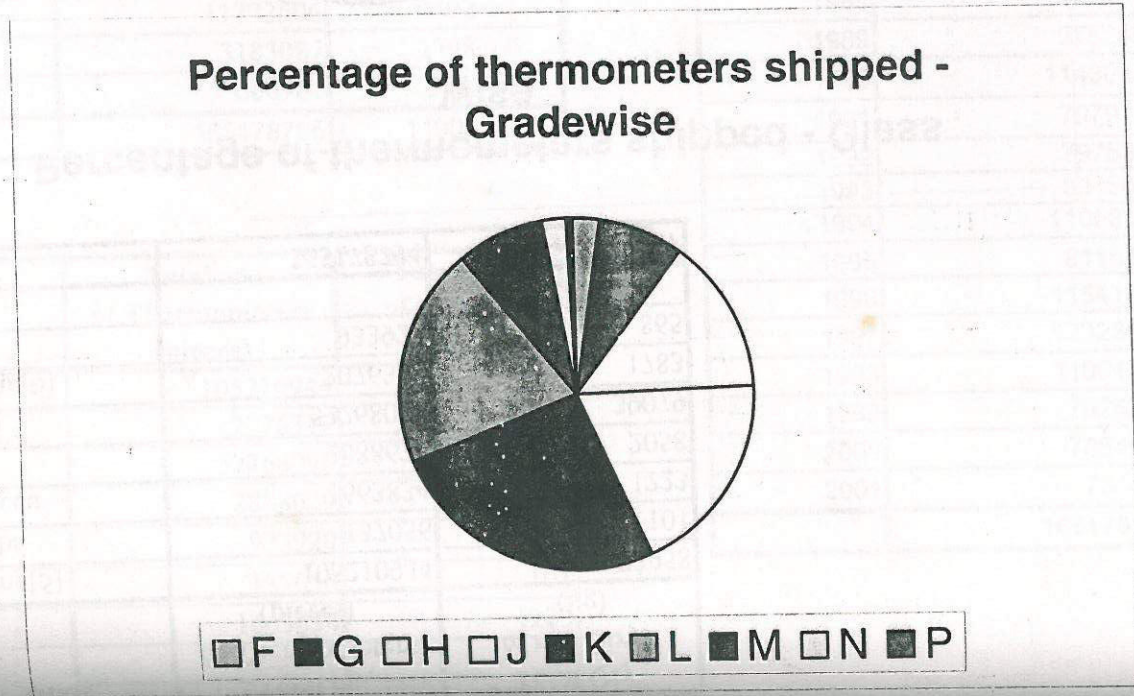
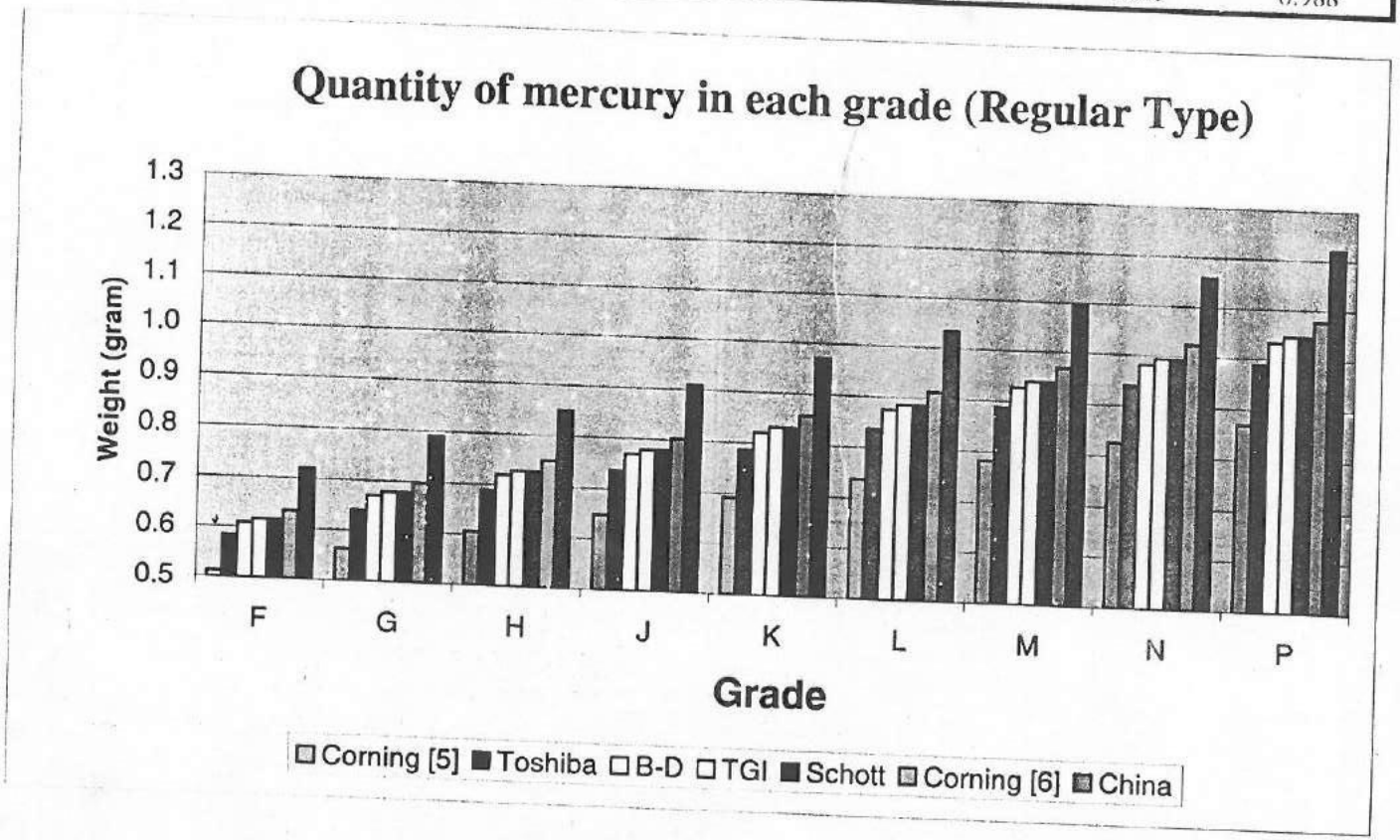


