

**Report on Oil Spillage happened on 15th October 2019
at Chandrapura Thermal Power Station (CTPS),
Chandrapura, Jharkhand**



Committee Members:

1. Dr A A Kazmi, Professor, Department of Civil Engineering, IIT- Roorkee
2. Sri Sandeep Roy, Scientist D, CPCB, Kolkata
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4. Sri R. N. Choudhary, Regional Officer, JSPCB, Dhanbad (Nodal Agency)

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INSPECTION REPORT of M/s Chandrapura Thermal Power Station (CTPS), Chandrapura, Jharkhand on Oil Spill

In the matter OA 18/2020/EZ (Praveen Kumar Singh Vs Damodar Valley Corporation &Ors)

As per direction of Hon'ble NGT, in the matter OA 18/2020/EZ Order Dt 15/06/2020, a team was constituted to assess the extent of Oil Leakage and Assessment of environmental damage caused by the Oil Spill. Accordingly, a report was submitted before Hon'ble NGT. However, in the said matter (Order Dt 11/11/2020) Hon'ble NGT directed the committee to submit a detailed report.

Affected areas and the CTPS:

In compliance of the above, the Committee visited the affected area to assess the environmental damage caused by the Oil Spill during 29th – 30th January 2021.

Details of Team Members are following:

1. Dr. A A Kazmi, Professor, IIT- Roorkee
2. Dr. Kanchan Kumari, Sr Scientist, NEERI, KZC, Kolkata
3. Shri Sandeep Roy, Scientist D, CPCB, Kolkata
4. Shri Sukhendu Biswas, Sr. Scientific Asst, CPCB, Kolkata.
5. Shri R. N. Choudhary, Regional Officer, JSPCB, Dhanbad
6. Shri Ashutosh Anand, C.E. , JSPCB, Dhanbad

Details of Officials from M/s CTPS present during the Inspection & Assessment work:

1. Shri P. K.Sikdar, Chief Engineer & Project Head
2. Shri Subhash Singh, Dy Chief Engr (Operation)
3. Shri M. K. Jha, Dy Chief Engr (Civil)
4. Shri Abhay Kr. Shrivastava, Dy Chief Engr (Mech) & DGM
5. Shri Raushan Kr Singh, EE (Mech)
6. Shri D. Das, Dy Chief Engr (Mech), Fuel

About the CTPS

The Chandrapura Thermal Power Station (CTPS) is situated in Bokaro District of Jharkhand state, having latitude and longitude of 23^o 44' 23.6"N and 86^o07' 39.4"E, respectively and is one of the biggest thermal power plants of India. The power plant is operated by the Damodar

Valley Corporation (DVC), an Indian governmental organization that operates in the Damodar River Basin area of West Bengal and Jharkhand states of India. The CTPS has started Power Generation in the Year 1964. Presently 2 Units i.e. Unit 7 & 8 (capacity 250 MW each) are operational as per the power demand. Unit # 1, 2, 3, 4, 5 & 6 had already been De-Commissioned in phased manner.

The Fuel oil is used in the Boiler during Lit up & for stability of flame during running of unit as per requirement. Specific Oil consumption for Power Generation is 0.3ml/Kwh (approx).

As informed, the Oil is transported through Railway Rake (Oil Tankers) which generally happen once in a year or as per requirement and further stored in Oil Storage Tank (capacity 2000 KL x 2, 890 KL x 3).

The Incident- Oil Leakage:

The incident of Oil Leakage occurred in the wee hours of 15th October 2019. As informed Rail Rake from IOCL, Haldia reached inside the plant and oil was being unloaded at CTPS site through new unloading system but considerable delay was being noticed in the system due to some technical reasons. Consequent upon non-functioning of new system, it was later unloaded through the old system. During this shifting, some quantity of spillage of Fuel oil occurred which was allowed to be collected in a sump tank and to be ultimately pumped into main storage tank. However, the connecting hume-pipe developed crack and oil leaked from hume-pipe and ingress in the nearby drainage system which is constructed to collect the Storm / Rain water and thus flew till oil catcher system established before a natural drain which joins to Damodar river.

Oil Leakage was detected by M/S CTPS after few hours around 4-5 AM. Jamadoba water intake station located downstream observed floating oil at its intake well and stopped operation due to the Oil spillage floating around the intake well which after water supply in Jahria, Dhanabd. Also alert were sent to concerned bodies which lead to identification of Oil spillage from M/S CTPS. CTPS started to stop the flow of fuel oil further in to Damodar River upon information.

- Leakage in Hume pipe was not detected well in time to avoid the Oil spill
- Late detection led to spread of F.O. Oil to Damodar River which is having multiple inlets for drinking water supply.

- M/S CTPS was having old system for Oil unloading and subsequently new unloading system was established. Drain for storm water passes through the Oil unloading area and which was having inlet very close to Hume Pipe connecting Oil sump.

M/s CTPS initiated necessary measures to collect the spilled oil from Drainage Channel and River, in presence of JSPCB officials M/S CTPS mostly installed brushwood Dams, flow barriers and then did skimming of oil from these barriers also fly ash was used to absorb oily water. M/s CTPS also constituted a team to monitor the said incident and as per the direction of JSPCB, this Oil Loading/ Unloading system is not in operation since 15th October 2019.

Assessment of the extent of the leakage and resultant contamination caused by the oil spread

Quantity of Oil Leakage:

The spilled Oil was collected by the CTPS staffs from Drainage Channel & River and stored in Oil Drums. Fly Ash was also used to soak spilled oil to control spillage of Oil. The data provided by Unit regarding Oil spillage is as follows:

Sl No.	Activity	Qty (KL)	Remark
1	Total Qty of Oil in the Storage Tanks (before filling) as on 14/10/2019	210.09	
2	Qty of Fuel Oil received through Railway Rake (Oil Tanker)	1351.99	Fuel oil dispatched by M/s IOCL, Haldia (Invoice No. 20202121B021478 Dt 12/10/2019)
3	Total Qty of Oil in the Storage Tanks (after filling) as on 15/10/2019	1559.37	
4	Qty of Oil Leaked out during Incident	2.7	

DT	NEW PLANT		KL	OLD PLANT			OP#7	KL	TOTAL STOCK (old+new)
	FO.Sto-1	FO.Sto-2		Total (New)	OP#2	OP#3			
14.10.2019	0.17	0.23	85.4864	0.5	0.5	0.4	124.6	210.09	
15.10.2019	0.17	0.63	170.9728	7	5.2	3.4	1388.4	1559.37	
Difference in levels								1349.29	KL
RECEIVED BY RAKE								1351.99	KL
Shortfall qty								-2.70	KL

No of drums of capacity 200 Lts present at site = 18
 Considering average oil qty in each drum as 100 Ltrs
 So the total Qty in each drum to be = 1800

Shotage Quantity = 2700-1800= 900 Liter (approx)

SDE (M), 21.10.2020

Fig: Shortfall quantity in storage tank as reported by M/S CTPS

M/S CTPS had stored collected oil from drain and brushwood dams in 18 nos. of 200 ltr capacity Drums. The drums containing Oil and water were earlier estimated to be half filled with Oil and half filled with water by expert committee, constituted by JSPCB. M/s CTPS was instructed by JSPCB to dispose collected Oil and Oil soaked ash as per Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 within stipulated time period. However considerable time has passed since the Oil spill incident happened but M/s CTPS has failed to dispose the above waste through authorized Hazardous waste Recycler or authorized Treatment Storage Disposal Facility. During the inspection M/s CTPS officials informed that their *In-House committee* of CTPS in the month of June 2020, about 8 months after the incident have assessed the quantity of Oil by manually removing water from drums and weighing the drums by the use of weigh bridge. They have assessed the quantity of oil recovered in 18nos. of drums is approximately 1950 litres and further 150 litres of oil to be soaked by Ash stored. M/s CTPS claims that total 2200 litres of spilled oil has been recovered and only 600litres of oil was discharged during the incident. However, the method adopted by the M/S CTPS is not scientific and cannot be relied upon and therefore their claim may be quashed. Due to the lack of valid data from reliable source this committee based on the observation of previous committee assumes the quantity of leaked oil to be 900 litres approximately.

