BEFORE THE NATIONAL GREEN TRIBUNAL

SOUTHERN BENCH CHENNAI

Original Application No. 161 OF 2021 (SZ)

IN THE MATTER OF:

Tribunal on its own motion Suo-Motu based On the news item published in Deccan Chronicle newspaper Chennai Edition dated 24.06.2021, under the caption "Penalise Company for dumping toxic waste in Kodaikanal: Activists and the New Indian Express newspaper Chennai Edition dated 25.06.2021 Under the caption "HUL Begins Solid-Remediation works in Kodaikanal"

... Applicant

Versus

The Chief Secretary to Govt. of Tamil Nadu
and Others

… Respondents

INDEX

DEPONENT

H.D. VARALAXMI, M.Tech
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CENTRAL POLLUTION CONTROL BOARD
(MoEF & CC, Govt. of India)
Regional Directorate (Chennai)
2nd Floor, 77-A, South Avenue Road,
Ambattur Industrial Estate, Chennai - 600 098

Place: Chennai
Date : 24.09.2021

Final Committee Report in compliance of Hon'ble National Green Tribunal, Southern Zone, Chennai, orders dated 30.07.2021 and 31.08.2021 in OA No. 161/2021 regarding Remediation of mercury contaminated soil at M/s Hindustan Unilever Limited (HUL), Kodaikanal

1. Background:

Hon'ble Tribunal in OA No. 161/2021, vide order dated 30.07.2021 constituted a joint committee and directed as follows:

"… In order to ascertain the genuineness of the allegations made in the newspaper report and also the alleged violations of directions issued by the NGT PB, New Delhi in OA no. 211/2018, we feel it appropriate to appoint joint committee consisting of 1) A Senior Scientist from CPCB, Regional Office, Chennai and 2) a Senior Scientist from TNPCB as designated by its Chairman to inspect the area in question and submit a report as to whether the directions issued by the Principal Bench in the year 2018 in OA no. 211/2018 are being strictly complied with by the 5th respondent/HUL while undertaking the remediation process and if there is any violation, what is the nature of violations committee by them and if any, environmental compensation has to be imposed on account of such violations, then the committee is also directed to assess the environmental compensation and submit the report to this tribunal on or before 31.08.2021 by e-filing.

In mean time committee is directed to inspect the area immediately, file an interim report regarding any prima facie violation before that date…"

Accordingly, CPCB and TNPCB jointly inspected the contaminated area of M/s Hindustan Unilever Limited (M/s HUL), Kodaikanal on 17.08.2021 and collected the soil samples. The joint committee submitted an interim report on 28.08.2021 and requested more time for submission of analysis report.

Accordingly, Hon'ble NGT in its order dated 31.08.2021 granted time to the joint committee and directed as follows;

"…. So considering the report submitted by the joint committee, we feel that some more time can be granted to them to file their final report, after getting the soil and water samples analysis from the laboratories.

The committee is also directed to serve a copy of the report submitted by the counsel appearing for the respondents, so that they can file their objection, if any, to the same as well before the next hearing date…."

Further, the case is posted for consideration of report on 29.09.2021.

2. **Compliance to the direction of Hon'ble NGT (PB),** in **OA No. 211/2018, in the matter of Navroz Mody Vs. Union of India & Ors, with respect to Environmental Impacts in Pambar Shola River in down gradient of M/s HUL.**

Hon'ble NGT, PB, Delhi in its order dated 01.11.2018 directed as *Considering the reported environmental impacts in Pambar Shola river in down gradient of closed thermometer factory, it is proposed that a detailed site assessment be carried out to ascertain the extent of contaminated and if required, an ecological risk assessment study may also be carried out.*

NEERI has undertaken the offsite assessment in Pambar-Shola. NEERI has carried out the assessment based on the information collected from previous studies, data collected from District Forest Office, Kodaikanal, toposheets etc., on the extent of the Pambar Shola, its flora and fauna etc. Broadly, the study encompasses two key ecosystems, viz. Pambar watershed and Pambar Shola. Since, the Pambar river flows through the Pambar Shola (hence the name), the Shola and other forest areas collectively form the Pambar watershed. Accordingly, the assessment of the two ecological units were carried out simultaneously and submitted the report in the Month of August 2021. A copy of the report is attached as **Annexure -1** for kind reference. The sampling details & conclusion of the report is as follows.

2.1 Details of Samples collected for assessment by NEERI

Forest Sampling Methodology

Sampling locations were selected close to the river. Forest samples were collected from 44 locations and consist of soil, lichen, moss, grass, bush/leaves and tree bark Details of samples collected from Pambar Shola forest area are given in the Table 1, and sampling locations in Pambar Shola forest area shown in Figure-1.

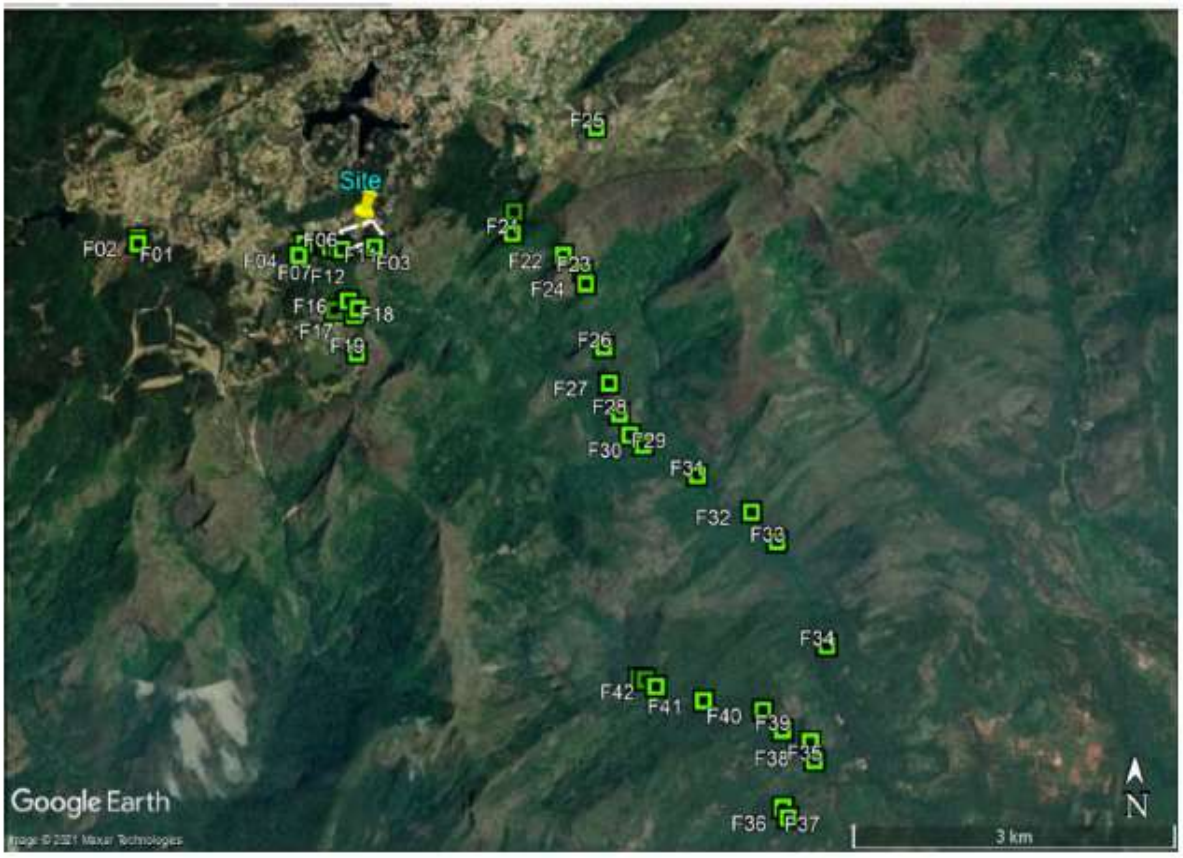

Figure 1: Sampling Locations in Pambar Shola Forest Area

Pambar River

The entire stretch of Pambar river, i.e. from the origin to its confluence point with Varaghanathi river, and further to the confluence point of Vaigai river, has been divided into three zones viz.

- **Zone-I:** origin of Pambar river to HUL factory site approx. 5 km upstream i.e. (sampling locations R2 to R6),
- **Zone-II:** HUL factory site to Kumbakarai falls (~15 km), (sampling locations R7 to R 14), and
- **Zone-III:** Kumbakarai falls to the confluence point with Varaganathi and further to the confluence point of Vaigai river (~15 km) (sampling locations R 15 to R 23).

The details of samples collected from Pambar river watershed are given in Table 1, and the sampling locations along Pambar river shown in Figure - 2.

Figure 2: Sampling Locations along Pambar River

Table 1: Number of Samples Collected from Pambar-Shola Forest Area & River

Matrix	**Pambar Shola Forest Area**	**Matrix**	**Pambar River**	
			Pre-monsoon	**Post-monsoon**
Soil	44	Water	23	23
Bark	44	Soil	23	23
Lichen	41	Sediment	22	22
Moss	31	Moss	4	10
Leaf	44	Algae	8	8
Bush	4	Fish	-	7
Grass	27			

2.2 Sample Preparation for Mercury Analysis:

The method adopted for Soil & Sediment samples, Vegetation samples (Bark, Lichen, Moss, Leaves, Grass) Water samples and Fish samples, Type of Instrument used for analysis and Quality control and Quality Assurance followed were narrated in **section 5.0** of the report (Ref. Annexure-1).

2.3 Screening levels and Guidelines:

The Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India prepared Guidance document for assessment and remediation contaminated sites in India (2015). In the said guidance document Canadian Soil Quality Guidelines (Canadian -SQGs) screening criteria have been adopted as a proxy screening criteria for India. In the present study, NEERI used Canadian -SQGs for Tier 1 screening. Following are the screening level used in this study;

- The screening level for mercury in soil is 6.6 mg/kg
- The screening level for waste water discharge into surface water bodies is 0.01 mg/l
- BIS limit for mercury in drinking water quality is 0.001 mg/l

2.4 Risk assessment Methodology:

A key component of sustainable environmental management is a risk-based approach focused on whether the site related impacts pose unacceptable currently or likely future risks to critical species residing in the site or near the site. The risk based approach incorporate a Tiered approach with the completion of screening level based (Tier 1) and quantitative site -specific risk assessment (Tier 2) that inform decision making regarding further action. The detailed approach of Tier 1 & Tier 2 risk assessment is briefed in **section 7.0** of the aforesaid NEERI report (Re. Annexure -1).

2.5 Results and Discussion:

The mercury analysis results of soil, bark, lichan, moss, leaves and bush samples collected from Pambar Shola forest area are presented in the **section 8.0 of the aforesaid NEERI** report (Ref. Annexure 1). The summary of results is as below;

i. The mercury concentration in 44 nos of soil samples collected from Pambar Shola forest area was reported to 0.950 mg/kg.

ii. Vegetation in the forest area are important receptor species exposed to mercury in air, soil and water. Species of lichen and moss are good indicators of atmospheric mercury concentration. The concentration of mercury found in lichen, moss, leaf, bark and grass samples collected from Pambar are given below;

Pambar Shola samples ⟶	**Lichen**	**Moss**	**Leaf**	**Bush**	**Bark**	**Grass**
Range of Mercury concentration reported ⟶	ND – 0.528	ND – 0.250	ND – 0.065	0.095 – 0.227	0.067 – 0.736	ND
Note : ND --- Not detected						

iii. The concentration of total mercury was reported as 'Not detected' in all water samples collected in pre & post monsoon period.

iv. Out of seven fish samples collected from various locations of Pambar river, four samples were reported 0.007 to 0.009 mg/kg (wet weight basis) of total mercury concentration. Whereas, in other three fish samples were reported as 'Not detected'.

v. The total mercury concentration in soil samples taken from river bank were reported upto 0.966 mg/kg in Pre-monsoon and upto 0.340 mg/kg in Post monsoon.

vi. The total mercury concertation in soil samples taken from Levinge pathway were reported as 4.7 mg/kg in pre-monsoon and 0.438 mg/kg in post- monsoon.

vii. The total mercury concentration in sediment samples taken from river were reported upto 0.412 mg/kg in pre-monsoon and 0.256 mg/kg in post- monsoon.

viii. The total mercury concertation in sediment samples taken from Levinge pathway were reported as 0.099 mg/kg in pre- monsoon and 0.015 mg/kg in post- monsoon.

ix. The total mercury concertation in Moss samples taken from Pambar river were reported in the range of 0.022 – 6.360 mg/kg in pre monsoon and upto 1.148 mg/kg in post- monsoon.

x. The total mercury concertation in Algae samples taken from Pambar river were reported upto 1.2 mg/kg in pre monsoon and 0.028 – 0.083 mg/kg in post- monsoon.