Grades (Regular)	Schott Avg. wt.	Corning[5] Avg. wt.	Corning[6] Avg. wt.	China Avg. wt.	BD-Accu Avg. wt.	TGI Avg. wt.	Toshiba Avg. wt.

Grades (Regular)	Schott Avg. wt. in gm (m1)	Corning[5] Avg. wt. in gm (m2)	Corning[6] Avg. wt. in gm (m2)	China Avg. wt. in gm (m3)	BD-Accu Avg. wt. in gm (m3)	TGI Avg. wt. in gm (m3)	Toshiba Avg. wt. in gm (m3)
F	0.617	0.513	0.635	0.719	0.609	0.617	0.583
G	0.678	0.564	0.698	0.791	0.669	0.678	0.640
H	0.728	0.606	0.750	0.850	0.719	0.728	0.688
J	0.779	0.648	0.803	0.909	0.769	0.779	0.736
K	0.831	0.692	0.856	0.970	0.821	0.831	0.786
L	0.885	0.737	0.912	1.033	0.874	0.885	0.837
M	0.939	0.782	0.968	1.096	0.927	0.939	0.888
N	0.993	0.826	1.023	1.159	0.981	0.993	0.939
P	1.045	0.870	1.077	1.219	1.032	1.045	0.988



B.1 General

Approximately 5.3 tonnes of glass cullets, as mercury recovered 3 &4 glass scrap, were stored in the Diraviyam scrapyard in Kodaikanal. This was sold to the scrapyard in November 1999 and was placed in two small stockpiles amongst other scrap waste. The glass scrap was treated for mercury recovery before disposal from the factory and contained between 0.15% and 1.04% metallic mercury.

The scrapyard is located within the residential/commercial area of Kodaikanal, where granite bedrock is exposed and soil cover is no more than 0.2 to 0.3 m. There is surface runoff from the site during rainy periods which discharges across the adjacent road and then downhill across other roads which are located at progressively lower elevations. It was considered essential that the glass scrap be removed from the scrapyard before the onset of the monsoon season in late 2001.

Two photographs taken at the site, one of the stockpile (Plate 1) and the other an aerial view of the scrapyard and its surrounds (Plate 2) are provided in the Plates section of the report.

A draft protocol for recovery, transport and on-site storage of the glass scrap was prepared by URS Dames & Moore, and originally submitted to the Tamil Nadu Pollution Control Board (TNPCB) on 18 March 2001. Comments made by Navroz Mody of the Tamilnadu Alliance Against Mercury (TAAM) were returned on 3 May 2001. These comments were reviewed by URS Dames & Moore and its expert subconsultant Dr Tom Van Teunenbroek of TNO in the Netherlands. Together a revised protocol which acceded to Greenpeace's request for whole body PPE to be worn by workers involved in the scrap recovery (the NIOSH requirement for mercury vapour concentrations in excess of 0.05 mg/m^3) was agreed and resubmitted to TNPCB for approval. The protocol which is detailed in Section 2.3.1 was in line with internationally accepted Guidelines for Chemical Hazards of the U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health (NIOSH) as published on their website http://www.cdc.gov/niosh/npg/nengapdx.html. This protocol was approved in principle by the working committee (constituted by the TNPCB) during HLL's presentation on 28 and 29 May 2001. A formal written approval was obtained from the TNPCB authorising HLL to retrieve the scrap glass from Diraviyam Scrap Yard.