To assess the resultant contamination caused by the oil spread, samples were collected from 5 locations from the oil spillage area and nearby River as mentioned below.

Sampling Location:

L1	:	Before oil catch pit
L2	:	At Confluence point
L3	:	U/s of River Damodar (Bhandaridah)
L4	:	D/s of River Damodar (Budidih)
L5	:	D/s of River Damodar (Jharia-Jambadoba)

The samples collected were analyzed in CPCB Zonal Laboratory facility, Kolkata.

Results Obtained are as given below:

Parameter	Location				
	L1	L2	L3	L4	L5
pH	8.15	8.29	8.79	8.59	7.64
Conductivity(μ S/cm)	390	514	325	408	510
DO (mg/l)	8.6	9.2	10.8	11.0	11.6
COD(mg/l)	8	16	8	9	10
BOD(mg/l)	< 2.5	7	< 2.5	< 2.5	< 2.5
Cl(mg/l)	17	29	14	18	27
Alkalinity (mg/l)	88	124	88	86	112
Hardness(mg/l)	149	174	123	135	188
Ca(mg/l)	37	44	26	34	40
Mg(mg/l)	14	16	14	12	21
TSS(mg/l)	6	28	< 5	< 5	< 5
TDS(mg/l)	225	287	172	232	289
NO ₃ -N(mg/l)	0.50	1.63	0.03	0.37	0.75
PO ₄ -P(mg/l)	0.420	0.184	0.290	0.205	0.023
SO ₄ (mg/l)	79	68	51	64	92
NH ₃ -N(mg/l)	2.94	2.64	0.03	0.38	0.10
Phenol(mg/l)	0.104	< 0.10	< 0.10	< 0.10	< 0.10
Na(mg/l)	18.30	25.35	11.80	17.80	23.90
K(mg/l)	3.15	5.36	2.58	4.48	4.64
O&G(mg/l)	< 5	< 5	< 5	< 5	< 5
Heavy Metals					
Pb (μ g/l)	1.6	2.99	5.6	2.27	1.45
Fe (μ g/l)	191.34	1101.83	290.39	128.91	187.15
Cu (μ g/l)	2.96	5.17	4.69	2.25	2.72
Ni (μ g/l)	7.89	8.97	7.97	3.15	4.54
Al (μ g/l)	127.6	556.41	177.92	61.0	52.44

Mn ($\mu\text{g/l}$)	54.72	293.91	31.96	20.03	37.21
As ($\mu\text{g/l}$)	0.91	1.21	0.61	0.35	0.47
T Cr ($\mu\text{g/l}$)	16.75	17.81	15.86	6.3	9.37
Zn ($\mu\text{g/l}$)	16.42	36.34	15.73	11.08	14.17

Conclusion:

Since considerable amount of time and a monsoon season have passed there is high chance of contaminant being washed away with storm water and then through River. The analysis results of samples collected from all 5 location from the spillage area are also shows no sign of contamination and are well within the limits.

Ecological assessment including impact on the aquatic community caused by the oil spill

1. Introduction

This work is an extension of the work and report submitted earlier to NGT under NGT Case (O.A. No. 18/2020 (EZ)). Hon'ble NGT had asked in its order dated to include Ecological Assessment including impact on aquatic community and extent of loss of biodiversity due to Oil spill. The said case is linked to oil spillage from CTPS and spreading of the oil downstream of river Damodar in the path of which Dhanbad, Chas, Jharia and Sindri areas fall, due to which drinking water supply to about 20 to 30 lacks people was reportedly affected. The oil spread was stated to have been caused by a leakage of huge quantity of oil in the premises of the Chandrapura Thermal Power Station (CTPS) run by the Damodar Valley Corporation (DVC) in the late hours of 13.10.2019.

1.1 Scope of the Work

🚧 Studies on soil, sediment & biological samples:

This particular study is connected to assess the present condition of the river sediment at specific places and soil at select areas around the river channels within the oil spillage affected zone. The samples were collected by CSIR-NEERI team along with the CPCB, JSPCB and IIT Roorkee officials at the oil spillage site at CTPS, upstream and downstream of Damodar River to study the following:

- Study on biota (Phytoplanktons, Zooplanktons, Benthic-macroinvertebrates & fish samples) across a few identified sites on Damodar River.
- Study of environmental samples (soil & sediments) across a few identified sites on and at the sides of Damodar River.

2. Sampling locations

The details of the sampling sites and the satellite images of the co-ordinates are given in **Table 1 and Figure 1 & 2.**

Table 1: Location of sampling sites

S. No.	Code	Latitude	Longitude
1.	L ₀ (Oil spillage point)	23°44'24"N	86°07'39.4"E
2.	L ₁ (Before oil catch pit)	23°44'21"N	86°08'02"E
3.	L ₂ (At confluence point)	23°43'45"N	86°08'06"E
4.	L ₃ (U/S of river Damodar, Bhandaridah)	23°45'08"N	86°03'26"E
5.	L ₄ (D/S of river Damodar, Budidih)	23°43'42"N	86°08'42"E
6.	L ₅ (D/S of river Damodar, Jharia-Jambadoba)	23°42'32"N	86°22'31"E