2.6 Conclusions of the NEERI study:

(i) Pambar Shola Forest

- Samples of soil, bark, lichen, moss, bush, grass and leaves were collected from 44 locations across Pambar Shola forest area and analysed for total mercury.

- Total mercury concentration in soil samples collected across the Pambar Shola forest were reported below 6.6 mg/kg (MoEF&CC guideline value) and 12 mg/kg (CCME- SQG) for the protection of human and environmental health, respectively.

- Total mercury in vegetation samples such as bark, lichen, moss, bush, grass and leaves collected across the Pambar Shola forest area are found in low concentration. Further, no visible evidence of distress to vegetation, flora and fauna was noticed during sampling activity.

(ii) Pambar River

- Samples of water, sediment, algae, fish and river bank soil, lichen, and moss, were collected from 23 locations both pre and post monsoon periods from the entire 25 km stretch of Pambar river and analyzed for total mercury.

- All water samples collected from Pambar river showed mercury below detectable limit (BDL).

- The concentrations of total mercury in soil samples were reported as 1.0 mg/kg less than screening level (i.e 6.6 mg/kg) during pre and post - monsoon periods.

- The concentration of total mercury in all sediment samples, collected from Pambar river reported below than Canadian screening level (i.e 0.486 mg/kg).

- The total mercury in lichen, moss, algae and fish samples were found in low concentration and did not show appreciable enrichment.

(iii) Risk Assessment

- Screening level based on Ecological Risk Assessment (Tier 1) of soil, sediment and water, indicated no/negligible risk to flora & fauna as the observed concentrations of total mercury are less than the screening levels.

- Based on the off-site field observations, sampling and analysis during Tier I Screening Level of Risk Assessment, and review of the previous Risk Assessment studies, it is observed that site at M/s HUL, Kodaikanal, is not likely to pose any off-site ecological risks, particularly to the ecologically sensitive Pambar Shola forest area.

- In conclusion, considering the recommendations of international regulatory agencies, the weight of evidence on the current & past mercury monitoring data, and the screening standards, further Detailed risk assessment of Pambar Shola is not deemed necessary.

3. Analysis results of the soil samples collected by the Joint Committee on 17.08.2021

In order to verify the dumping of contaminated soil, if any, the joint committee collected soil samples at various locations to ensure about any contamination carry over to the downstream (off - site) of the unit. The committee also collected the soil samples from the remediation area to ensure and confirm the mercury contamination, whether it is below the Site Specific Target Level (SSTL) of 20 mg/kg. The analysis result of the samples collected is given below;

Sampling location	Mercury Conc. (mg/kg)
Remediation Area	
Field Soil - 0707 block - Grid-25 - Layer-2	BLQ[LOQ:2.0]
Field Soil - 0607 block - Grid-55 & 25	BLQ[LOQ:2.0]
Field Soil - 0608 block - Grid-23 - Layer-2	BLQ[LOQ:2.0]
Field Soil - 0708 block - Grid-21 - Layer-2	2.26
Washed Soil Heaps	
Heap 1	2.80
Heap 2	BLQ[LOQ:2.0]
Heap 2	BLQ[LOQ:2.0]
Heap 2	2.98
Heap 3	3.56
Heap 4	2.25
Heap 4	2.41
Heap 4	4.00

Heap 5	BLQ[LOQ:2.0]
Heap 5	BLQ[LOQ:2.0]
Silt Trap (Settling tank)	2.21
Silt Trap 3	3.90
Silt Trap 4	14.03
Note: (i) BLQ – Below level of quantification, (ii) LOQ – Level of quantification	

- From the above table, it is observed that, out of four samples taken from the excavated area & keeping for back filling, three samples reported less than 2.0 mg/kg (i.e Below level of quantification) of total mercury concentration and one sample reported as 2.26 mg/kg of total mercury concentration.

- The concentration of total mercury in the soil, stored in the open yard covered with tarpaulin is found much below than 20 mg/kg, which ensures that treated/washed soil is only stored in the open yard.

4. Conclusion/ Observations of the Committee:

(i) The unit has obtained all necessary approvals and started trail commission of Soil Retorting treatment. The delay in remediation work is due to COVID-19 situation. However, the unit has submitted the Pert Chart targeting to complete the remediation & post remediation work by October, 2024.

(ii) During the committee visit, no illegal or open dumping of excavated untreated soil storage is observed. The unit claims that the washed soil having mercury content less than 20 mg/kg is stored in open yard with tarpaulin closing which is ready for refilling after validation of NEERI. However, the committee has collected the said samples to ensure the authenticity and based on the analysis report, it shows that mercury concentration is much below than 20 mg/kg, which ensured washed soil stored in open yard.

(iii) As per the direction of Hon'ble Tribunal in OA No. 211/2018 in the matter of Navroz Mody Vs. Union of India & Ors., NEERI has conducted study of Pambar-shola and Pambar River (off- site assessment) and it is concluded in the report that total mercury contamination in the off-site is within the limit of screening levels.

(iv) The unit has provided silt settling tank & silt traps in order to trap the soil carry over from the contaminated site. The silt trap system is designed based on the ***consultation/suggestions & recommendation of the Indian Institute of Soil and Water Conservation (ICAR-IISWC).*** The trapped silt will be collected and taken for the remediation as per the remediation protocol.

In view of the above, it is concluded that the unit had started to carry out remediation work & trail commissioning as per the Hon'ble Tribunal direction in OA No. 211/2018 by following the protocols under supervision/examination of the Scientific Expert Committee (SEC) and Local Area Environment Committee (LAEC).

By considering the above facts and observation of the Joint Committee, the Hon'ble Tribunal may pass appropriate Order (s)/Direction (s) as deemed fit.

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TNPCB, Dindigul

H.D. Varalaxmi
Sc. E & Regional Director
CPCB, Regional Directorate (Chennai)

Site Assessment of Pambar Shola and Pambar River in the Down Gradient Direction of the Mercury Contaminated Site of Hindustan Unilever Ltd. Closed Thermometer Factory, Kodaikanal

CSIR- National Environmental Engineering Research Institute

Nehru Marg, Nagpur – 440 020

August 2021

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1.0 Introduction

A mercury thermometer manufacturing factory at Kodaikanal was set up by Ponds India Ltd. in 1983. The factory commenced production in January 1984, and it came under the management of Hindustan Unilever Limited (HUL) in September 1998, consequent upon the merger of Ponds India Ltd. with HUL. The factory was a 100 % export oriented unit. The clinical thermometers manufactured were mainly exported to the countries such as Australia, Europe, South America and USA. The factory produced around 9 million thermometers per year, and about 165 million pieces were exported between 1984 and 2001.

Detection of glass scrap with residual mercury at a scrapyard at Moonjikal, Kodaikanal and the consequent mercury contamination issues and regulatory actions led to the closure of the factory operations in March 2001. Remedial measures were initiated by HUL immediately, which included (i) retrieval of glass scrap with residual mercury from the scrapyard, (ii) environmental site assessment and risk assessment of mercury, (iii) construction of silt traps to prevent discharge of contaminated soil from the factory site, (iv) comprehensive medical examination of employees, and (v) export of all mercury bearing materials such as glass scrap, finished and semi-finished thermometers, elemental mercury, and effluent treatment plant (ETP) sludge totalling about 290 metric tons (MT) to M/s Bethlehem Apparatus, USA with prior consent and approval of Tamil Nadu Pollution Control Board (TNPCB) and Ministry of Environment, Forest and Climate change (MoEF&CC).

The Supreme Court Monitoring Committee (SCMC) on hazardous waste management visited the HUL factory site in September 2004 and directed the Tamil Nadu Pollution Control Board (TNPCB) to take immediate steps towards assessment and remediation of mercury-contaminated areas. The SCMC also directed the TNPCB to involve CSIR-National Environmental Engineering Research Institute (CSIR-NEERI), Nagpur during the assessment and remediation of mercury-contaminated areas. Keeping in view of the directive of SCMC, the TNPCB requested CSIR-NEERI, Nagpur, to get associated with the studies on decontamination of the machineries, equipment and materials and

remediation of soil and biomass contaminated with mercury. TNPCB also directed HUL, to finalize the proposals for decontamination of plant and machinery and remediation of mercury-contaminated areas in consultation with CSIR-NEERI. The decontamination and disposal of plant and machinery were completed in 2006 under the guidance of CSIR-NEERI.

CSIR-NEERI prepared a detailed document “Protocol for Remediation of Mercury contaminated site at HUL Thermometer Factory, Kodaikanal (February 2007)”. The protocol delineated the approach, methodology, and technical aspects to be considered during the remediation of mercury-contaminated areas at the site. The protocol recommended soil washing followed by thermal retorting for treating the contaminated soils. It also envisages that treatment of impacted soils shall be carried out within the facility itself, with the treated soils backfilled on the site, once the remediation criteria have been met. The protocol was submitted to TNPCB for approval. The Protocol was reviewed by the Scientific Experts Committee (SEC) constituted by the SCMC. Based on SEC recommendations, the TNPCB set a remediation criterion of 20 mg/kg for the site with a 95 % confidence level to be implemented with none of the treated soils to exceed 25 mg/kg.

The proposed technology for remediation of mercury-contaminated soil consists of soil washing to selectively concentrate elemental mercury into the fine soil fraction, followed by vacuum thermal retorting of the fine soil fraction. The Detailed Project Report (DPR) was presented to the TNPCB and the SEC. The TNPCB approved the DPR on the recommendation of the SEC. Further, the remediation standard was set to 20 mg/kg by TNPCB based on further study and additional inputs.

Following the approval from TNPCB, pilot-scale soil remediation trials were undertaken at the site between August and November 2017. Based on the results of the soil remediation trials, and the discussions held in the meeting TNPCB/ SEC in November 2017, the TNPCB/ SEC directed HUL to submit a “Soil Remediation Upscaling Plan” that details the soil remediation activities to be undertaken at the site. The TNPCB granted permission to HUL in June, 2018 for soil remediation to the remediation standard of 20 mg/kg. Further, the

TNPCB order granting permission was challenged in NGT. However, the NGT in its order dated 01 November 2018 cleared remediation of the contaminated site to the SSTL of 20 mg/kg. In addition, the NGT ordered to carry out a detailed offsite assessment in the down gradient of the HUL site *viz.* Pambar Shola to ascertain the extent of contamination, and if required to conduct an Ecological Risk Assessment study. The NGT order was challenged in the Supreme Court. After hearing the matter, the Supreme Court dismissed the petition and thereby clearing the soil remediation to the SSTL of 20 mg/kg.

CSIR- NEERI has been associated with HUL site remediation work, on the direction of SCMC. Hence, CSIR-NEERI was assigned to conduct the offsite assessment in compliance with the NGT order dated 01 November 2018.

2.0 Scope of the Study

The NGT in its order dated 01 November 2018 directed HUL to clean up the mercury-contaminated site to the SSTL of 20 mg/kg, and also to carry out offsite assessment study in Pambar Shola. The relevant portion of NGT order is reproduced verbatim.

i. "*To permit remediation of mercury contaminated soil in the premises of closed thermometer factory and its adjoining areas to the recommended remediation target level of 20 mg/kg (total mercury) with valid authorization from Tamil Nadu Pollution Control Board.*

ii. *Considering the reported environmental impacts in Pambar Shola river in the down gradient direction of closed thermometer factory, it is proposed that a detailed site assessment be carried out to ascertain the extent of contamination and if required, an ecological risk assessment study also be carried out*."

2.1 Objectives

1. To carry out site reconnaissance survey in Pambar Shola forest area and Pambar river.
2. Develop a grid/transect based sampling plan and collect representative samples of soil, tree bark, lichen, moss, leaves, bush, and grass across the Pambar Shola forest area. Develop a zone-based sampling plan and collect representative samples of river water, soil, sediment, and receptor species such as lichen, moss, algae and fish along the Pambar river.
3. Analysis of environmental and receptor species samples for total mercury.
4. To compare the observed mercury concentrations with the applicable screening standards (Tier I) as per the Ministry of Environment, Forests & Climate Change (MoEF & CC) guidance document on contaminated site assessment (2015).
5. To assess the need for undertaking an Ecological Risk Assessment study.