B.2 Scrap Removal Protocol

The scrap removal Protocol consisted of the following steps:

i. Cordoning off access to the scrapyard immediately prior to commencement of operations and secure the area with police.

ii. Use of a fine spray of water on the stockpiles, avoiding surface runoff, to minimise dust generation.

iii. Erection of a tarpaulin/HDPE partition above man height around the perimeter of that part of the scrapyard was to be disturbed to further minimise dust emissions offsite.

iv. Monitoring of mercury concentrations in air using a Jerome 431-X Mercury Vapour Analyser accurate to 0.003 mg/m^3 (the NIOSH time weighted average for mercury vapour is 0.05 mg/m^3). Further details of the monitoring are provided in section 2.3.2.

v. Clearing and drumming of waste and soil with workers equipped with Personal Protective Equipment (PPE) as recommended by NIOSH i.e., rubber boots, hand gloves, full body overalls, eye and hair protection and respirators/dust masks.

vi. Placement of the glass waste and excavated soil in open-top 200 litre steel drums and sealing with steel lids.

vii. Manually loading of drums onto truck using ramps.

viii. Lining of the truck with HDPE sheeting to contain potential spills during loading and transport, and securing with tarpaulin cover.

ix. The truck being driven to the HLL factory site under police escort.

x. On arrival at the factory and unloading the drums, weighing, labelling and transportation to a secure store room.

Decontamination of the PPE and implements used during the operation by washing in the factory and the water discharged to the factory effluent treatment plant.

Springs or seeps of water downslope of the scrapyard were not identified before or during the operations and hence there was no need to collect water samples for mercury analysis as specified in the Protocol initially approved by the TNPCB working committee. Previously carried out testing of stormwater runoff from the site produced mercury concentrations of less than 0.0003 mg/l , which indicate no significant off site migration of mercury in water runoff from the site.

B.3 Monitoring and Supervision of Scrap Removal

The glass scrap was removed from the scrap yard on 20 June 2001 together with comingled other unrelated scrap and excavated soil. This material was placed in a total of sixty-five 200 litre drums and is securely stored at the HLL Factory in Kodaikanal.

All activities associated with the removal of the glass scrap were carried out in accordance with the Protocol and under the supervision of a committee constituted by the TNPCB. Following the removal of the scrap, the surface soil within the footprint of the two stockpiles was validated by obtaining samples and testing. The validation exercise confirmed that the mercury residue in the site soils was at concentrations well below the Dutch Intervention value of 10 mg/kg, specifically ranging between 0.56 and 5.67 mg/kg. The results of the validation sampling and the results of the water sampling carried out on stormwater runoff from the site are presented in Table B-1. The air monitoring locations, and the soil and water sampling locations are also shown in Table B-1.