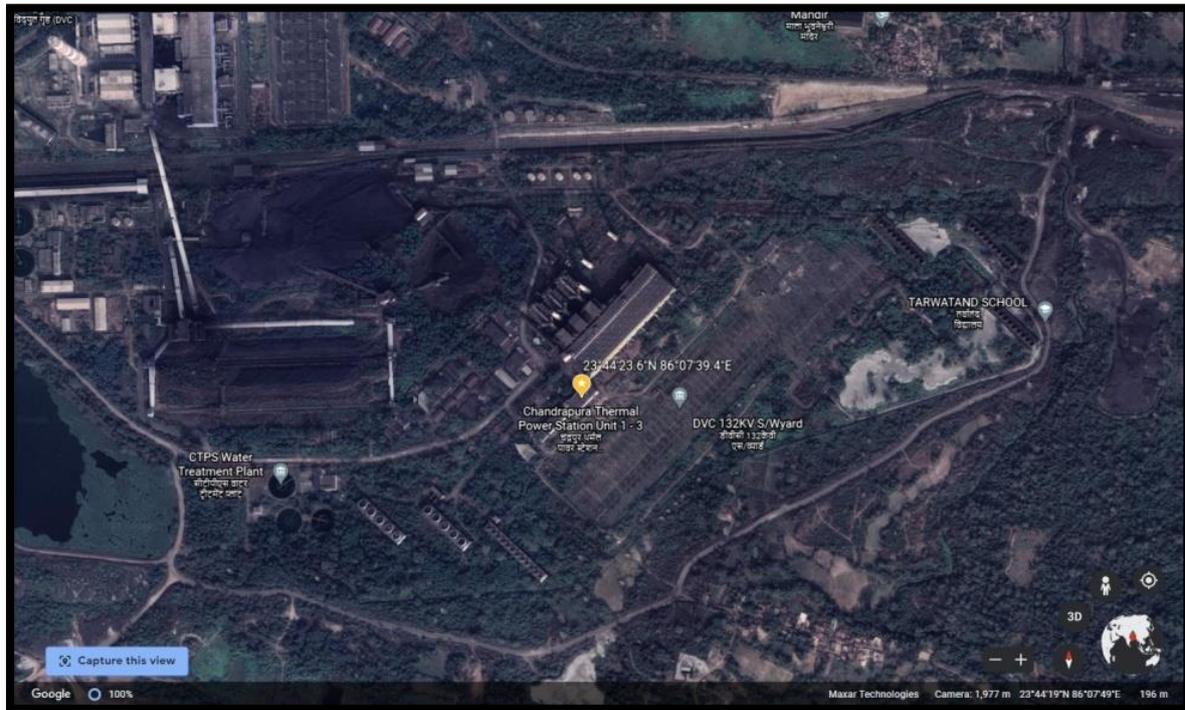
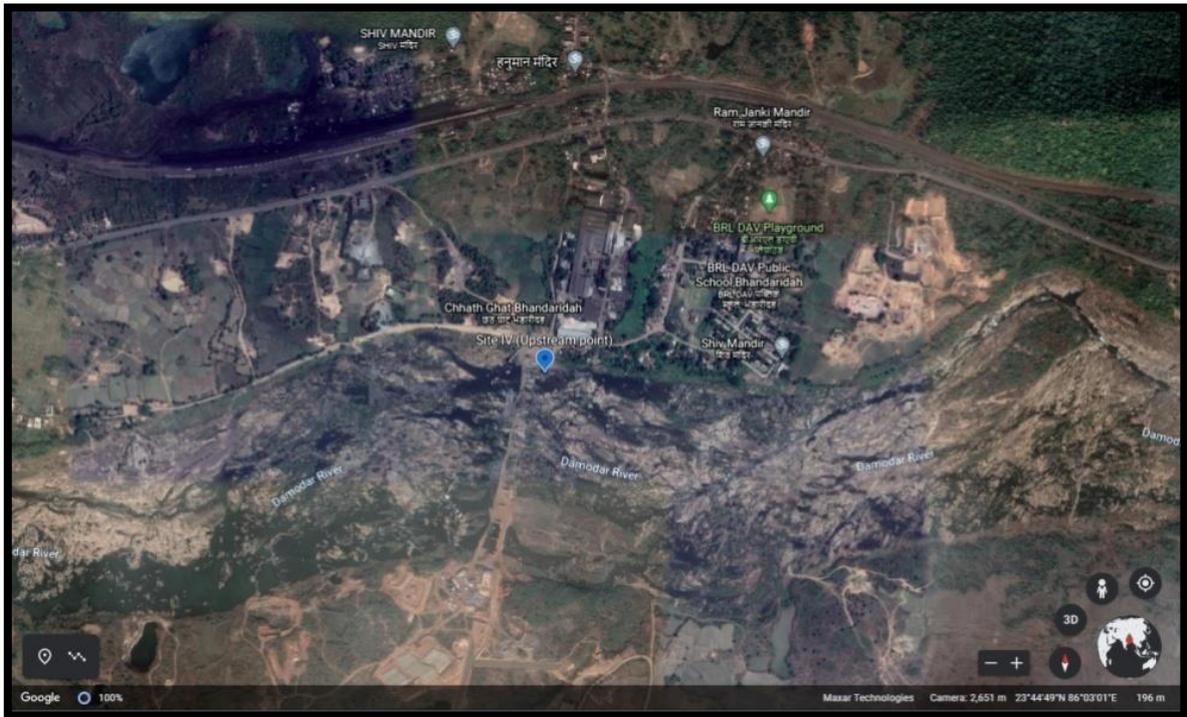
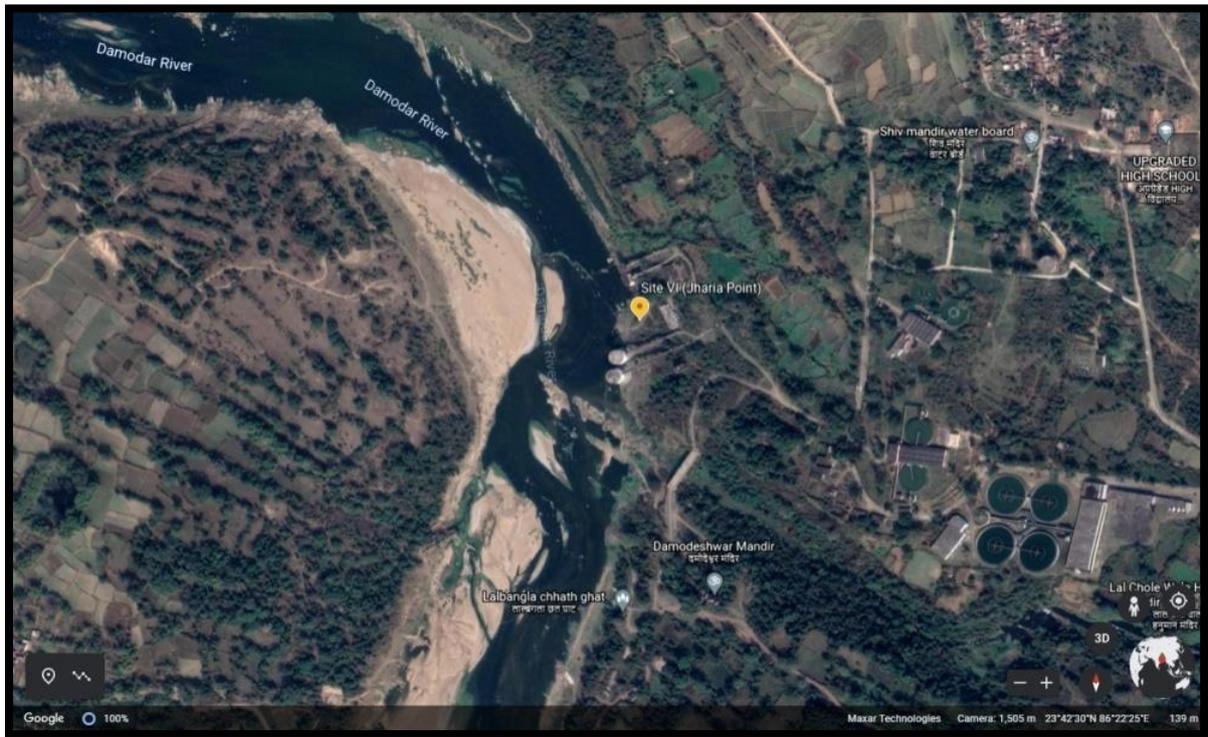


Fig 1- Sampling site at Chandrapura Thermal Power Station (CTPS)



2a



2b



2c

Figure: 2a, b, c: Satellite images of the other sampling sites on Damodar river

3. Material and Methods

Samples were collected during 29th-30th January, 2021 from the below mentioned sampling locations by standard sampling protocols, followed by immediate preservation and transport to the laboratory for further analysis. **Table 2** highlights the details of sample collected with respect to individual sites.