3.0 Study Area

3.1 HUL Mercury Contaminated Site

The HUL owned closed thermometer factory site (hereafter referred to as HUL site) is located in the hill station of Kodaikanal, Dindigul district, Tamil Nadu. The area forms part of Palani Hills, the easternmost part of Western Ghats and covered under Survey of India toposheet Nos. 58 F/8 and 58 F/12. The HUL site is located at an elevation of approximately 2,180 m above mean sea level (amsl), and the annual mean temperature ranges between 8 and 24 ºC. The area receives an annual rainfall of about 1650 mm. The HUL site is irregular in shape and occupies an area of approximately 85,000 m^2. The southern boundary of the site slopes steeply into the reserved forest called Pambar Shola. A narrow access path, called “Levinge path” (named after the then Collector of Madurai), runs parallel to the site's southern boundary. This path lies immediately above the precipitous slopes and is primarily on bedrock with only a thin veneer of soil. The general land use to the north and east of the site is largely low density private residential properties along Saint Mary’s Road.

Kodaikanal Lake is located 500 m north of HUL site, but within a different catchment area.

The access road to the HUL site, St. Mary's Road, forms the drainage divide between the Pambar river sub-catchment to the south, which includes the factory site, and the Kodaikanal Lake catchment to the north. Drainage across the site is primarily *via* a small stream, which originates at the north-eastern corner of the site and flows in a southwest direction and falls in the Levinge path, traverses about 300 m, and joins the Pambar river.

The Pambar river, locally called Levinge stream, originates from the reservoir located about 4 km west of the HUL site. It flows approximately 300 m south of the HUL site boundary and flows in a south-east direction through the dense forest Pambar Shola, part of Kodaikanal Wildlife Sanctuary, and reaches the Periyakulam plains. Pambar river has several waterfalls, notable ones are Vattakanal falls, situated about 1.5 km upstream side, and Kumbakarai falls, situated about 15 km south of HUL site in the downstream side. The Pambar Shola ends at Kumbakarrai falls and thereafter, the river flows through the plains and forms several distributaries that feed a series of tanks. The mainstream joins with Varahanathi, a tributary of Vaigai river at Periyakulam. The Varahanathi joins with Vaigai river, about 10 km after Vaigai Dam. The length of Pambar river is about 25 km, out of which it traverses about 15 km through Pambar-Shola forest area. The location map of the study area is given in Figure 1.

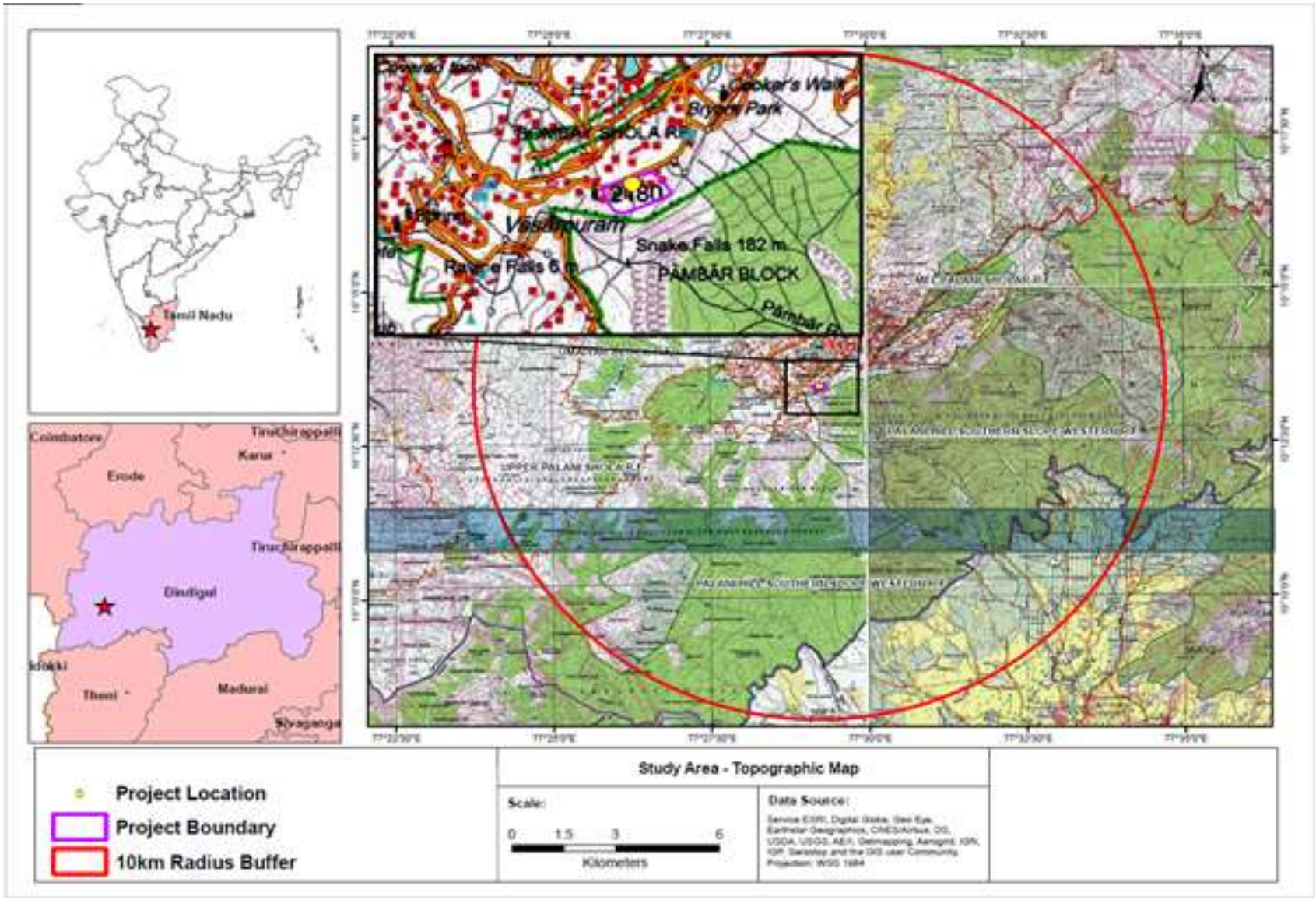

Figure 1: Location Map of the Study Area

3.1.1 Site Geology

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 sub-horizontal joints and exfoliation joints in the uppermost weathering profile. The soil profile is very shallow, comprises a few centimetres of predominantly sandy material in the upper part of the site, grading down into densely vegetated peaty soils in the south. The maximum thickness of soil across the site varies between 1.5 and 3.0 meters. Two shallow dug wells are present in the HUL site, where groundwater occurs under unconfined to semi-confined conditions. Groundwater is generally available in these wells throughout the year.

3.2 The Sholas – An Overview

Shola forests are a characteristic feature of the Western Ghats. They are found in the Anamalais, Nilgiris and Palani hills of Tamil Nadu and in the high ranges of Kerala and Karnataka. From the bio-geographical point of view, the Nilgiris hills form an important component of the southern Western Ghats complex. Altitude, climate and rainfall have combined to make the Sholas a particularly rich habitat for plants and animals. A Shola is an evergreen forest of the Western Ghats, located along the streams and are in hollows and surrounded by large tracts of Savanna. The Sholas are low forest of the plateau, which protects the hill slopes from erosion and conserves the springs and water sources.

3.2.1 General Characteristics

Southern montane wet temperate forests are generally referred to as Sholas under the classification 11A/C1 by Champion and Seth (1968). Sholas have unique vegetation and are important from the point of phytogeographic studies. The streams that originate in the sholas form the lifeline of the villages of the Upper Palnis as well as important source of irrigation in the plains. Hence, these Shola forests are valuable, and their preservation is of great importance. Sholas harbour and houses many micro and macro faunas that have a complex food web and constitute a fragile ecosystem. The Sholas are generally confined

to the sheltered valleys, glens, hollows and depressions owing to their fastidiousness as regards to soil moisture (Ranganathan, 1938).

3.2.2 Factors Governing the Distribution of Sholas

Shola patches occur as a rule at the heads of streams in the folds of converging slopes, concave inclinations and depressions caused by landslips on the slopes of the hills. The Sholas require an adequate amount of soil moisture for their growth. A dense layer of humus in varying stages of decomposition overlying a black soil of loose texture with a high proportion of organic matter is the characteristic feature of Sholas. This, in turn, increases the soil water content by holding up the water received by precipitation and preventing too rapid runoff.

Shola forests are distributed from 1,500 m to 2, 550 m altitude, where the rainfall varies from 1,000 to 7,500 mm per annum. The actual quantity of rainfall is not a determining factor, but the temperature and soil moisture play a vital role for its sustenance. Shola species are shallow-rooted to the maximum of 90 cms even where the soil depth is more. Shola species grow on all kinds of soils of Nilgiris irrespective of their chemical and mechanical composition, exhibiting a very wide tolerance. The underlying rocks are Archaen igneous origin consisting of minerals such as silica, feldspar, muscovite and biotite with small amount of accessory ferromagnesium minerals. The Shola soils are rich in organic matter, and the soil pH ranges from 4.13 to 5.34.

3.2.3 The Palanis

The Palanis are an Eastern offshoot of the Western Ghats with roughly 65 km East-West with a maximum height of around 2,200 m above mean sea level (amsl) in Kodaikanal. Because of the geographical position, this mountain range gets the benefits of both the South-West and North-East monsoons. The indigenous vegetation of the Palani hills consists of Sholas and grasslands. These Sholas once occupied the undulating plateau over 75 % of the Upper Palanis (Srivastava, 2001). In Kodaikanal, Sholas generally commence at about 1500 m and ascend to the summit of the ranges. These forests have the richest assemblage of evergreen trees, forming a close canopy. Most of the

trees attain a height of 20-30 m, and at higher altitudes, the trees are stunted. There is a gradual change in the composition of Shola vegetation in the Palanis. Some of the notable branched trees are *Rhododendron nilagiricum*, *Gaultheria fragrantissima*, *Vaccinium leschenalultii*, *V. nilgherrens*e, *Turpinia nepalensis* and shrubs *viz. Ulex europenus*, *Cytisus scoparius*, *Eupatorium glandulosum*, *Sarothamus scoparius* and *Rubus ellipticus* are common in Sholas of Kodaikanal (Bir and Chantha, 1987). Important characteristics of Sholas in Palanis are given in **Table 1**.

Table 1

Important Characteristics of Sholas in the Palanis (Srivastava, 1999)

Sl. No	**Characteristics/Trees**	**Area (hectares)**
1	Total extent of the shola under good shola vegetation	2,366.92
2	Area under partially degrades sholas	886.11
3	Area under degraded sholas	1,569.40
4	Total area under grassland and swamps, rocks etc.	18,799.71
5	Wattle	7,720.51
6	Pine	1,872.73
7	Blue gum	624.44
8	Other Eucalyptus species	4,414.10
9	Other miscellaneous species	2,574.56
	Total	**17,188.34**

The Sholas and grasslands of Palani hills safeguard the watershed of the Amaravathi and Vaigai basins. The grasslands retain 3% of the rainwater, whereas the flora of Sholas packed with decaying leaves and due to its richness in humus, retain 33% of the rainwater. Through sponge action, they release the retained water gradually. When this thick mat of the soil profile is destroyed, it leads to instant runoff accompanied by soil erosion and floods in the Palanis. **Table 2** gives the details of Sholas in the upper Palanis in Tamil Nadu.

Table 2

List of Sholas in the Palanis and their Details (Subbarayalu, 1997)

Sholas	Elevation (m)	Area (ha)
Bear shola	2,065	22.00
Berijam	2,100	177.00
Blackbourne shola	1,700	9.46
Gundar shola	2,100	120.00
Mannavanur	1,980	70.00
Pambar shola	1,920	618.00
Vembadi	2,500	4.00

3.2.4 Pambar Shola

Pambar Shola, a reserve forest of the Tamil Nadu forest department, is home to some of the most threatened and endemic species of flora and fauna. It is the largest Shola of the Palanis and has an aerial extent of 618 ha. While some species have close relatives only in the evergreen of northeast India or southeast Asia, some others are found nowhere else in the world.

3.2.5 Floral Diversity

Pambar shola comprises 56 different species of plants like trees, shrubs and herbs, which plays a vital role in ecological balance. Pambar Shola is home to about 17 species of plants on the red data list (threatened species) that are found only in these forests and not anywhere else in the world.