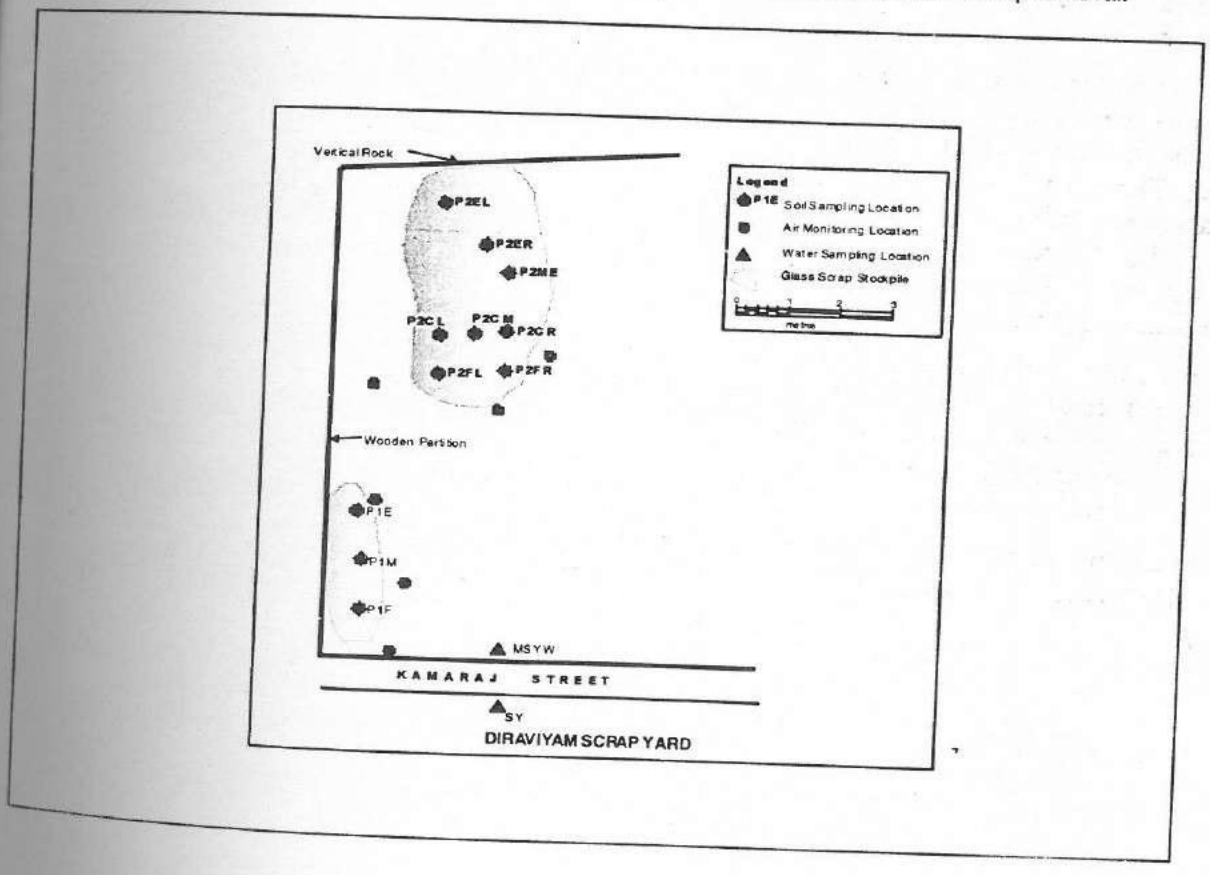
Mercury in air was monitored throughout the scrap retrieval operation on 20 June 2001. In all thirty six readings were taken, spread over six locations across the scrapyard. Fifteen of these readings gave zero measurements, the remaining twenty-one readings were between zero and 0.019 mg/m^3 with a mean of 0.007 mg/m^3. In retrospect, based on the above readings, a much lower level of NIOSH stipulated PPE for workers involved in recovery of the waste would have been appropriate.

The scrap removal operation was supervised by a team appointed by the working committee set up by the TNPCB. The team comprised representatives of the NGOs including Greenpeace.

Table B-1
Diraviyam Scrap Yard Validation Results

Sampling Code	Type of Sample	Depth of Sample in cm	Total Hg in soil (mg/kg)
P 1F	Soil	10	0.64
P 1M	Soil	10	0.56
P 1E	Soil	10	1.89
P 2FL	Soil	10	1.20
P 2FR	Soil	10	0.56
P 2CL	Soil	10	2.08
P 2CM	Soil	10	1.09
P 2CR	Soil	10	5.67
P 2EL	Soil	10	1.62
P 2ER	Soil	10	2.23
P 2ME	Soil	10	2.04
MSYW *	Water	-	<0.0003 (mg/L)
SY *	Water	-	<0.0003 (mg/L)

* Samples collected prior to scrap removal. All other samples collected subsequent to scrap removal.



General

The following environmental legislation sets out policies and regulations to control environmental pollution in India:

- The Air (Prevention and Control of Pollution) Act, 1981 and subsidiary Rules;
- The Water (Prevention and Control of Pollution) Act, 1974 and subsidiary Rules;
- The Water (Prevention and Control of Pollution) Cess Act, 1977 and subsidiary Rules; and
- The Environment (Protection) Act, 1986 and subsidiary Rules.

Under the Environment (Protection) Act, all industries requiring a consent under Section 25 of the Water (Prevention and Control of Pollution) Act or under Section 21 of the Air (Prevention and Control of Pollution) Act or both, or requiring authorisation under the Hazardous Wastes (Management and Handling) Rules, 1989, are required to submit an environmental statement for the financial year ending 31 March in Form V to the State Pollution Control Board on or before 30 September every year.

Air Pollution Control

Air emissions are controlled by The Air (Prevention and Control of Pollution) Act, 1981. The State Pollution Control Boards (formed under Section 3 of The Water Act) are responsible for laying down, in consultation with the Central Board, standards for emissions of air pollutants from industries and any other source. The Environment (Protection) Rules 1986 provide the national standards for emissions and discharges of environmental pollutants from various sources. Since the States have not laid down more stringent standards, the national standards as prescribed in Schedule I of the Rules are applicable.