Table 3: Sampling Matrix with respect to individual sites*

Sr. No.	Code	Environmental samples		Biological samples		
		Soil	Sediment	Phytoplanktons	Zooplanktons	Benthos
1.	L ₀ (Oil spillage point)	Yellow				
2.	L ₁ (Before oil catch pit)	Yellow	Blue	Green	Green	
3.	L ₂ (At confluence point)	Yellow	Blue	Green	Green	Blue
4.	L ₃ (U/S of river Damodar, Bhandaridah)	Yellow	Blue	Green	Green	Blue
5.	L ₄ (D/S of river Damodar, Budidih)	Yellow	Blue	Green	Green	Blue
6.	L ₅ (D/S of river Damodar, Jharia-Jambadoba)	Yellow	Blue	Green	Green	Blue

* Fishes were also collected from Damodar River

3.1- Sample collection

3.1.1 Soil and sediments

Sampling of soil and sediment was carried out at the above sites in order to assess specific impacts of oil spillage that may remain detectable at present (**Plate 1-3**). Sampling was carried out using standard sampling protocols. Observations and information on soil colour, crop type, use of chemical fertilizers, water temperature, pH, discharges, confluence, surrounding vegetation were also noted for drawing necessary conclusions.



Plate 1: Soil sampling





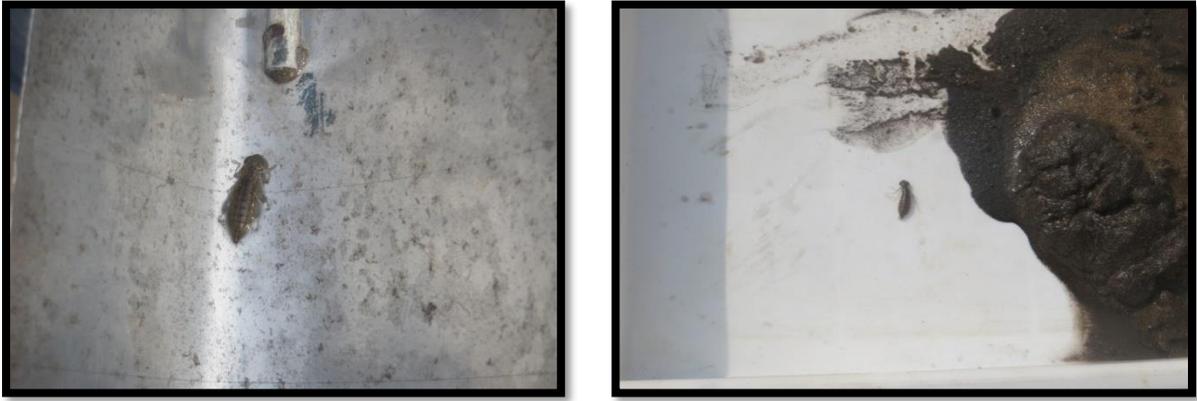


Plate 2: Collection of Biological Samples

3.1.2 Aquatic Fauna

The biological species specific for a particular environmental condition are the best indicators of the environmental quality which includes different biological species such as phytoplankton, zooplanktons, fishes, benthic invertebrates, etc. Studies on biological aspects of certain ecosystems are important in environmental impact assessments in view of the conservation of environmental quality and safety of natural flora and fauna including human beings.

3.1.2.1 Fish

Fish samples of different weight and length were collected from Damodar River using cast net and with the help of local fishermen (**Plate 3**). Weight and length of fishes collected were recorded and analysed to assess the health condition of fishes using Condition factor. Estimation of Condition Factor (CF) of the fishes is a useful marker to check the health of the fishes living in a particular water body.



Plate 3: Fishes collected from Damodar River

3.1.2.2 Benthic Invertebrates

The benthos samples were collected as per the standard sampling protocol of Central Pollution control Board (CPCB), New Delhi. Samples were collected from Site III (Drain Confluence Point), Site IV (Upstream Point), Site V (Downstream Point) and Site VI (Jharia Point) by using Iron net (**Plate 4**). Saprobic and diversity scores were calculated. All the samples were marked and stored in 4% formaldehyde solution (Formalin) in sample containers, stored in iceboxes and transported to laboratory for further analysis.

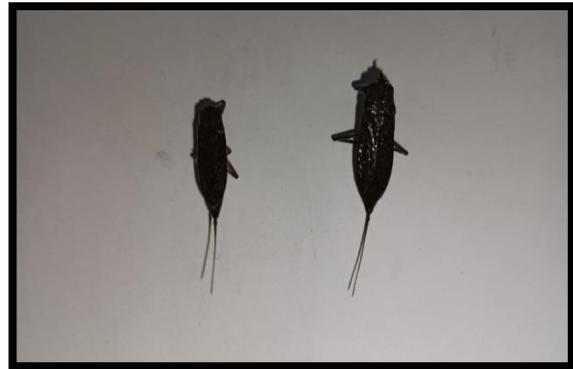




Plate 4: Benthic Macro-invertebrate collection

3.1.2.3 Planktons

Samples were collected at the surface of water column, using a clean polythene bucket for collection and analysis of phytoplankton species. Samples were fixed in Lugol's iodine solution and preserved in 2% Formalin. Organisms were counted in a drop of centrifuged, decanted and concentrated volume of sample placed on glass slides under a microscope. Number of individuals of each plankton was counted in 40x magnification.



Plate 5: Plankton collection

For zooplankton collection, around 20 L of river water was passed through a plankton net (mesh size 50 μm) to concentrate the zooplanktons. The entire water was centrifuged, decanted and concentrated to make 1ml volume earmarked for observation in S-R (Sedgwick-Rafter) counting cell (**Plate 5**). The zooplanktons species were counted in 10x magnification and expressed as number of species present per m^3 of river water.

4. Results and Discussion

4.1 Soil and Sediment

4.1.1 Soil

The physico-chemical characteristics of soils are reported in **Table 2&3**. The water holding capacity, porosity and bulk density of the soil samples were observed to be in the range of 54.67% to 61.65%, 48.23% to 52.25% and 1.11 to 1.20g/cm³, respectively. The soil was alkaline in nature (pH 6.96-7.95) and its electrical conductivity (EC) was in the normal range (0.096-0.253 ds/m) but its organic carbon content (0.21-1.39%) was higher than normal range of 0.4-0.6% found in Indian soils (ICAR, 1996). The total nitrogen concentration was in the optimum range of 0.02-0.14% whereas available potassium (K) and phosphorus (P) were in the range of 0.25-0.76% and 0.11-0.26% respectively.

The exchangeable cations (Na, K, Ca and Mg), CEC and ESP values of soils are represented in **Table 4**. Amongst the exchangeable cations, calcium was predominant followed by magnesium, sodium, and potassium with their concentration in the range 6.4-15.4cmol(p+) Kg⁻¹, 0.4-2.0cmol(p+) Kg⁻¹, 0.02-0.42cmol(p+) Kg⁻¹ and 0.03-0.29 cmol(p+) Kg⁻¹ respectively. CEC and Exchangeable Sodium Percentage (ESP) of the soils varied in the range of 8.44-20.29 cmol(p+)/kg and 0.17-3.0 respectively. The soil had fallen in the category of moderately alkaline based on analysis results, which is highly preferred for plant growth and ESP of soil also did not exceed the limit defined for sodic soil (> 15), thereby showing no adverse effect of sodium concentration (Amacher et al. 2007). Water soluble cations and anions are represented in **Table 5**, indicating abundance of ions in soil enhancing the soil fertility. The contents of the trace and heavy metal evaluated by hand held XRF were (ND-20 mg/kg) for Pb, Ni (20-90 mg/kg), Cr (30-70 mg/kg), and Zn (70-100 mg/kg). The results indicated that the concentrations of total heavy metals were within the permissible response limits (ProPECC PN 3/94 Dutch Screening criteria) in the soils (Table-7.1) and hence, contamination of the soils by heavy metals may be negated.