3.2.6 Avifaunal Diversity

Almost all the high altitude endemics of the Western Ghats are seen in Pambar Shola. Interestingly, the threatened and endemic Nilgiri Wood-Pigeon *Columba Elphinstonii*, which was rare during the 1980s, has now become quite common and found to breed in these Shola patches. No decline has been observed in other endemic species, including *White-bellied Shortwing, Brachypteryx major* and Nilgiri Flycatcher *Eumyias albicaudata*,

which is evident from their common occurrence in the gardens and campuses of Kodaikanal town. From the Bombay Natural History Society (BNHS) ringing data of the last 30 years, it was found that the Black-and-Orange Flycatcher *Ficedula Nigrorufa* and White-bellied Shortwing from neighboring forest patches (Poombarai) have shown a steady increase in the total bird catch since the 1970s. However, the Nilgiri *Pipit Anthus nilghiriensis* has decreased, mainly due to the plantation of exotic trees in Shola grasslands (Balachandran et al. 2003). Of the 16 restricted-range species of the Western Ghats (Stattersfield et al. 1998), seven have been reported from this Important Bird and Biodiversity Area (IBA).

3.2.7 Faunal Diversity

The major predators are the Tiger *Panthera tigris* and Leopard *Panthera pardus* but the sightings of these two predators have become rare in these sholas due to human disturbance. Barking Deer *Muntiacus muntjak* is the commonest ungulate. The Gaur *Bos frontalis* and Wild Boar *Sus scrofa* population show increase. Wild Dog *Cuon alpinus* and Sambar *Cervus unicolor* have decreased. Indian Giant Squirrel *Ratufa indica* is found in all suitable forest patches. The Bonnet Macaque *Macaca radiate* has increased to pest proportion as tourists feed the animals.

4.0 Methodology

A team of CSIR-NEERI scientists, which include Contaminated Site Assessment Experts and Forestry Experts conducted the offsite reconnaissance survey with the permission of the Principal Chief Conservator of Forest, and Chief Wildlife Warden, Chennai and District Forest Officer, Kodaikanal during September-October 2020 (Premonsoon) and March 2021 (Postmonsoon).

The offsite assessment in Pambar-Shola was planned based on the information collected from previous studies, data collected from District Forest Office, Kodaikanal, toposheets etc., on the extent of the Pambar Shola, its flora and fauna etc. Broadly, the study encompasses two key ecosystems, *viz.* Pambar watershed and Pambar Shola. Since, the Pambar river flows through the

Pambar Shola (hence the name), the Shola and other forest areas collectively form the Pambar watershed. Accordingly, the assessment of the two ecological units were carried out simultaneously.

4.1 Methodology Adopted for Sampling

4.1.1 Forest Sampling Methodology

Pambar-Shola is a dense forest and most of the areas are inaccessible. Further, considering the steep slopes and presence of wild animals, transect sampling method was followed. The trekking path from Shenbaganur to Kumbakarai falls (about 15 km length) is the only accessible way to the Pambar Shola. This transect runs parallel to Pambar river with a maximum distance of about 7 km from Shenbaganur, and slowly it converges towards Kumbakarai falls. Sampling locations were selected close to the river. Forest samples were collected from 44 locations and consist of soil, lichen, moss, grass, bush/leaves and tree bark. Soil samples were composite of 5 grab samples collected from an area of 2 × 2 m from each site. All samples were collected in zip-lock bags, preserved in ice boxes and brought to the lab for analysis. Details of samples collected from Pambar Shola forest area are given in the **Table 3,** and sampling locations in Pambar Shola forest area shown in **Figure 2.**

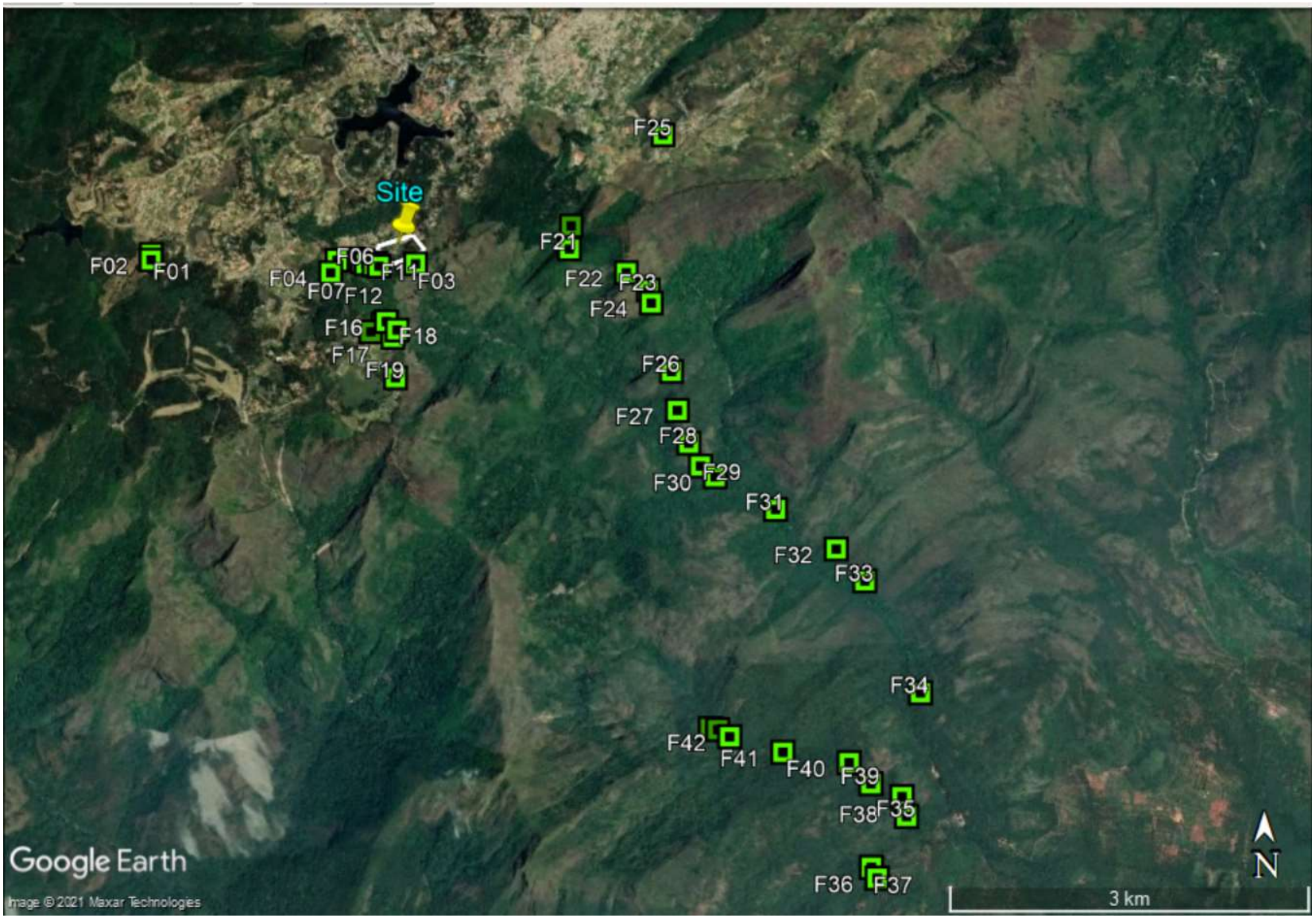

Figure 2: Sampling Locations in Pambar Shola Forest Area

Table 3

Number of Samples Collected from Pambar-Shola Forest Area

Sl. No	Matrix	Pambar Shola
1	Soil	44
2	Bark	44
3	Lichen	41
4	Moss	31
5	Leaf	44
6	Bush	4
7	Grass	27

4.1.2 Pambar River

The entire stretch of Pambar river, *i.e.* from the origin to its confluence point with Varaghanathi river, and further to the confluence point of Vaigai river, has been divided into three zones *viz.*

- Zone-I: origin of Pambar river to HUL factory site approx. 5 km upstream i.e. (sampling locations R2 to R6),
- Zone-II: HUL factory site to Kumbakarai falls (~15 km), (sampling locations R7 to R 14), and
- Zone-III: Kumbakarai falls to the confluence point with Varaganathi and further to the confluence point of Vaigai river (~15 km) (sampling locations R 15 to R 23).

The Pambar river stretch, after the meeting point of HUL factory stream outlet, runs through a very steep valley (about 800 m depth), hence this middle stretch is not accessible (about 7 km downstream of HUL site). From each sampling location, water, sediment, algae, river bank soil, lichen, and moss samples were collected.

Samples of water were collected from the main current of the river in glass bottles directly from the undisturbed water flow. Glass bottles were rinsed thrice

with a portion of river water before collection. Samples were acidified on site using 1 ml ultrapure nitric acid (1:1) to pH <2.

Soil samples were collected from the river bank at a depth of 0-10 cm, after removing surface debris and dried leaf, if any. From each sampling point, soil samples were collected from an area of 2 × 2 m, one from each corner and one from the centre. The five grab samples were composited at site, and the composited sample was packed in zip-lock bags, preserved in iceboxes and brought to the lab for analysis.

Sediment samples were collected using Van-Veen sediment grab sampler/scoop. Sediment samples were collected from each site, drained to reduce water content, packed in zip-lock bags, preserved in ice boxes, and brought to the lab.

Algae samples were collected from the river sampling points based on their availability. Lichen and moss samples were collected from the trees close to river flow. Lichen, moss and algae samples were packed in zip-lock bags at the site immediately, kept in ice boxes and brought to the lab for analysis. Details of samples collected from Pambar river watershed are given in **Table 4,** and the sampling locations along Pambar river shown in **Figure 3.**

4.1.3 Fish Sampling

Fish population is generally less in Pambar river. Only small fishes of length 3-5 cm were spotted in select places, where flow of water is slow. Fishes were caught using folded cloths and brought live to the camp by keeping them in water-filled polythene bags. From each site 5 to 10 fishes were caught and the weight of fishes ranged between 10-15 g. Subsequently, they were preserved in dry ice, packed in icebox and sent by courier to CSIR-NEERI, Nagpur for analysis.

4.1.4 Sample Preservation

Water samples were collected in 250 ml glass bottles with PTFE cap liner and were preserved on site with the addition of 1 ml of 1:1 suprapure HNO_3 to pH <2. Samples were not filtered as total mercury content was desired. Samples

were kept in ice box with ice packing and shipped to CSIR-NEERI, Nagpur for analysis. Similarly, soil, sediment, algae, lichen, moss, bush/leaves, grass samples were packed in zip-lock bags, kept in ice boxes and shipped to CSIR-NEERI for analysis.

Table 4

Number of Samples Collected from Pambar River Watershed

Sl. No	Matrix	Pambar River	
		Premonsoon	Postmonsoon
1	Water	23	23
2	Soil	23	23
3	Sediment	22	22
4	Moss	4	10
5	Algae	8	8
6	Fish	–	7

'–' Indicates 'no sample collected'