Prior to its amendment in 1987, The Air Act was enforced through mild court-administered penalties on violators. The 1987 Amendment strengthened enforcement and introduced stiffer penalties. Now, Boards may close down a defaulting industrial plant or may stop its supply of electricity or water. The Boards may also apply in court to restrain emissions that exceed prescribed standards. The Act was extended to include noise as an air pollutant.

The Environment (Protection) Rules of 1986, with amendments up to April 1999, specify the standards of emission and or discharge of environmental pollutants from 80 industries, operations or processes. No standard has been established for mercury.

Water Pollution Control

The Indian legal system provides four major sources of law for addressing water pollution problems:

- Administrative permit system under the Water (Prevention and Control of Pollution) Act, 1974 and subsequent Rules of 1975 and amendments in 1978
- Provisions under the Environment (Protection) Act and Rules of 1986 relating to water quality standards
- Public nuisance actions
- Common riparian law.

The Water Act empowers the State Pollution Control Boards to:

- Establish and enforce effluent standards for factories discharging pollutants
- Control sewage and industrial effluent by approving, rejecting or conditioning applications for permission to discharge
- Minimise water pollution by advising on appropriate sites for new industry
- Prescribe standards for the discharge of effluent or quality of receiving waters
- Monitor compliance with permitted effluent discharge standards.

Prior to its amendment in 1988, enforcement under the Water Act was achieved through criminal prosecutions initiated by boards, and through applications to magistrates for injunctions to restrain polluters. The 1988 Amendment strengthened the Act's implementation provisions. Now, the Board may close a defaulting industrial plant or withdraw its supply of power or water by administrative order, penalties are more stringent, and a citizens' suit provision bolsters enforcement machinery.

Effluent standards have been stipulated under the Environment (Protection) Rules, 1986. The standards for discharge of mercury are as follows:

- Inland surface water: 0.01 mg/l (max)
- Public sewers: 0.01 mg/l (max)
- Marine coastal areas: 0.01 mg/l (max)

The Water Prevention and Control of Pollution Cess Act of 1977 was passed to help meet the expenses of the Central and State Water Boards. The Act creates economic incentives for pollution control and requires local authorities and certain designated industries to pay cess (tax) for water consumption. These revenues are used to implement the Water Act.

Hazardous Substances

The Manufacture, Storage & Import of Hazardous Chemical Rules, 1989, apply to industries that use or store specified hazardous chemicals. These Rules pertain to directives and procedures for:

- Storage of hazardous chemicals;
- Inventory of hazardous chemicals;
- Identification of major hazards posed;
- Preparation of on-site emergency plans;
- Workers' operational safety; and
- Disclosure of product safety information in material data sheets.

Amendments passed in 1987 to the 1948 Factories Act introduced special provisions on hazardous industrial activities. The 1987 Amendment, among other things, empowers states to appoint site appraisal committees to advise on the initial location of factories using hazardous processes. The Act also requires the occupier of a factory to maintain workers' medical records and employ operations and maintenance personnel who are experienced in handling hazardous substances. A Schedule to the Act

prescribes permissible limits of exposure to toxic substances and requires the creation of safety committees to consist of workers and managers who are required to review a factory's safety measures periodically.

A review of the list of specified chemicals indicates that mercury, in the forms of alkyl mercury, mercury fulminate, and methyl mercury, are listed under these Rules.

Hazardous Waste Management

The first comprehensive rules to deal with hazardous wastes were issued in 1989 under the framework of The Environment (Protection) Act of 1986. These rules, The Hazardous Waste (Management and Handling) Rules apply to designated categories of waste generated in quantities exceeding specified limits, and provide for their proper handling, storage and disposal with the requirement for a permit.

Waste Category No. 4 under the rules is mercury bearing waste. Any operation that generates more than a total of 5 kilograms per year (calculated as pure metal) must ensure proper collection, reception, treatment, storage, and disposal of this waste. Rule 3i(b) refers Schedule 2 of the Hazardous Waste Rules and was updated on 6 January 2000. Class A, and specifically Class A6, mercury and mercury compounds, is nominated as Hazardous Waste if the concentration exceeds 50 mg/kg.

Air Quality

The Indian Occupational Health and Safety Regulations for air quality in the Workplace specifies a maximum time weighted average of 0.05 mg/m^3 of Hg. There are no regulations or guidelines for mercury in air emissions or ambient air.

Biological Monitoring of Mercury. Kodaikanal Factory, Hindustan Lever Limited

Mean Urinary Mercury Values of Current and Ex-employees

1988 - 2001

Year	Group mean values of Hg in urine in µg/lit
1988	22.7
1989	16.4
1990	26.4
1991	31.9
1992	24.2
1993	22.6
1994	21.9
1995	26.1
1996	31.8
1997	26
1998	24.3
1999	21.3
2000	24.8
2001	12.9

Average 23.81

12.9 to 31.9

Note: WHO recommends that on a group basis the value of Hg in urine should not exceed 50 µg/lit.