Soil respiration is greatly involved in organic matter turnover, hence in nutrient cycles and plant nutrition. It is used by soil scientists to investigate the effects of different soil management strategies and agricultural practices including inorganic and organic amendments on soil quality and health. In the present study, the obtained soil respiration was found to be optimum (21.05-36.55 $\mu\text{gCO}_2/\text{g/day}$) with the highest value at L3 location (upstream point), showing optimum soil microbial activity (Zhang et al., 2010) (**Table 3**).

Total Hydrocarbons was detected only at L₀ i.e. the oil spillage site at the premises of CTPS (32.95 g/kg in soil) while it was not detected elsewhere (**Table 6**). Therefore, it indicates that at present there is no hydrocarbon residue in the soil along the river course.

Table 2: Physical parameters of soil and sediment samples

S. No.	Site	Parameters				
		pH	EC (dS/m)	Bulk density (g/cm ³)	Water holding capacity (%)	Porosity (%)
Soil						
1	L ₀ (Oil spillage point)	7.95±0.59	0.09±0.06	1.13±0.01	56.43±0.07	48.23±0.03
2	L ₁ (Before oil catch pit)	7.26±0.1	0.12±0.04	1.18±0.03	52.69±0.09	50.24±0.017
3	L ₂ (At confluence point)	7.13±0.05	0.18±0.07	1.11±0.01	61.65±0.011	50.09±0.02
4	L ₃ (U/S of river Damodar, Bhandaridah)	7.74±0.07	0.16±0.02	1.13±0.05	56.08±0.03	49.84±0.01
5	L ₄ (D/S of river Damodar, Budidih)	7.47±0.02	0.18±0.08	1.20±0.02	59.52±0.01	52.25±0.015
6	L ₅ (D/S of river Damodar, Jharia-Jambadoba)	6.96±0.08	0.25±0.07	1.18±0.01	54.67±0.02	48.65±0.03
Sediment						
7	L ₁ (Before oil catch pit)	7.63±0.07	0.19±0.09	1.39±0.04	36.12±0.01	31.24±0.02
8	L ₂ (At confluence point)	7.2±0.01	0.12±0.09	1.41±0.01 2	41.88±0.01 4	37.4±0.07
9	L ₃ (U/S of river Damodar, Bhandaridah)	7.23±0.06	1.17±0.03	1.22±0.01	51.76±0.05	49.68±0.012
10	L ₄ (D/S of river Damodar, Budidih)	7.11±0.04	0.14±0.07	1.37±0.01 1	44.73±0.05	42.37±0.07
11	L ₅ (D/S of river Damodar, Jharia-Jambadoba)	7.06±0.08	0.19±0.08	1.39±0.03	35.08±0.08	28.54±0.02

Table 3: Chemical parameters of soil and sediment samples

S. No.	Site	Parameters				
		Organic Carbon (%)	Total Nitrogen (%)	Total Phosphorus (%)	Total Potassium (%)	Soil respiration ($\mu\text{gCO}_2/\text{g soil/day}$)
Soil						
1	L ₀ (Oil spillage point)	1.39±0.01	0.14±0.00	0.17±0.02	0.31±0.10	25.65±2.62
2	L ₁ (Before oil catch pit)	0.8±0.01	0.08±0.00	0.26±0.01	0.38±0.02	21.2±0.28
3	L ₂ (At confluence point)	0.47±0.01	0.05±0.00	0.2±0.04	0.25±0.09	23.95±8.13
4	L ₃ (U/S of river Damodar, Bhandaridah)	0.64±0.01	0.06±0.00	0.18±0.02	0.34±0.03	36.55±8.27
5	L ₄ (D/S of river Damodar, Budidih)	0.21±0.01	0.02±0.00	0.11±0.02	0.43±0	21.05±3.32
6	L ₅ (D/S of river Damodar, Jharia-Jambadoba)	0.64±0.04	0.19±0.06	0.13±0.05	0.76±0.02	26.5±0.71
Sediment						
7	L ₁ (Before oil catch pit)	0.47±0.01	0.12±0.09	0.16±0.02	0.22±0.023	
8	L ₂ (At confluence point)	0.4±0.01	0.17±0.06	0.21±0.00	0.16±0.06	
9	L ₃ (U/S of river Damodar, Bhandaridah)	0.81±0	0.14±0.04	0.14±0.01	0.84±0.017	
10	L ₄ (D/S of river Damodar, Budidih)	0.21±0.02	0.19±0.00	0.09±0.02	0.19±0.04	
11	L ₅ (D/S of river Damodar, Jharia-Jambadoba)	0.84±0	0.08±0.00	0.08±0.07	0.54±0.08	

Table 4: Exchangeable cations, Cation Exchange Capacity (CEC) and Exchangeable Sodium Percent (ESP) of soil and sediment samples

S. No.	Site	Parameters (Cmol (+))/kg					
		Calcium	Magnesium	Sodium	Potassium	CEC	ESP (%)
Soil							
1	L ₀ (Oil spillage point)	9.0±0.28	1.0±0.28	0.02±0.00	0.03±0.00	11.55±0.71	0.17±0.03
2	L ₁ (Before oil catch pit)	15.4±0.28	2.0±0.57	0.1±0.00	0.29±0.01	20.29±1.0	0.48±0.03
3	L ₂ (At confluence point)	6.8±0.00	0.4±0.00	0.23±0.01	0.08±0.00	10.02±0.71	2.34±0.09
4	L ₃ (U/S of river Damodar, Bhandaridah)	6.4±0.00	0.4±0.00	0.08±0.00	0.06±0.00	8.44±0.71	0.97±0.04
5	L ₄ (D/S of river Damodar, Budidih)	8.4±0.00	0.8±0.00	0.03±0.00	0.06±0.00	11.79±0.71	0.27±0.02
6	L ₅ (D/S of river Damodar, Jharia-Jambadoba)	9.6±0.00	1.4±0.28	0.42±0.00	0.28±0.00	14.21±0.98	3.0±0.23
Sediment							
7	L ₁ (Before oil catch pit)	5.0±0.28	1.4±0.28	0.07±0.00	0.11±0.00	9.08±0.71	0.82±0.05
8	L ₂ (At confluence point)	5.8±0.28	0.8±0.57	0.06±0.00	0.09±0.00	8.76±1.13	0.74±0.09
9	L ₃ (U/S of river Damodar, Bhandaridah)	7.4±0.28	1.8±0.28	0.24±0.00	0.19±0.00	11.63±0	2.05±0.01
10	L ₄ (D/S of river Damodar, Budidih)	3.8±0.28	0.8±0.57	0.05±0.01	0.09±0.00	7.24±0.98	0.76±0.19
11	L ₅ (D/S of river Damodar, Jharia-Jambadoba)	9.8±0.28	6.6±0.28	0.55±0.01	0.93±0.02	19.39±0.73	2.86±0.05

Table 5: Water soluble cations in samples of soil and sediment collected from different sites