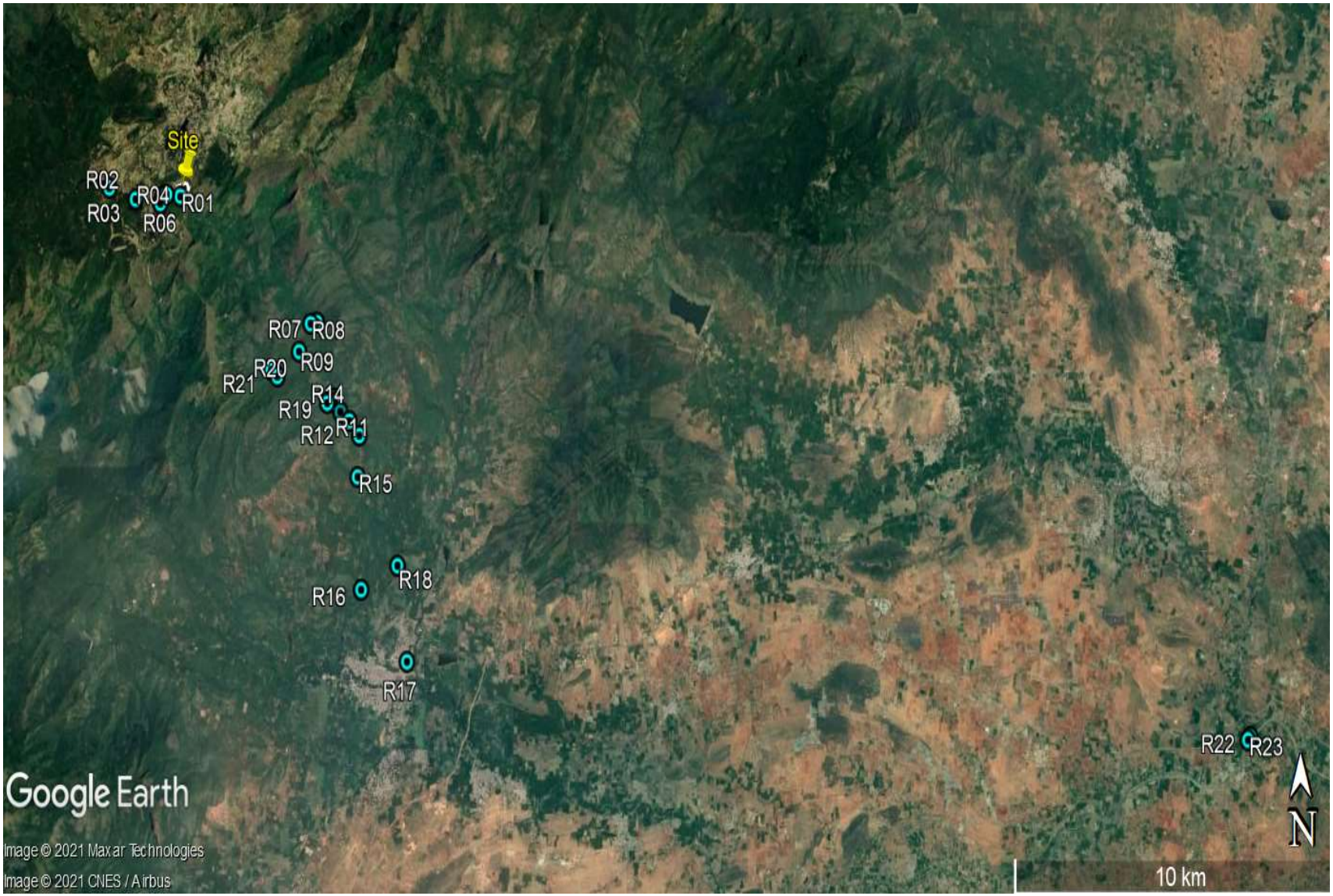

Figure 3: Sampling Locations along Pambar River

5.0 Sample Preparation for Mercury Analysis

5.1 Soil and Sediment

Soil and sediment samples were prepared according to US EPA method 3050 B. Samples were air-dried in a clean room and homogenized thoroughly to < 2 mm size. An aliquot of 1 g of sample was taken in a clean 250 ml beaker, and 10 ml of 1:1 HNO_3 was added and digested in a hot plate at 80-85 ºC for 2 h. The contents were cooled, and 2 ml of deionized water and 3 ml of H_2O_2 were added. The solution was digested for another 2 h, and volume reduced to 2 ml. The contents of the beaker were cooled to room temperature and made up to 100 ml using 0.1 % HNO_3 prepared in 18 mΩ.cm ultrapure water. Blank samples were prepared in the same way with pure sand, which was previously digested with HNO_3 and found to have no detectable mercury content. Results are reported on dry weight basis.

5.2 Bark, Lichen, Moss, Leaves, and Grass Samples

Lichen, moss, leaves, grass and bark samples were prepared according to the method of ICP vegetation survey (2015) and other published methods (Lodenius and Tulisalo, 1995). Lichen and moss samples were cleaned to remove the root portion, and samples were rinsed with deionized water. Samples were dried in oven at 60 ºC to remove moisture completely. The dried samples were ground using mortar and pestle, homogenized and a 0.2 g portion was digested at 95 ºC with 1.5 ml of HNO_3 and 0.5 ml of H_2O_2, for about 2 h till a clear solution was obtained. Results are reported on dry weight basis.

5.3 Water Samples

Water samples were digested with HNO_3 + HCl by following US EPA method 200.8. To a 100 ml portion of well mixed water sample, 2 ml of 1:1 ultrapure HNO_3 and 1 ml of 1:1 HCl were added and digested on hot plate at 80-85 ºC for about 2 h till the volume is reduced to 20 ml. The contents were cooled and diluted to 50 ml with deionized water.

5.4 Fish Samples

Fish samples were thawed at room temperature and washed with tap water and then with deionized water. Since the size of the fishes were very small, after the removal of scales and fins, the whole fish was further processed. Samples were oven dried at 70-80 ºC, homogenized and digested by the method of Yan et al. (2010). A 1.0 g portion of homogenized fish sample was weighed into 100 ml volumetric digestion flask and a mixture of 10 ml HNO_3–H_2SO_4 (7:3) was added. The mixture was then digested at 95 ºC for about 3-4 h until the solution was clear. The sample solution was then cooled and diluted to 100 ml with deionized water. Moisture content was determined in another portion of the sample and the results are reported as wet weight basis.

5.5 Instrumental Analysis

Total mercury in all the samples were determined by ICP-MS (Perkin Elmer, Nexion 300, ICP-MS) following US EPA method 6020 A. The instrument was optimized as per manufacturer's instructions. External calibration standards were prepared in the range of 5- 25 µg/l and the instrument was optimized for maximum sensitivity. Calibration blank and sample blanks were run before sample analysis.

5.6 Quality Control and Quality Assurance

Stringent Quality Control and Quality Assurance (QA/QC) procedures were followed during sample collection, sample preparation and instrumental analysis. Blank samples were run between every 10 samples. Spiked samples were run for every 20 samples and the recovery of added spikes were in the range of 85-110 %.

Three soil certified reference materials *viz.* CRM021-100G (4.70±0.179 mg/kg), sandy loam soils CRM 043-50G (22.4±0.889 mg/kg), CRM025-50G (99.80±10.7 mg/kg), were used and the obtained values were in the range of 75-115 %. Method detection limits (MDL) and limit of quantitation (LOQ) were calculated from the corresponding blank results as 3 and 10 standard deviations i.e. 3σ and 10 σ, respectively. Results below the LOQ were reported

as “not detected (ND)”. However, for statistical calculations, ‘ND’ was replaced by MDL/2 values. **Table 5** gives MDL and LOQ of different matrices.

Table 5

Method Detection Limit and Limit of Quantitation of Different Sample Matrices

Sl. No	Sample matrix	Method detection limit (MDL) mg/kg or mg/l	Limit of quantitation (LOQ) mg/kg or mg/l	Replacement value used for statistics mg/kg or mg/l
1	Water	0.0009	0.0030	0.0004
2	Soil/Sediment	0.0030	0.0100	0.0015
3	Lichen, Moss, Leaf, Bush, Algae	0.0024	0.0080	0.0012
4	Bark	0.0015	0.0050	0.0007
5	Fish	0.0020	0.0066	0.0010

6.0 Screening Standards and Guidelines

Most of the developed countries have established guideline values/screening criteria (called by various terms, depending on the country; Intervention Value (Netherlands), Guideline Value (UK) Soil Environmental Quality Guideline (Canada), Regional Screening Level (US)) for contaminants to allow the regulator to determine whether a site is potentially contaminated or not and poses a risk to human and/or ecological receptors. A brief discussion of standards used across the world are given below.

6.1 Dutch Soil Remediation Circular

The ‘Dutch Ministry of Public Housing, Land-use and Environmental Guidelines - Soil and Groundwater Standards’ framework is described in the Soil Remediation Circular (2000). They are risk-based standards wherein the contaminants are subdivided into two categories *viz.* Target values (‘T’) and Intervention values (‘I’), depending upon the concentrations and classified as follows:

- The target values indicate the level at which there is sustainable soil quality. It represents the background concentration of a chemical constituent in uncontaminated soils. Target values give an indication of the benchmark for environmental quality in the long term on the assumption of negligible risks to the ecosystem. However, Target values are not clean-up criteria standards.
- Intervention values define sites where some form of intervention is required. Exceeding an Intervention value is taken to indicate significant soil contamination, which may have a serious impact on human health and/or the environment, depending upon the presence of sensitive receptors. Intervention values are a trigger for the assessor to investigate further whether the concentrations of the contaminant of concern pose a human and/ or ecological risk. Exceedance of an Intervention value does not necessitate remediation, and the general approach adopted by Dutch/ Canadian standards is to undertake a site specific risk assessment.
- The Dutch Intervention Value for mercury in soil is 36 mg/kg.
- The Dutch Intervention Value for mercury in sediment is not specified.
- The Dutch Intervention Value for mercury in surface water is 0.3 ug/L.

Currently there are no guidelines for mercury in vegetation matrices such as bark, moss, lichen, leaf, bush, and grass.

6.2 Canadian Environmental Quality Guidelines

Canadian Environmental Quality Guidelines (EQGs, CCME, 1999) are defined as numerical concentrations or narrative statements that are recommended as levels that should result in negligible risk to biota, their functions, or any interactions that are integral to sustaining the health of ecosystems and the designated resource uses they support. The EQGs have evolved to address the protection of atmospheric, aquatic, and terrestrial resources, including air quality, marine water quality, marine and freshwater sediment quality, tissue quality for the protection of wildlife, aquatic life, and soil quality for agricultural, residential/parkland, commercial, and industrial land uses.

EQGs need not to be considered as blanket values for national environmental quality. Variations in environmental conditions will affect environmental quality in different ways. Therefore, the users of EQGs may need to consider local conditions and other supporting information (e.g., sites specific background concentrations of naturally occurring substances) during the implementation of EQGs. Exceedance of EQGs does not signify immediate intervention/remediation, but the Canadian guidelines typically recommend a risk assessment to be undertaken so that regulators will take appropriate interventions.

- The Canadian Soil Quality Guideline (SQG) for the protection human health is 6.6 mg/kg for agricultural and residential/ parkland use. The SQG for environmental health is 12 mg/kg for agricultural, residential and parkland land use. However, if one were to undertake a Tier I screening of the Pambar Shola analytical data with respect to environmental health, the screening guideline in that case would be 12 mg/kg.
- The Canadian screening standard for mercury in sediment is 0.486 mg/kg.
- The Canadian screening standard for mercury in surface water is 0.026 µg/l.

Currently, there are no guidelines for mercury in vegetation matrices such as bark, moss, lichen, leaf, bush, and grass.

6.3 USEPA Screening Levels

The United States Environmental Protection Agency (USEPA, 2021) Screening Levels (SLs) are risk-based contaminant concentrations derived from standardized equations combining exposure information assumptions with USEPA toxicity data. These are generic tables for individual contaminants in air, drinking water and soil. Regional Screening Levels (RSLs) are considered by the USEPA to be protective for humans (including sensitive groups) over lifetime period. They were developed to standardize and accelerate the evaluation and cleanup of contaminated soils and were primarily focussed on identifying and defining areas and contaminants. At sites where the contaminant concentration is below SL, no further action is warranted, and

when it exceeds the SL, further assessment or investigation involving receptor species is required.

- The USEPA screening standard for mercury in soil is 11 and 46 mg/kg for resident and industrial soils, respectively.
- The USEPA screening standard for probable effect concentration of mercury in sediment is 0.486 mg/kg.
- The USEPA maximum contaminant level (MCL) for mercury in tap water is 2.00 ug/L.

6.4 MoEF & CC Guidelines

The Ministry of Environment, Forest, and Climate Change, through a detailed assessment (undertaken by a renowned Global Environmental Consultancy) of guidelines and screening criteria adopted by other countries, have adopted the Canadian SQGs as a proxy screening criteria for India, in the absence of any country specific guidelines (MoEF, 2012). The same guidelines have also been used in the MoEF&CC (2015) document “Inventory and Mapping of Probably Contaminated Sites in India”. Therefore, in the present study, the Canadian SQGs have been primarily used, although we have also screened the mercury monitoring data against other conservative screening standards set out in the USEPA Regional Screening Levels and the Dutch Intervention Standards.

- The MoEF&CC screening level for mercury in soil is 6.6 mg/kg.
- The MoEF&CC screening level for waste water discharge into surface water bodies is 0.010 mg/l.
- The BIS limit for drinking water quality is 0.001 mg/l.

7.0 Risk Assessment Methodology

7.1 Risk Assessment Based on Screening Level

A key component of sustainable environmental management is a risk-based approach focused on whether or not site related impacts pose unacceptable current or likely future risks to critical species residing on the site or near the site. The risk-based approach incorporates a tiered approach with the

completion of screening level based (Tier 1), and quantitative site-specific risk assessment (Tier 2) that inform decision making regarding further actions.

7.2 Screening Level Tier I Risk Assessment

Tier 1 screening, is the first step in a tiered risk-based site assessment approach to help narrow down the range of contaminants requiring further assessment or remediation. The screening level (Tier 1) assessment will provide an evaluation of the potential risks and the need for further assessment.