Source: Recommended Health-Based Limits in Occupational Exposure to Heavy Metals. Report of a WHO Study Group. Technical Report Series 647, WHO, Geneva, 1980.

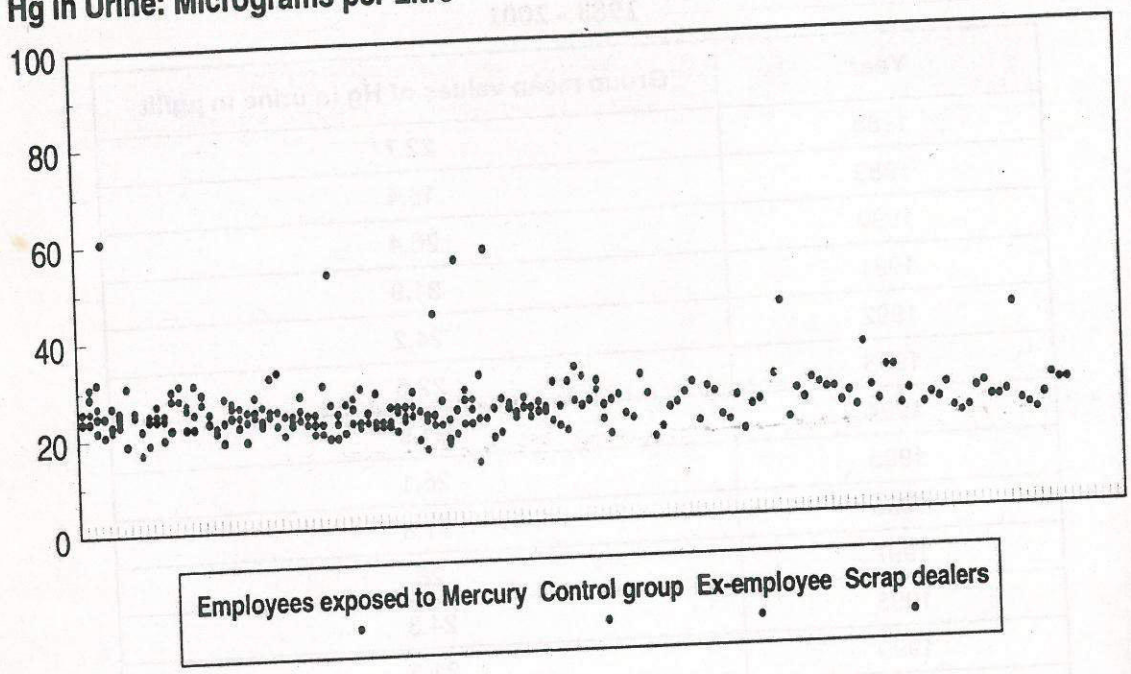
March 2001

The following is a graphic representation of the levels of mercury in the urine of examined employees. The graph in the form of a scatter diagram clearly depicts that all employees, ex-employees and scrap dealers' mercury levels in urine are far below the accepted individual threshold value of 100 µg/Lit. The sample size of the surveyed population comprised of 129 employees [exposed to mercury over the years], 54 ex-employees [exposed to mercury in the past], 66 employees not working in the mercury areas [canteen, transport, security staff, administrative department/office, gardening, MEPZ] and 6 scrap dealer/scrap dealer's employees.

66
55
121
129
250

129
126

Hg in Urine: Micrograms per Litre

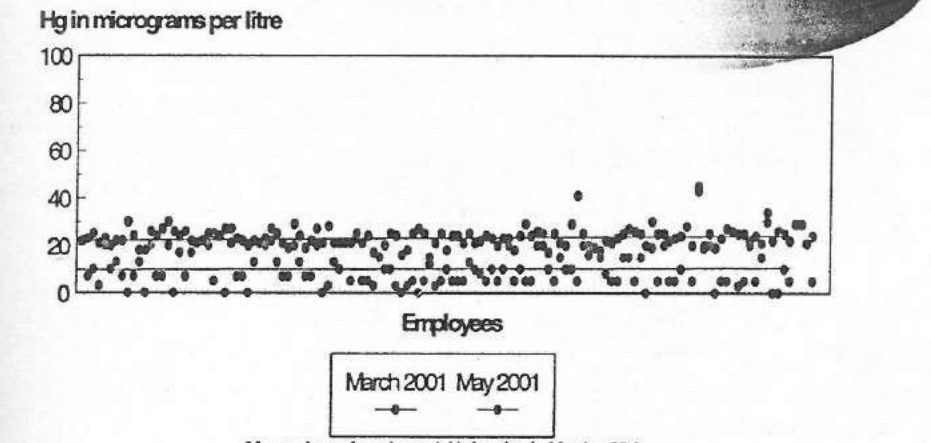


Note: WHO recommends an upper limit of Hg in urine of 100 µg/Lit for individual exposures.
Source: Early detection of occupational diseases, WHO, Geneva, 1986.