S. No	Site	Parameters (meq/l)							
		Calcium	Magnesium	Sodium	Potassium	HCO ₃	Chloride, (Cl)	Phosphates(PO ₄)	Sulphates (SO ₄)
Soil									
1	L ₀ (Oil spillage point)	0.4±0.03	0.2±0.00	0.15±0.05	0.17±0.01	5.5±0.04	0.84±0.07	0.06±0.01	ND
2	L ₁ (Before oil catch pit)	0.4±0.01	0.2±0.02	0.27±0.02	0.31±0.05	6±0.01	1.12±0.013	0.02±0.05	ND
3	L ₂ (At confluence point)	0.6±0.01	0.6±0.01	0.37±0.07	0.21±0.05	3.5±0.01	1.12±0.01	0.04±0.01	ND
4	L ₃ (U/S of Damodar, Bhandaridah)	0.6±0.02	0.2±0.00	0.7±0.02	0.13±0.07	6±0.02	0.84±0.06	0.01±0.00	0.14±0.07
5	L ₄ (D/S of river Damodar, Budidih)	0.6±0.01	0.2±0.00	0.33±0.00	0.09±0.01	6±0.018	1.12±0.01	0.05±0.03	ND
6	L ₅ (D/S of Damodar, Jharia-Jambadoba)	0.6±0.01	0.2±0.00	0.37±0.02	0.92±0.02	5±0.014	0.84±0.01	0.03±0.01	0.02
Sediment									
7	L ₁ (Before oil catch pit)	0.6±0.01	0.2±0.01	0.93±0.07	0.2±0.01	5.5±0.07	0.56±0.05	0.02±0.01	ND
8	L ₂ (At confluence point)	0.6±0.00	0.2±0.01	0.28±0.01	0.15±0.00	4.5±0.01	1.40±0.07	0.04±0.01	ND
9	L ₃ (U/S of Damodar, Bhandaridah)	0.6±0.05	0.2±0.12	0.39±0.05	0.53±0.07	6±0.014	0.28±0.01	ND	ND
10	L ₄ (D/S of river Damodar, Budidih)	0.5±0.01	0.3±0.02	0.24±0.05	0.35±0.011	5±0.00	0.84±0.01	0.01±0.00	0.04±0.01
11	L ₅ (D/S of Damodar, Jharia-Jambadoba)	0.8±0.00	ND	0.77±0.03	0.37±0.01	4.5±0.01	0.56±0.017	0.01±0.00	ND

Table 6: Total Hydrocarbons estimation in soil and sediment samples collected from different sites

S. No.	Site	Total Hydrocarbons (g/kg)
	Soil	
1	L₀ (Oil spillage point)	32.95
2	L₁ (Before oil catch pit)	ND
3	L₂ (At confluence point)	ND
4	L₃ (U/S of river Damodar, Bhandaridah)	ND
5	L₄ (D/S of river Damodar, Budidih)	ND
6	L₅ (D/S of river Damodar, Jharia-Jambadoba)	ND
	Sediment	
7	L₁ (Before oil catch pit)	1.59
8	L₂ (At confluence point)	1.00
9	L₃ (U/S of river Damodar, Bhandaridah)	ND
10	L₄ (D/S of river Damodar, Budidih)	0.55
11	L₅ (D/S of river Damodar, Jharia-Jambadoba)	ND

*. **L₀**: Focal point of oil spillage immediately near the sump tank and out of impact assessment zone

Table 7: Heavy metal concentrations in soil and sediment sample in (mg/kg)

S. No.	Site	As	Cr	Pb	Zn	Cu	Ni
	Soil						
1	L₀ (Oil spillage point)	ND	40	20	90	20	20
2	L₁ (Before oil catch pit)	ND	70	ND	100	50	90
3	L₂ (At confluence point)	ND	30	10	70	30	40
4	L₃ (U/S of river Damodar, Bhandaridah)	ND	50	20	70	20	70
5	L₄ (D/S of river Damodar, Budidih)	ND	50	20	70	10	70
6	L₅ (D/S of river Damodar, Jharia-Jambadoba)	1.0	50	ND	100	30	90
	Sediment						
7	L₁ (Before oil catch pit)	10	ND	10	320	ND	ND
8	L₂ (At confluence point)	ND	30	ND	80	10	10
9	L₃ (U/S of river Damodar, Bhandaridah)	ND	20	ND	120	40	90
10	L₄ (D/S of river Damodar, Budidih)	ND	40	10	50	ND	ND
11	L₅ (D/S of river Damodar, Jharia-Jambadoba)	10	30	20	110	20	50

Table 7.1 : Screening & Response Level of Contaminants in Soil

S. No.	Chemical Name	Soil (Screening and Response Levels)				
		Response levels (Dutch Intervention levels) 1)	Screening levels			
			Soil Quality Guidelines for the Protection of Environmental and Human Health 2)			
			Agricultural	Residential/ parkland	Commercial	Industrial
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	
1	Lead	530	70	140	260	600
2	Arsenic	50	12	12	12	12
3	Copper	190	63	63	91	91
4	Chromium (total)	-	64	64	87	87
5	Nickel	100	50	50	50	50
6	Zinc	720	200	200	360	360
7	Total hydrocarbons (TPH) (mineral oil)	5000	--	--	--	--

1) Referring to Dutch intervention values (of the Circulairebodemsanering– Circular Soil Remediation) which represent a level above which unacceptable risks may occur. The risk model by which these levels were determined takes into account residential situation where people live and partly eat crops from the site. In this way these levels provides relatively low level of risk, i.e. a conservative approach. The levels in this list are fixed number, no dependency on soil characteristics has to be applied.

2) Referring to CCME Canadian Environmental Quality Guidelines, these levels represent a level of negligible risk and provide a level that is regarded to enable a healthy functioning system for different types of and use.

The physico-chemical characteristic of sediment samples collected from different sites are reported in **Table 2&3**. The water holding capacity, porosity and bulk density of the sediments samples were observed to be in the range of 35.08-41.88%, 28.54-49.68 and 1.22 to 1.39g/cm³ for sediment samples. The sediments was alkaline in nature (pH 7.06-7.63) and its Electrical conductivity was in the normal range (0.12-0.19 ds/cm). Organic carbon content (0.21 -0.84%) was higher than the normal range found in Indian sediments(0.4-0.6%)(ICAR, 1996). The total Nitrogen concentration was in the optimum range of 0.02-0.08% whereas the nutrient level (K and P) were in lower concentration i.e. 0.16-0.84% and 0.20-0.28%.

The exchangeable cations (Na, K, Ca and Mg) CEC and ESP is represented in **Table 4**. Amongst the exchangeable cations, calcium was predominant followed by magnesium, sodium, and potassium with their concentration in the range 3.8-9.8cmol(p+) Kg⁻¹, 0.8-6.6cmol(p+) Kg⁻¹, 0.05-0.24cmol(p+) Kg⁻¹ and 0.09-0.93cmol(p+) Kg⁻¹ respectively. CEC and Exchangeable Sodium Percentage (ESP) of the sediments varied in the range of 7.24-19.39 cmol(p+)/kg and 0.74-2.86 respectively. Water soluble cations and anions are represented in **Table 5** indicating abundance of ions in sediments. The contents of the trace and heavy metal were (ND-20 mg/kg) for Pb, Ni (ND-90 mg/kg), Cr (ND-40 mg/kg), As (ND-10 mg/kg), and Zn (50-520 mg/kg). The results indicated that the concentrations of total heavy metals were within the permissible limit in the sediments and hence there are remote chances of contamination of the sediments (ProPECC PN 3/94 Dutch Screening criteria).