A screening level Tier 1 risks assessment includes comparison for site characterisation data (e.g. soil) to established national or international risk-based screening levels. In addition, background concentrations can be an important part of a screening level (Tier 1) risk assessment as risk-based standards are based on generic understanding of fate and transport modelling and laboratory toxicity testing. This approach for developing screening levels often results in the calculation of screening levels that are below background level and do not account for ecological and receptors that can develop that cannot be accounted for laboratory conditions. Accordingly, a robust screening level Tier 1 risk assessment consider both risk-based criteria and background concentrations.

Typically, available risk-based criteria and/or background data are limited to soil. Therefore, a screening level risk assessment is typically limited to assessing measured soil concentrations against relevant screening levels and/or background concentrations.

7.3 Tier II Risk Assessment

If a screening level Tier 1 indicates impact greater than risk-based screening levels, a Tier 2 risk assessment may be warranted. A Tier 2 ecological risk assessment will be developed considering these key elements:

- Ecological Survey and Identification of Representative Ecological Receptors
- Identification of Significant Dietary Exposure Pathways

- Site Soil and Biota Sampling
- Contaminant fate and transport information (e.g. mobility, plant uptake)
- Critical or at-risk habitats present at the Site.
- Identification of Assessment Endpoints
- Exposure Assessment
- Receptor-Specific Exposure Parameters
- Exposure Dose Calculation
- Ecological Toxicity Reference Values
- Ecological Risk Characterization

8.0 Results and Discussion

8.1 Pambar-Shola Forest Area

The mercury analysis results of soil, bark, lichen, moss, leaves, and bush samples collected from Pambar Shola forest area are given in Annexure I.

8.1.1 Concentration of Mercury in Soil

Mercury concentrations in 44 soil samples collected from the Pambar shola forest area ranged between ND and 0.950 mg/kg, with an average concentration of 0.141 ± 0.241 mg/kg. Mercury concentrations of all the soil samples were less than the MoEF&CC guideline value of 6.6 mg/kg, for residential/agricultural purposes. Further, the soil mercury concentrations did not exceed the Canadian soil quality guideline value of 12 mg/kg for Environmental Health. Summary of soil mercury concentrations, and screening levels are given in **Table 6**.

Table 6
Summary of soil mercury concentrations from Pambar-Shola and applicable screening values

Soil	Hg concentration, Range (mg/kg)	Hg, mean concentration ±SD (mg/kg)
Pambar Shola	ND – 0.950	0.141±0.241
MoEF&CC Screening levels	6.6	
Canadian Guideline value	6.6	
Dutch Intervention Value	36	
USEPA	40	

SD: standard deviation; ND: not detected

8.1.2 Concentration of Mercury in Bark, Lichen, Moss, Leaves, Bush, and Grass Samples

Vegetation in the forest area are important receptor species exposed to mercury in air, soil and water. Species of lichen and moss are good indicators of atmospheric mercury concentration. Trees generally store heavy metals in bark; hence, tree bark is a matrix for several heavy metal contamination studies, including mercury. Though age, and inter species differences influence accumulation levels, observed mercury levels can be useful for ecological risk assessment. The concentration of mercury found in lichen, moss, leaf, bark and grass samples collected from Pambar Shola are given Annexure I. Summary of mercury results of Pambar Shola are given in **Table 7**.

Table 7

Summary of vegetation samples collected from Pambar Shola

	Lichen	Moss	Leaf	Bush	Bark	Grass
Pambar Shola samples Range (mg/kg)	ND–0.528	ND–0.250	ND–0.065*	0.095-0.227	0.067-0.736	ND#
Mean±SD (mg/kg)	0.044 ±0.086	0.050 ±0.065		0.159 ±0.059	0.200 ±0.119	

SD: standard deviation; ND: not detected
* Only two values were above detection limit, hence average and standard deviation were not calculated; # all sample results are ND

In general, the concentrations of mercury in the vegetation samples collected from the Pambar Shola, are less than 1 mg/kg. There are no guideline values/standards for mercury levels in vegetation samples.

In lichens, mercury ranged between ND and 0.528 mg/kg, the highest concentration was reported from a location (F 44) on Vellakavi to Kumbakarai footpath, about 6 km south of Vellakavi village. All bark samples had low concentration of mercury ranging between 0.067-0.736 mg/kg. Leaf samples generally reported below the detection limit. Moss samples of Pambar Shola showed almost similar distributions i.e. ND–0.250 mg/kg; mean 0.050 ±0.065 mg/kg. Bush samples from Pambar Shola had similar mercury levels, indicating no appreciable enrichment in bush species.

Overall, the mercury accumulation levels and patterns indicate, relatively low concentrations of mercury in vegetation samples, with no exceedance of 1.0 mg/kg in any of the species.

8.2 Pambar River Watershed

8.2.1 Concentration of Mercury in Water Samples

Concentration of total mercury in water, sediment, soil, moss, algae collected from Pambar river during pre and postmonsoon periods are given in Annexure II and III. Summary of total mercury concentration in water samples and applicable screening standards are given in **Table 8**.

Table 8

Summary Results of Water Samples Collected from Pambar River

	Hg concentration Range (mg/l)	Hg Average Concentration ± SD (mg/l)
River water (premonsoon)	ND	–
River water (post monsoon)	ND	–
Levinge Pathway (premonsoon)	ND	–
Levinge Pathway (postmonsoon)	ND	–
MoEF&CC guideline value for discharge into surface water bodies	0.010 mg/l	
BIS 10500:2012, Drinking water standards	0.001 mg/l	
Canadian Guideline value	0.000026 mg/l	
Dutch Intervention Value	0.0003 mg/l	
USEPA Regional Screening Level (MCL)	0.002 mg/l	

SD: standard deviation; ND: not detected; MCL: maximum contaminant level; BIS: Bureau of Indian Standards

During the premonsoon period, twenty-three were samples were collected from the Pambar river and all samples had mercury below the detection limit and reported as “not detected”. During postmonsoon period also, all river water samples had mercury below detection limit. The samples collected from HUL factory stream discharge point (R 01) showed “ND”, during pre and postmonsoon periods. This indicates, the concentration of mercury in all the water samples were less than the applicable screening standards (MoEF&CC and BIS; USEPA RSL’s). The screening levels of CCME and Dutch Standards are lower than the detection limits of the analytical methodology followed in this study (0.0009 mg/l, cf. Table 5).

8.2.2 Concentration of Mercury in Fish Samples

The concentration of total mercury in the seven fish samples collected from various locations of Pambar river ranged from ‘not detected’ (ND) in three

sample to 0.009 mg/kg (Table 9). As per the FSSAI (2011) guideline, the concentration of mercury in fish should not exceed 0.5 mg/kg. All the fish samples reported total mercury concentrations below this limit.

Table 9

Concentration of Mercury in Fish Samples

Sl. No	Sample Code	Location GPS		Location	Mercury (mg/kg) wet weight basis
		North	East		
1	F 01	10.08.517	77.33.232	Pambarru river down stream at Chota Dam - Vatta Pallam	0.008
2	F 02	10.10.782	77.31.856	Kumbakarai main falls	0.009
3	F 03	10.10.836	77.31.796	50 m above from Kumbakarai main falls	0.007
4	F 04	10.10.926	77.31.778	50 m further above from F 04	ND
5	F 05	10.11.403	77.31.249	Near bridge (Vellakavi trekking path to Kumbakarai - R 09	0.008
6	F 06	10.08.802	77.32.921	Pambarru river - Near Temple (R - 18)	ND
7	F 07	10.10.379	77.32.267	Kumbakarai falls - Kartar village (Kila Vadagarai) (R - 11)	ND

ND: not detected

8.2.3 Concentration of Mercury in Soil Samples

The results of soil samples collected from river bank as well as river sediments during pre and post monsoon periods are given in Annexures II & III. Summary statistics of soil mercury levels, and applicable screening levels are summarized in the following **Table 10**.

Table 10

Summary of Soil Samples Collected from Pambar River

	Hg concentration Range (mg/kg)	**Hg Average Concentration ± SD (mg/kg)**
Pambar river (premonsoon)	ND–0.966	0.082 ± 0.205
Pambar river (post monsoon)	ND–0.340	0.031±0.086
Levinge Pathway (premonsoon)	4.700	–
Levinge Pathway (postmonsoon)	0.438	–
MoEF&CC Screening levels	6.6 mg/kg	
Canadian SQG for human health	6.6 mg/kg	
Canadian SQG for environmental health	12.0 mg/kg	
Dutch Intervention Value	36 mg/kg	
USEPA	40	

SD: standard deviation; ND: not detected

Table 10 indicates, the premonsoon soil mercury concentrations ranged between ND and 0.966 mg/kg, with an average of 0.082 ± 0.205 mg/kg, whereas the postmonsoon mercury concentrations ranged between ND and 0.340 mg/kg, with an average concentration of 0.031 ± 0.086 mg/kg. All the soil samples collected along the Pambar river, during both the pre and post-monsoon sampling periods were below the MoEF&CC screening criteria of 6.6 mg/kg.

The soil sample collected near HUL Site stream discharge point on the Levinge pathway, had mercury concentration of 4.700 mg/kg during premonsoon, whereas the postmonsoon period concentration was 0.438 mg/kg. This variation could be due to the heterogeneous nature of the contamination. The mercury concentration of soil from Levinge path location, is slightly elevated, but less than MoEF&CC screening level of 6.6 mg/kg. On perusal of DPR and the Soil Remediation upscaling plan, this area has already been included in

remediation plan. Therefore, the soils form this area may be removed during the remediation phase of the project and treated at the site.

8.2.4 Concentration of Mercury in Sediment Samples

River sediments buildup contaminants transported by river water over a period of time. Sediment mercury levels more than the guideline values pose risk to sediment dwelling organisms and other aquatic flora and fauna. Summary of sediment mercury concentrations, and screening levels are given in **Table 11**.

The sediment mercury concentrations during the premonsoon season was in the range of ND–0.412 mg/kg; average 0.076 ± 0.104, and that during the post monsoon season was ND–0.256 mg/kg; average 0.019 ± 0.059 mg/kg. Mercury concentrations in the sediment samples collected from Levinge pathway were 0.099 mg/kg during the pre-monsoon season and 0.015 mg/kg during the post monsoon period. Of the twenty-three sediment samples collected both during the premonsoon and postmonsoon season all sediment samples were reported at concentrations less than the most conservative screening criteria of the Canadian Guidelines of 0.486 mg/kg. Given the low concentration of mercury in the sediment samples not exceeding the Canadian guidelines, no/negligible risk is expected for sediment dwelling organisms.

Table 11

Summary of Sediment Samples Collected from Pambar River

	Hg concentration Range (mg/kg)	**Hg Average Concentration ± SD (mg/kg)**
Pambar river (premonsoon)	ND– 0.412	0.076 ± 0.104
Pambar river (post monsoon)	ND– 0.256	0.019 ± 0.059
Levinge Pathway (premonsoon)	0.099	–
Levinge Pathway (postmonsoon)	0.015	–
MoEF&CC guideline value for sediment	Not specified	
Canadian Guideline value	0.486 mg/kg	
Dutch Intervention Value	Not specified	
USEPA	0.486 mg/kg	

SD: standard deviation; ND: not detected

8.2.5 Concentration of Mercury in Moss and Algae Samples

Moss species are good indicators of atmospheric pollutants, including mercury. From the river sampling sites, four moss samples were collected and the mercury concentration in these samples ranged between 0.02 and 6.36 mg/kg. The highest concentration of 6.36 mg/kg was reported from the moss sample collected from the HUL stream discharge point (R 01). During postmonsoon season, mercury levels in moss samples were in the range of ND–1.148 mg/kg and the highest concentration was reported from the HUL stream discharge point. Summary of moss and algae samples collected from Pambar river is given in **Table 12**.

Table 12

Summary of Moss and Algae Samples Collected from Pambar River

Sl No	**Type of Sample**	**No. of Samples**		**Concentration Range (mg/kg)**		**Average ± SD (mg/kg)**	
		Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
1	Moss	4	10	0.022–6.360	ND–1.148	1.697±3.113	0.212±0.375
2	Algae	8	8	ND–1.200	0.028–0.083	0.155±0.422	0.045±0.017

SD: standard deviation; ND: not detected; ‘Pre’ and ‘Post’ indicate premonsoon and postmonsoon, respectively.

During premonsson, algae samples collected from 8 locations in Pambar river showed mercury concentration in the range of ND–1.2 mg/kg. During postmonsoon, mercury in algae ranged between 0.028–0.083 mg/kg. During postmonsoon, algae were absent in the HUL site discharge point. No enrichment of mercury was observed in moss and algae samples in the downstream direction.