A repeat examination in May 2001 of all current employees has indicated that the levels of mercury in urine has further dropped to a mean level of around 10 µg/Lit [since the operations at the factory has been suspended since the first week of March 2001] as compared to a mean level of around 23 µg/Lit in March.

The following is a graphic representation of the comparison between May 2001 and March 2001.

Biological monitoring results
May 2001 vs March 2001



Mean values of employees' Hg in urine in March 23.1
Mean values of employees' Hg in urine in May 10.1

Review of the Occupational Health Surveillance Study on employees at Hindustan Lever Limited's Mercury Thermometer Plant at Kodaikanal, 22nd December 2001

Expert Committee report

by

Indian Association of Occupational Health, India

10th January 2002

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Review of the Occupational Health Surveillance Study on employees

at Hindustan Lever Limited's Mercury Thermometer Plant at Kodaikanal

Preamble

The Indian Association of Occupational Health [IAOH] with over 2350 occupational health physicians, industrial hygienists, safety professionals, social workers and counselors is the country's leading NGO in the discipline of Occupational Health. The IAOH has 21 branches across the country and collaborates with national and international institutions in the discipline of Occupational Health. The IAOH has also been invited on several government committees to represent the occupational health profession.

The IAOH was established way back in 1948 as the Society for Study in Industrial Medicine (SSIM) in Jamshedpur and in 1970 the SSIM was rechristened as the Indian Association of Occupational Health. The Mission statement of IAOH encapsulates the reason for its existence and the statement reads as under

" The Indian Association of Occupational Health is committed to enable occupational health professionals to make India's workplace healthy, safe and green – free from the ill effects of hazards, by evolving effective solutions ".

The IAOH plays a pioneering role in mitigating and eliminating occupational health hazards in industries.

Scope of the current study

The Indian Association of Occupational Health received a request from Hindustan Lever Limited to set up an appropriate expert committee to review their occupational health surveillance study of employees in their thermometer plant at Kodaikanal and to let them have the IAOH's expert opinion on the occupational health surveillance. Consequently the IAOH established the following committee to study the occupational health surveillance in its entirety as also visit the site and review

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occupational health measures in place. The committee members are

1. Dr. G. K. Kulkarni – President of the Indian Association of Occupational Health, India and Indian representative for Project TROHI [Towards Regional co-operation on Occupational Health Initiatives for the Asia Pacific Region]. Dr Kulkarni is also the CMO of Siemens Ltd. Mumbai.

2. Dr. S. M. Shanbhag – Vice President of the Indian Association of Occupational Health, India and Country representative designate for MEDICHEM in India as well as the Group Medical Advisor, Reliance Industries Limited, Mumbai.

3. Dr. T. K. Joshi – Project Director and Occupational Health and Environment Consultant, Center for Occupational and Environmental Health, Govt. of Delhi. New Delhi. Dr. Joshi has also been the country representative on Occupational Health with the World Health Organisation and has been a consultant with the International Labor Organisation.

4. Dr. G. G. Davay, Past President, Indian Association of Occupational Health, India and Former Medical Inspector of Factories, Government of Maharashtra. Dr. G. G. Davay has a special professional interest in chemicals and fibres and is currently Chairman, Occupational Health Services Foundation of India.

5. Dr. S. R. Keshavamurthy, Past President of the Indian Association of Occupational Health, India and CMO AMCO Batteries, Bangalore. Dr. Keshavamurthy is a specialist in Occupational and environmental aspects of heavy metals.

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Expert committee's report on the occupational health surveillance and site visit.

The expert committee was presented the details of Risk Assessment' undertaken by HLL to evaluate the degree of environmental and occupational health effects resulting form mercury exposure on employees in the unit and also had a physical tour of the factory.. The committee was also explained on site the biological monitoring for mercury in urine. The committee then reviewed the comprehensive occupational health surveillance procedures in place and the results thereof. The key features of the occupational health surveillance and its results are

1. All employees with a urine level of more than 100 µg/l were rotated to a mercury free environment, and monitored closely to ensure that their levels came back to permissible limits. This was in conformity with a WHO [1986] recommendation of dealing with even asymptomatic individuals with Hg in urine levels > 100 µg/l. There were only a few Individuals having Hg urine level of >100 µg/l during their working life time.
2. Group mean levels for the years 1988 to 2001 were well below a WHO expert committee [1980] recommended level of 50 µg/l. For most years from 1988 they were below 27 µg/l except for the years 1991 (31.9 µg/l) and 1996 (31.8 µg/l).
3. The annual clinical evaluation of all employees from the year 1988 onwards also did not reveal any clinical or biochemical abnormalities which could be attributed to mercury exposure.
4. The unit maintains appropriate records for biological and clinical evaluations for individual employees as well as the entire group for the years 1988 onwards.