Total Hydrocarbon concentrations was found at L₁ before oil catch pit of CTPS, L₂ (confluence point) and L₄ D/S of river Damodar (Budidih) i.e. 1.59, 1.00 and 0.55g/kg in sediment indicating the presence of hydrocarbon residue in the sediments along the river course. Moreover, the sites fall in the category B of the contaminated land according to ProPECC PN 3/94 thereby indicating negligible impact.

No detection was found in sediment samples at site L₃ U/S of river Damodar (Bhandaridah) and L₅ D/S of river Damodar (Jharia-Jabadoba) indicating no contamination.

4.2 Fish

4.2.1. Condition Factor (CF) of the sampled fishes from Damodar River

Fishes are the best bio-indicator species to study bio accumulation and bio-magnification of trace elements. Fishes play a good role in biomonitoring of aquatic ecosystem (Kumari and Khare, 2018).

Estimation of Condition Factor (CF) of the fishes is a useful marker to check the health of the fishes living in a particular water body. It is the ratio of the length and weight of the fish body. It is determined by the following formula: -

$$\text{CF} = \frac{\text{Weight of the fish (gm)}}{\text{Length of the fish (cm}^3\text{)}} \times 100$$

Condition of fish in general is an expression of relative fatness of fish. The relative robustness, or degree of well-being, of a fish is expressed by “coefficient of condition,” denoted by ‘K’ (also known as Fulton’s condition factor, or length-weight factor, or Ponderal Index). Variations in a fish's coefficient of condition (or K-factor) primarily reflect state of sexual maturity and degree of nourishment. Condition values may also vary with fish age, season and in some species, with sex. K- Factor shows variations with different species and size of fishes, but in general, larger values are indicative of better fish condition.

During the study, the value of condition factor ranged from 1.02 to 2.2 for *Labeorohita* and *Oreochromis niloticus*, respectively, underlying general good health of the carps (**Table 6.1 and Plate 6**). Species exhibiting CF values of greater than one is considered to be in healthy condition.

Table 8: Condition factor of various fishes collected from different sites

S.No	Scientific names	Local Names	Average Length (cm)	Average Weight(gm)	Condition Factor(CF)
1.	<i>Labeorohita</i>	Rohu	3	0.28	1.04

2.	<i>L. bata</i>	Bata	2.7	0.20	1.02
3.	<i>Oreochromis niloticus</i>	Tilapia	3	0.29	1.07
4.	<i>Oreochromis niloticus</i>	Tilapia	2.7	0.20	1.02
5.	<i>Oreochromis niloticus</i>	Tilapia	29.5	601.25	2.2



Plate 6: Estimation of Length of fishes

4.3 Planktons

4.3.1: Microscopic identification:

The identified species of phytoplanktons and zooplanktons has been shown in **Plate 7** and **8**.

Phyto planktons



Gomphonema sp.



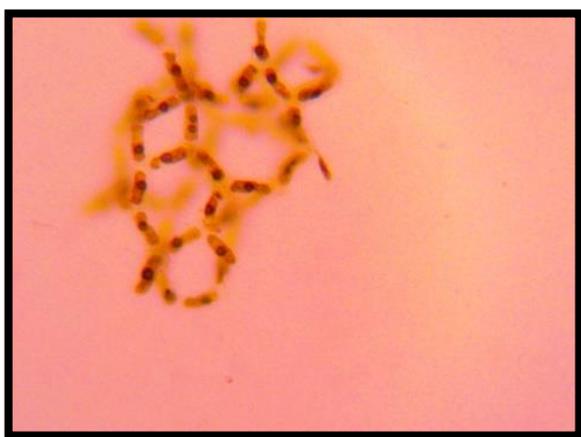
Chlorococcum sp.



Nitzschia sp.



Fragilaria sp.



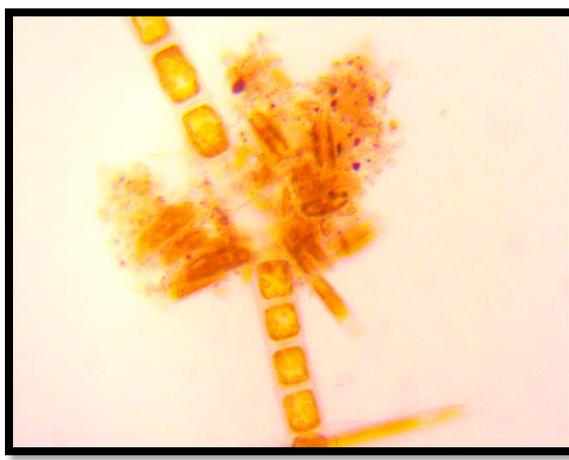
Pediastrum sp.



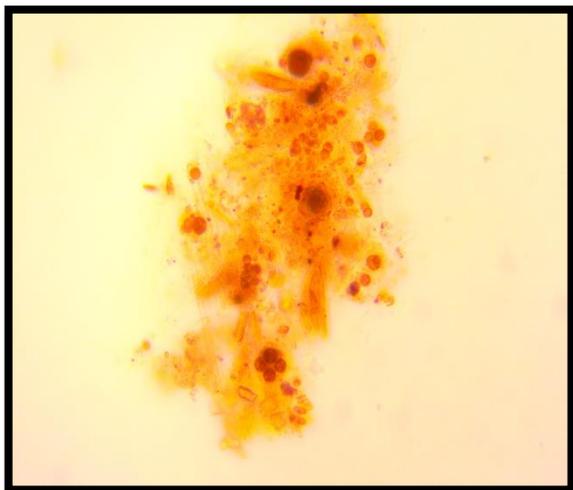
Ulothrix sp.



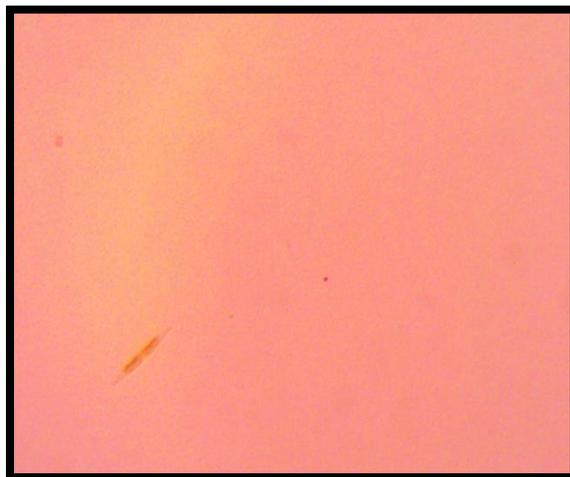
Ulothrix



Oscillatoria and Navicula sp.



Chlorococcum and Navicula sp.



Nitzschia sp.

Plate 7: Microscopic identification of phytoplanktons

Zooplanktons



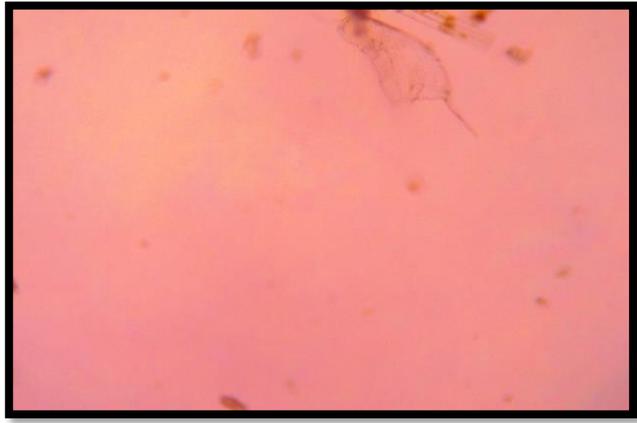
Nauplius oocyte



Brachionus Sp.