9.0 Requirement of Detailed Risk Assessment of Pambar Shola

The process of ecological risk assessment is conducted in phases with the progression to a subsequent phase based on the outcome of the previous phase indicating a potential risk that warrants further assessment.

For the mercury-contaminated HUL site, a Tier I Risk Assessment was originally undertaken in by URS Dames & Moore (2002). However, the SCMC directed TNPCB to undertake a Site Specific Risk Assessment at the site (which is also known as a Tier II Risk Assessment) for determining the remediation standard. A Risk Assessment was originally undertaken by NEERI in 2006. This Site Specific Risk Assessment included a Tier III probabilistic Risk Assessment to determine the ultimate remedial criteria to be adopted for the site remediation. Thereafter, a validation of Site Specific Risk Assessment was undertaken by the Indian Institute of Technology (IIT), Delhi, in 2010, as decided by TNPCB based on the concerns raised by a few stakeholders. The IIT Delhi report (2010) also carried out Risk Assessment study on ecological receptors such as sparrows and quails.

The MoEF&CC (2012) adopted the Canadian Soil Quality Guidelines for determining soil contamination status at sites across India, thereby bringing in the Canadian Soil Quality Guidelines (for Human Health and Environmental Health) for the site investigation and risk assessment.

All these lines of evidence consider the phases of comparison of site data to generic ecological screening level (CCME[1]) as well as to the SSTLs.

9.1 Canadian Council of Ministers of the Environment (CCME) Screening Level

The first stage of risk assessment is typically the comparison of site data to existing guidelines. The Canadian Council of Ministers of the Environment (CCME) have established an ecological screening level of 12 mg/kg that is protective for direct exposures of ecological receptors to the soil. In this study, the data has been screened against the more protective Canadian Soil Quality Guideline for the protection of Human Health (6.6 mg/kg).

9.2 Site Specific Target Levels

An ecological risk assessment was conducted by IIT, Delhi in 2010 to derive ecological target soil values that were protective of ecological species dietary exposure to mercury, due to uptake of mercury from soil into biota (e.g. plants, insects etc.). The assessment identified the avian receptors quail and sparrow would be the most sensitive ecological receptor for dietary exposures. The assessment considered exposure to soil, insects and earthworms. The assessment modelled the uptake of mercury from soil into insects and earthworms. The soil targets were calculated to be 36 mg/kg and 22 mg/kg for the quail and sparrow, respectively. The Risk Assessment is considered to be very conservative (an order of magnitude is estimated) as it has purposefully omitted the ratio of the contaminated area to the home range of the species for the direct soil exposures.

9.3 Pambar Shola/ River Soil Data Comparison

Comparison of soil mercury concentration of Pambar Shola and Pambar river of this study with the screening levels CCME and IIT Delhi showed that all the soil samples were within the SSTL or CCME SQG for environmental health or the more conservative CCME SQG for Human Health. A summary of the data with comparison to the CCME and IIT soil levels are presented in Table 13.

Table 13

Summary of Pambar Shola/ River Soil Mercury Concentrations (mg/kg)

Total No. of Soil Samples	Pambar Shola and Pambar river Soil mercury concentration					Soil Risk Based Levels (mg/kg)	
Samples	Not Detected	Detected	Min (mg/kg)	Max (mg/kg)	95% UCL (mg/kg)	CCME	IIT
90	42	48	0.014	4.700	0.396[2]	6.6	22.4

UCL: Upper confidence limit; CCME: Canadian Council of Ministers for Environment; IIT: Indian Institute of Technology, Delhi

The mercury concentrations in all soil samples are all below the CCME and IIT soil criteria. The risk-based levels consider both direct toxicity of mercury in soil to ecological receptors and dietary exposure of mercury due to bioaccumulation within the food chain. Regulatory agencies such as US EPA (2007), EPA-Australia (2007) etc. use the 95 % upper confidence level (UCL) of the mean to estimate the probable risk to receptors. The 95 % UCL of soil mercury concentration of Pambar Shola and Pambar river is 0.396 mg/kg, which is over an order of magnitude less compared to CCME SQG of 6.6 mg/kg.

10.0 Conclusions

Based on the off-site assessment study undertaken and the mercury monitoring data, the following conclusions are drawn.

Pambar Shola Forest

- Samples of soil, bark, lichen, moss, bush, grass and leaves were collected from 44 locations from Pambar Shola forest area and analyzed for total mercury.

[2] The 95 percent upper confidence limit (95% UCL) of the mean provides a better estimate of the long term average ecological receptor exposure to soil. The 95% UCL was calculated using the USEPA ProUCL statistical software.

- The mercury concentrations in soil samples collected across the Pambar Shola forest were below the MoEF&CC guideline value of 6.6 mg/kg and the CCME SQG of 12 mg/kg for the protection of human and environmental health, respectively.
- The mercury concentrations in vegetation samples such as bark, lichen, moss, bush, grass and leaves collected across the Pambar Shola forest area are generally less. There is no visible evidence of distress to vegetation, flora and fauna was noticed.

Pambar River

- Samples of water, sediment, algae, fish and river bank soil, lichen, and moss, were collected from 23 locations both pre and post monsoon periods from the entire 25 km stretch of Pambar river and analyzed for total mercury.
- All water samples collected from Pambar river showed mercury below detectable levels.
- The concentrations of mercury in soil samples were low and less than 1.0 mg/kg during pre and postmonsoon periods, with the exception of the location at the Levinge path. All soil mercury concentrations are below the MoEF&CC guideline value of 6.6 mg/kg.
- All sediment samples from Pambar river showed mercury below the Canadian Guidelines of 0.486 mg/kg.
- Mercury concentrations in lichen, moss, algae and fish samples were less and did not show appreciable enrichment.

Risk Assessment

- Screening level based Ecological Risk Assessment (Tier 1) of soil, sediment and water indicated no/negligible risk to flora and fauna, as the observed concentrations are far less than the screening levels.
- Based on the offsite field observations, sampling and analysis, Tier I Screening Level Risk Assessment, and review of the previous Risk Assessment studies, it is observed that HUL site is not likely to pose any off-site ecological risks, particularly to the ecologically sensitive Pambar Shola forest area.

- In conclusion, considering the recommendations of international regulatory agencies, the weight of evidence on the current and past mercury monitoring data, and the screening standards, a further detailed risk assessment of the Pambar Shola is not deemed necessary.

References

Chatha, G. S., & Bir, S. S. (1987). Population analysis of some woody species from Palni Hills, south India. *J Cytol Genet*, *22*, 83-94.

Canadian Council of Ministers for Environment (CCME). Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health, 1999.

Champion, H.G. and Seth, S.K. (1968). A Revised Survey of the Forest Types of India. The Manager of Publications, Delhi.

Circular on Target Values and Intervention Values for Soil Remediation", "Dutch Target and Intervention values", 2000.

CSIR-NEERI (2015) Assessment of mercury levels in soil, sediment, and water samples from the off-site area of Hindustan Unilever Limited factory (HUL), Kodaikanal, Tamil Nadu, India.

Food Safety and Standards Authority of India (FSSAI, 2011), Food safety and standards (contaminants, toxins and residues) regulations, 2011

Indian Institute of Technology Delhi (2010). Site Specific Cleanup Standards for HUL's Mercury Thermometer Manufacturing Factory at Kodaikanal, Tamil Nadu.

ICP Vegetation Survey (2015) International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops. http://icpvegetation.ceh.ac.uk

Lodenius, M., and Tulisalo, E. (1995). Open digestion of some plant and fungus materials for mercury analysis using different temperatures and sample sizes. *Science of the total environment*, *176*(1-3), 81-84.

Ministry of Environment and Forests (MoEF, 2012) Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India.

Ministry of Environment, Forest & Climate Change (MoEF&CC, 2015) Inventory and Mapping of Probably Contaminated Sites in India.

Ranganathan, C. R. 1938. Studies in the ecology of the shola grass-land vegetation of the Nilgiri Plateau. Indian Forester 64:523-541.

Srivastava, R. K. "Biotic Pressure and Entry of Exotics in Shola Grassland Ecosystem of Upper Palnis," Indian Journal of Forestry, Vol. 24, No. 3, 2001, pp. 324-327.

Standards Australia, 2005, AS 4482.1-2005, Australian Standard: Guide to the Sampling and Investigation of Potentially Contaminated Soil. Part 1: Non-volatile and Semi-volatile compounds.

Stattersfield, A. J., Crosby, M. J., Long, A. J. and Wege, D. C. (1998) Endemic bird areas of the world: priorities for biodiversity conservation. Bird Life Conservation Series No. 7. Cambridge, U.K.: BirdLife International.

Yan, H., Rustadbakken, A., Yao, H., Larssen, T., Feng, X., Liu, T., & Haugen, T. O. (2010). Total mercury in wild fish in Guizhou reservoirs, China. *Journal of Environmental Sciences*, *22*(8), 1129-1136.

USEPA Method 200.8 (1994). Determination of trace elements in waters and wastes by inductively coupled plasma - mass spectrometry.

USEPA Method 3050 B (1996). Acid digestion of sediments, sludge, and soils United States Environmental Protection Agency (USEPA). Regional Screening Level (RSL) Summary Table May 2021

United States Environmental Protection Agency (USEPA). A Guidance Manual to Support the Assessment of Contaminated Sediments in Freshwater Ecosystems. Vol. III, 2002.

United States Environmental Protection Agency (USEPA, 2021). Regional Screening Level (RSL) Summary Table.

United States Environmental Protection Agency, ProUCL Version 4.0 User Guide, April 2007.

URS Dames & Moore (2002) Environmental site assessment and preliminary risk assessment for mercury, Kodaikanal thermometer factory, Tamil Nadu. Prepared for Hindustan Lever Limited (HLL), 165-166 Backbay Reclamation, Mumbai 400 020

Annexure I

Results of total mercury in samples collected from Pambar Shola Forest Area

Sl. No	Sample Location	Location Code	Latitude	Longitude	Soil mg/kg	Bark mg/kg	Lichen mg/kg	Leaf mg/kg	Bush mg/kg	Grass mg/kg	Moss mg/kg
1	Saleth Madha Church behind	F 01	10.13.393	077.28.970	0.084	0.197	ND	ND	-	-	0.017
2	Levinge Path - factory fencing starting	F 02	10.13.366	077.28.080	0.053	0.274	0.084	ND	-	ND	0.191
3	LP - towards eastern side 150 m from factory stream outlet	F 03	10.13.346	077.29.322	0.095	0.409	0.025	ND	-	ND	0.081
4	From Vattakanal falls towards eastern side	F 04	10.13.305	077.28.924	0.117	0.325	0.039	ND	0.095	-	0.119
5	Vattakanal falls - before Lion Cave - River bank	F 05	10.13.352	077.28.986	0.098	0.243	0.135	ND	-	ND	0.105
6	50 m towards Northern side from F 06	F 06	10.13.346	077.29.089	0.142	0.099	ND	ND	0.186	-	0.073
7	50 m towards Eastern side from F 06	F 07	10.13.363	077.28.953	0.086	0.267	ND	ND	-	ND	0.159
8	From Vattakanal falls to 30 m uphill	F 08	10.13.370	077.29.029	0.097	0.402	0.101	ND	-	ND	-
9	Pambar shola 100 m from factory fencing	F 09	10.13.361	077.29.074	0.283	0.133	0.075	ND	-	ND	0.101
10	From Levinge Path 100 m downhill	F 10	10.13.350	077.29.135	0.077	0.196	0.143	ND	0.126	-	0.071
11	Further 50 m down	F 11	10.13.335	077.29.150	0.950	0.408	0.076	0.012	-	ND	0.114
12	Towards eastern side downhill to falls side	F 12	10.13.341	077.29.127	0.145	0.190	0.025	ND	-	ND	0.046