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IAOH Expert committee conclusions

The expert committee would like to compliment Hindustan Lever Limited for its comprehensive occupational health surveillance measures in place at Kodaikanal factory as well as its initiatives in significantly minimizing occupational exposure to mercury through its site occupational health and safety measures

In India the permissible limit for mercury in the atmosphere is 0.05 mg/m^3. The unit has been doing regular environmental assessment of air borne concentrations of mercury in work environment in the plant to comply with these limits and has systems in place to ensure adequate safeguards in the event of deviation. Coupled with the periodical biological monitoring and annual clinical evaluations, the occupational health and safety measures instituted by Hindustan Lever Limited have succeeded in keeping the exposure of the factory employees to Hg to well within acceptable limits.

The committee has specifically reviewed on site, the methodology for biological monitoring of Hg in urine using a cold wave AAS and is satisfied with the calibration and quality control measures in place to ensure appropriate biological monitoring on a consistent basis. These results have also been recently validated by a comparison between results obtained through in house biological monitoring vis-a-vis running the samples externally on an Inductively Coupled Plasma Spectrometry [ICP]

Keeping in context the comprehensive occupational health surveillance conducted over the past 12 years viz

- The periodic biological monitoring at a frequency exceeding industry standards
- The detailed individual annual clinical evaluations including biochemical tests &
- The recently conducted comprehensive clinicoepidemiological study

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The IAOH expert group is of opinion that with the measures taken by HLL for protecting workers health and adequate safety measures in place, any adverse consequences of mercury exposure on workers' health are highly unlikely at the thermometer factory in Kodiakanal.

The expert group has been briefed on apprehensions of some of the ex-employees who feel that some of their current problems like gum trouble or skin related conditions have been due to past exposures to mercury. In view of the comprehensive occupational health measures in place and after a thorough review of the systems, procedures and findings of biochemical and clinical evaluations, the expert group believes that the health complaints like gum and skin involvement attributed to mercury exposure by some former workers may be unrelated to their past employment in the thermometer factory and other factors may be responsible for such common skin & gum morbidity

Signed this report on 10th January 2002.

Dr. G. K. Kulkarni

Dr. S. M. Shanbhag

Dr. G. G. Davay

Dr. T. K. Joshi

Dr. S. R. Keshavamurthy

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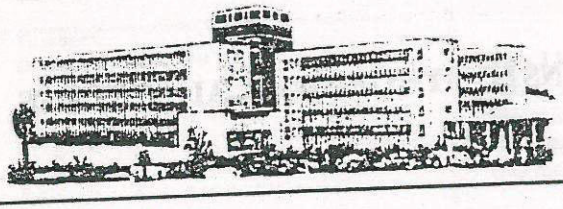

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Note for the Record

Comments on the Presentation by Dr. Rajgopal, Corporate Medical Advisor, Hindustan Lever Limited on the "Effectiveness of Occupational Health and safety measures in the Thermometer factory at Kodaikanal", Tamil Nadu for prevention of adverse health effects due to exposure to mercury .

Presentation made at Centre for Community Medicine and Clinical Epidemiology Unit at the All India Institute of Medical Sciences, New Delhi on Friday the 9th November 2001 at 4 p.m.

A] Members Present:

Dr. M G Karmarkar, Retd. Professor & Head, Department of Laboratory Medicine.
Dr. Anurag Shrivastav, Professor, Dept. of Surgery & Member Clinical Epidemiology Unit
Dr. C.S. Pandav, Additional Professor, Dept. of Centre for Community Medicine & Member Clinical Epidemiology Unit
Dr. R.M. Pandey, Associate Professor, Dept. of Biostatistics and Member Clinical Epidemiology Unit
Dr. K. Anand, Assistant Professor, CRHSP, Ballabgarh and Member Clinical Epidemiology Unit

B] Summary of The study:

Dr. Rajgopal presented the background information related to the environmental and health effects of mercury before proceeding to the details of the Kodaikanal study. He explained the procedures in place for assessment of both the exposure and the effect of mercury on the employees of the unit.

Monitoring air levels of Hg on frequent basis
2 Monitoring urinary levels of Hg on a monthly basis
3 Health Checkups on an annual basis including clinical and biochemical tests

He also elaborated the utility of biological monitoring as an important tool in environmental epidemiology to monitor occupational health of employees.

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