Sl. No	Sample Location	Location Code	Latitude	Longitude	Soil mg/kg	Bark mg/kg	Lichen mg/kg	Leaf mg/kg	Bush mg/kg	Grass mg/kg	Moss mg/kg
13	Towards southern side from factory fence (Church back side) towards falls	F 13	10.13.356	077.29.071	0.431	0.248	0.024	ND	0.227	-	0.019
14	Upper side of Vattkanal falls - Shurbudin compound down path	F 14	10.13.030	077.29.115	0.017	0.139	0.017	ND	-	ND	0.250
15	Downhill towards falls from F 14	F 15	10.13.067	077.29.172	0.128	0.248	0.059	ND	-	ND	ND
16	Another 50 m down closed Lion Cave	F 16	10.13.077	077.29.187	0.088	0.736	0.080	ND	-	-	0.077
17	Shurbudin Compound End	F 17	10.13.004	077.29.219	0.850	0.196	0.072	ND	-	-	ND
18	New view point - 50 m from Shurbuin house	F 18	10.13.038	077.29.238	ND	0.181	ND	ND	-	ND	ND
19	Near Dolphin Nose	F 19	10.12.817	077.29.233	0.015	0.147	0.017	ND	-	ND	-
20	Shenbaganur to Kumbakari trekking path - 1 km down	F 20	10.13.522	077.30.052	ND	0.188	ND	ND	-	-	0.021
21	50 m downhill from R 20 - trekking path	F 21	10.13.414	077.30.044	0.035	0.210	0.047	ND	-	-	ND
22	Further 100 m downhill	F 22	10.13.303	077.30.311	0.253	0.242	0.043	ND	-	-	ND
23	Further 100 m downhill	F 23	10.13.222	077.30.414	0.027	0.287	ND	ND	-	-	ND
24	Further 100 m downhill	F 24	10.13.161	077.30.428	ND	0.165	0.019	ND	-	-	ND
25	Further 125 m downhill towards south	F 25	10.12.949	077.30.485	0.155	0.194	0.024	ND	-	ND	ND
26	Further 100 m downhill towards south	F 26	10.12.844	077.30.522	ND	0.109	ND	ND	-	-	0.079

Sl. No	Sample Location	Location Code	Latitude	Longitude	Soil mg/kg	Bark mg/kg	Lichen mg/kg	Leaf mg/kg	Bush mg/kg	Grass mg/kg	Moss mg/kg
27	Further 100 m downhill towards south	F 27	10.12.664	077.30.549	0.085	0.224	0.061	ND	-	ND	ND
28	Further 100 m downhill towards south	F 28	10.12.513	077.30.602	0.747	0.161	ND	ND	-	ND	-
29	Further 100 m downhill towards south	F 29	10.12.408	077.30.656	0.049	0.121	0.062	ND	-	ND	ND
30	Further 100 m downhill towards south	F 30	10.12.369	077.30.724	ND	0.187	ND	0.065	-	ND	ND
31	Further 100 m downhill towards south	F 31	10.12.209	077.31.004	ND	0.114	ND	ND	-	ND	ND
32	Further 100 m downhill towards south	F 32	10.12.028	077.31.284	0.817	0.067	ND	ND	-	ND	ND
33	Further 100 m downhill towards south	F 33	10.11.883	077.31.514	0.102	0.093	ND	ND	-	ND	ND
34	Puliyan Plot -Vengaya parai	F 34	10.11.377	077.31.666	ND	0.122	ND	ND	-	-	ND
35	Northern side of Kumbakari main falls	F 35	10.10.824	077.31.595	ND	0.195	-	ND	-	-	-
36	100 m uphill towards north from Kumbakari falls	F 36	10.10.550	77.31.457	0.053	0.086	ND	ND	-	ND	-
37	Further 100 m towards uphill	F 37	10.10.598	77.31.431	ND	0.134	ND	ND	-	-	-
38	Kumbakarai - Vellakavi trekking path other side of the falls	F 38	10.10.912	077.31.575	ND	0.149	ND	ND	-	ND	-
39	100 m uphill towards Vellakavi	F 39	10.10.970	077.31.433	0.020	0.067	-	ND	-	ND	-

Sl. No	Sample Location	Location Code	Latitude	Longitude	Soil mg/kg	Bark mg/kg	Lichen mg/kg	Leaf mg/kg	Bush mg/kg	Grass mg/kg	Moss mg/kg
40	Way to Vannathi parai Forest range	F 40	10.11.064	077.31.334	0.031	0.075	ND	ND	-	ND	-
41	150 m up hill (Mile stone 6 km to Vellakavi)	F 41	10.11.111	077.31.030	ND	0.142	0.011	ND	-	ND	-
42	Vannathi parai - Kazhuthai Oodai	F 42	10.11.181	077.30.786	0.060	0.214	0.016	ND	-	ND	-
43	100 m upward towards Vellakavi	F 43	10.11.213	077.30.731	ND	0.113	-	ND	-	ND	-
44	100 m upward towards Vellakavi	F 44	10.11.218	077.30.697	ND	0.101	0.528	ND	-	-	-

LOQ: Soil/Sediment: 0.010 mg/kg, Lichen, Moss, Leaves, Bush, Grass, Algae: 0.008 mg/kg, Bark: 0.005 mg/kg; ”–” indicate sample not collected

Annexure II

Results of total mercury in samples collected from Pambar water shed (Premonsoon period)

Sl. No	Sample Location	Location Code	Latitude	Longitude	Water mg/l	Soil mg/kg	Sediment mg/kg	Moss mg/kg	Algae mg/kg
1	Levinge Path - Factory stream outlet	R 01	10.13.313	077.29.224	ND	4.700	0.099	6.360	1.200
2	Fairy Falls	R 02	10.13.418	077.28.029	ND	0.014	0.142	0.380	-
3	Pambar Falls - Opp. St. Peter's school	R 03	10.13.278	077.28.471	ND	0.053	ND	-	0.022
4	Vattakanal Falls	R 04	10.13.227	077.28.890	ND	ND	0.036	-	ND
5	50 m towards down falls	R 05	10.13.324	077.28.935	ND	0.218	ND	-	ND
6	150 m towards down falls (before Lion Cave)	R 06	10.13.338	077.28.993	ND	0.966	0.054	-	ND
7	Vengaya Parai	R 07	10.11.759	077.31.543	ND	0.107	ND	-	-
8	100 m from main falls towards up	R 08	10.11.744	077.31.436	ND	ND	0.149	-	-
9	Near Bridge (Vellakavi trekking path to Kumbakarai)	R 09	10.11.403	077.31.249	ND	0.073	0.037	0.030	ND
10	Before main falls	R 10	10.10.831	077.31.836	ND	ND	0.077	0.022	-
11	Kumbakarai Falls - Kartar village (Kila Vadagarai)	R 11	10.10.379	077.32.267	ND	0.059	0.168	-	-
12	100 m towards main falls	R 12	10.10.556	077.32.098	ND	ND	ND	-	-
13	Further 100 m towards main falls	R 13	10.10.667	077.31.949	ND	ND	0.040	-	-
14	Kumbakarai Main falls	R 14	10.10.782	077.31.856	ND	0.069	ND	-	-
15	Near Alaguparai	R 15	10.09.877	077.32.246	ND	0.020	0.122	-	-
16	Velankulam - Behind Banyan Tree 3 km from Alaguparai	R 16	10.08.515	077.32.320	ND	ND	0.412	-	-
17	Pambarru Culvert - Batalagundu - Periyakulam Road (Minor bridge)	R 17	10.07.649	077.33.088	ND	ND	-	-	-

Sl. No	Sample Location	Location Code	Latitude	Longitude	Water mg/l	Soil mg/kg	Sediment mg/kg	Moss mg/kg	Algae mg/kg
18	Pambarru river - Near Angalaparmeswari temple - (Kumbakarai - Periyakulam Road) 3 km from Kumbakarai tea shop	R 18	10.08.804	077.32.920	ND	0.136	0.251	-	-
19	Kazhuthai Oodai - adjusant Kumbakarai falls	R 19	10.10.775	077.31.728	ND	ND	ND	-	ND
20	Vannathi Parai	R 20	10.11.101	077.30.889	ND	0.044	ND	-	ND
21	100 m uphill towards Vellakavi - Kazhuthai Oodai	R 21	10.11.181	077.30.786	ND	ND	0.089	-	-
22	After confluence in Vaigai river	R 22	10.06.715	077.47.022	ND	ND	ND	-	-
23	Varaha nadhi mouth	R 23	10.06.681	077.46.982	ND	0.025	ND	-	-

LOQ: Water 0.003 mg/l, Soil/Sediment: 0.010 mg/kg, Lichen, moss, leaves, algae: 0.008 mg/kg, Bark: 0.005 mg/kg; ”–” indicate sample not collected

Annexure III
Results of total mercury in samples collected from Pambar water shed (Postmonsoon period)

Sl. No	Sample Location	Location Code	Latitude	Longitude	Water mg/l	Soil mg/kg	Sediment mg/kg	Moss mg/kg	Algae mg/kg
1	Levinge Path - Factory stream outlet	R 01	10.13.313	077.29.224	ND	0.438	ND	1.148	-
2	Fairy Falls	R 02	10.13.418	077.28.029	ND	ND	0.256	0.448	0.045
3	Pambar Falls - Opp. St. Peter's school	R 03	10.13.278	077.28.471	ND	ND	ND	0.068	0.036
4	Vattakanal Falls	R 04	10.13.227	077.28.890	ND	ND	ND	ND	-
5	50 m towards down falls	R 05	10.13.324	077.28.935	ND	ND	ND	0.008	0.028
6	150 m towards down falls (before Lion Cave)	R 06	10.13.338	077.28.993	ND	0.237	ND	ND	0.044
7	Vengaya Parai	R 07	10.11.759	077.31.543	ND	ND	ND	ND	-
8	100 m from main falls towards up	R 08	10.11.744	077.31.436	ND	ND	0.108	ND	-
9	Near Bridge (Vellakavi trekking path to Kumbakarai)	R 09	10.11.403	077.31.249	ND	ND	ND	0.435	-
10	Before main falls	R 10	10.10.831	077.31.836	ND	0.072	ND	-	0.083
11	Kumbakarai Falls - Kartar village (Kila Vadagarai)	R 11	10.10.379	077.32.267	ND	ND	ND	-	-
12	100 m towards main falls	R 12	10.10.556	077.32.098	ND	ND	ND	-	-
13	Further 100 m towards main falls	R 13	10.10.667	077.31.949	ND	ND	ND	-	-
14	Kumbakarai Main falls	R 14	10.10.782	077.31.856	ND	ND	ND	-	-
15	Near Alaguparai	R 15	10.09.877	077.32.246	ND	ND	ND	-	0.045
16	Velankulam - Behind Banyan Tree 3 km from Alaguparai	R 16	10.08.515	077.32.320	ND	ND	ND	-	-

Sl. No	Sample Location	Location Code	Latitude	Longitude	Water mg/l	Soil mg/kg	Sediment mg/kg	Moss mg/kg	Algae mg/kg
17	Pambarru Culvert - Batalagundu - Periyakulam Road (Minor bridge)	R 17	10.07.649	077.33.088	ND	0.340	-	-	-
18	Pambarru river - Near Angalaparmeswari temple - (Kumbakarai - Periyakulam Road) 3 km from Kumbakarai tea shop	R 18	10.08.804	077.32.920	ND	ND	ND	0.009	0.031
19	Kazhuthai Oodai - adjacent Kumbakarai falls	R 19	10.10.775	077.31.728	ND	ND	ND	-	0.050
20	Vannathi Parai	R 20	10.11.101	077.30.889	ND	ND	ND	-	-
21	100 m uphill towards Vellakavi - Kazhuthai Oodai	R 21	10.11.181	077.30.786	ND	ND	ND	-	-
22	After confluence in Vaigai river	R 22	10.06.715	077.47.022	ND	ND	ND	-	-
23	Varaha nadhi mouth	R 23	10.06.681	077.46.982	ND	ND	ND		

LOQ: Water 0.003 mg/l, Soil/Sediment: 0.010 mg/kg, Lichen, moss, leaves, algae: 0.008 mg/kg, Bark: 0.005 mg/kg; ”–” indicate sample not collected

BEFORE THE NATIONAL GREEN TRIBUNAL (SOUTHERN ZONE) CHENNAI

ORIGINAL APPLICATION NO. 161 OF 2021 (SZ)

IN THE MATTER OF:

Tribunal on its own motion Suo-Motu based On the news item published in Deccan Chronicle newspaper Chennai Edition dated 24.06.2021, under the caption "Penalise Company for dumping toxic waste in Kodaikanal: Activists and the New Indian Express newspaper Chennai Edition dated 25.06.2021 Under the caption "HUL Begins Solid-Remediation works in Kodaikanal"

... Applicant

Versus

The Chief Secretary to Govt. of Tamil Nadu and Others

… Respondents

Final Committee Report in compliance of Hon'ble National Green Tribunal, Southern Zone, Chennai order dated 30.07.2021 & 31.08.2021 in OA No. 161/2021 (SZ) regarding remediation of mercury contaminated soil at M/s Hindustan Unilever Limited (HUL), Kodaikanal

Advocate D. S. Ekambaram

COUNSEL FOR CPCB