Cyclops sp.



Daphnia sp.



Chaetognatha sp.



Keratella sp.



Acartia sp.

Plate 8: Microscopic identification of Zooplanktons

4.3.2 Diversity score of Planktons

In the present study, phytoplankton composition and diversity with relation to Shannon Weiner Diversity Index was studied in order to draw the inference about water quality status and productivity and level of pollution in that particular water body. Total of 9 species each of phyto and zooplanktons belonging to 5 different families were recorded. The overall species of the Phytoplankton were represented mainly by five groups Chlorophyceae, Bacillariophyceae, and Cyanophyceae. Whereas the dominant groups in zooplanktons were Rotifera, Copepoda, Cladocera, Amphipoda, Sagittoidea and Protozoa (Table 8 & 9).

Table 9: Diversity score calculation of phytoplanktons and zooplanktons

Phytoplanktons				
Site	Number (species/ml)	Family	Composition (%)	Diversity Score
L₁ (Before oil catch pit)	25	Bacillariophyceae	100	1.44
L₂ (At confluence point)	49	Bacillariophyceae	60	3.34
		Chlorophyceae	40	
L₃ (U/S of river Damodar, Bhandaridah)	56	Chlorophyceae	27.5	5.59
		Bacillariophyceae	72.5	
L₄ (D/S of river Damodar, Budidih)	81	Bacillariophyceae	50	3.49
		Cyanophyceae	50	
L₅ (D/S of Damodar, Jharia-Jambadoba)	32	Chlorophyceae	22	1.78
		Bacillariophyceae	78	
Zooplanktons (species per m³)				
L₁ (Before oil catch pit)	500	Copepoda	40	1.43
		Protozoa	60	
L₂ (At confluence point)	800	Cladocera	12.5	2.52
		Copepoda	25	
		Amphipoda	62.5	
L₃ (U/S of river Damodar, Bhandaridah)	1000	Sagittoidea	20	2.70
		Rotifera	60	
		Protozoa	20	

SWI- Shannon-Wiener Diversity Index

<1: indicate maximum impact of pollution or adverse effect

1-2: indicate medium impact of pollution or adverse effect

>2: indicate minimum impact of pollution or adverse effect

The calculated Shannon-Wiener Diversity Index for the phyto and zooplanktons was found to be above 1 which means the water body has minimal level of pollution having negligible impact on the life of aquatic life. Some site showed the diversity even above 3 for phytoplanktons showing a good water quality.

Table 10: Species of Phytoplanktons and Zooplanktons observed in water samples

Family	Species
Phytoplankton	
Bacillariophyceae	<i>Navicula sp.</i>
	<i>Nitzschia sp.</i>
	<i>Gomphonema sp.</i>
	<i>Fragilaria sp.</i>
Cyanophyceae	<i>Oscillatoria sp.</i>
Chlorophyceae	<i>Pediastrum sp.</i>
	<i>Chlorococcum sp.</i>
	<i>Ulothrix sp.</i>
	<i>Chrolococcum sp.</i>
Zooplankton	
Copepoda	<i>Acartia sp.</i>
	<i>Cyclops sp.</i>
	<i>Nauplius oocyte</i>
Rotifera	<i>Brachionus sp.</i>
	<i>Keratella sp.</i>

Cladocera	<i>Daphnia sp.</i>
Amphipoda	<i>Amphipoda sp.</i>
Protozoa	<i>Protozoa sp.</i>
Sagittoidea	<i>Chaetognathasp.</i>

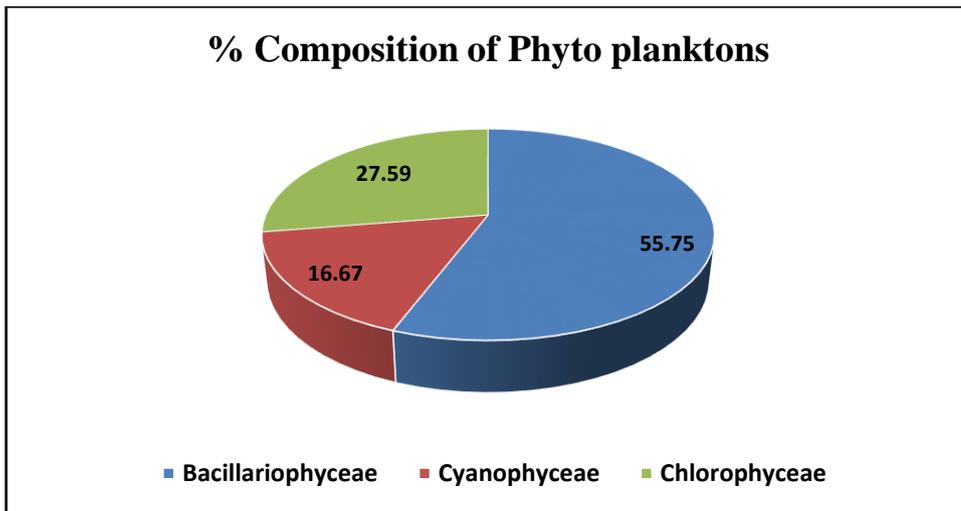


Figure 2: Percent composition of different families of Phytoplankton found at various sites

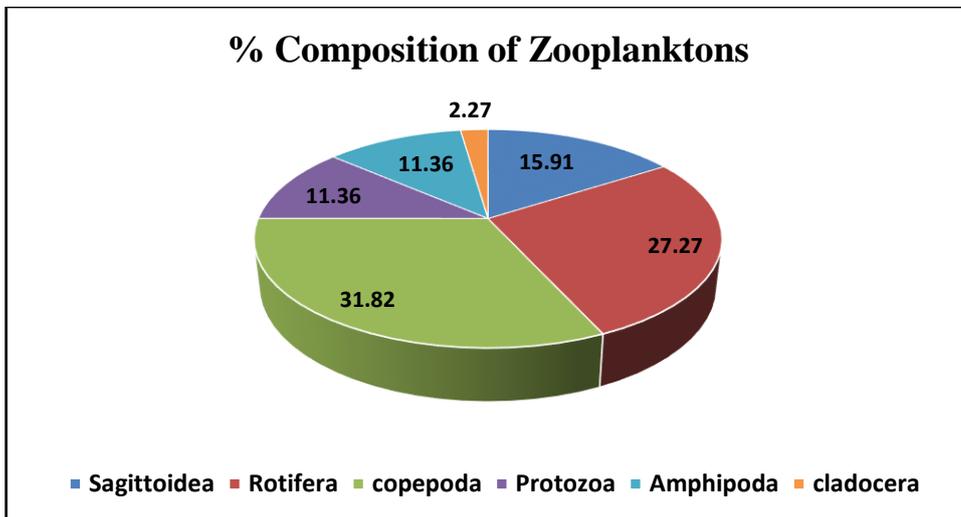


Figure 3: Percent composition of different families of Zooplankton found at various sites

Moreover, among Phytoplanktons, Bacillariophyceae was the most abundant family followed by Chlorophyceae and Cyanophyceae. Among Zooplanktons, Copepoda and Rotifera were the most

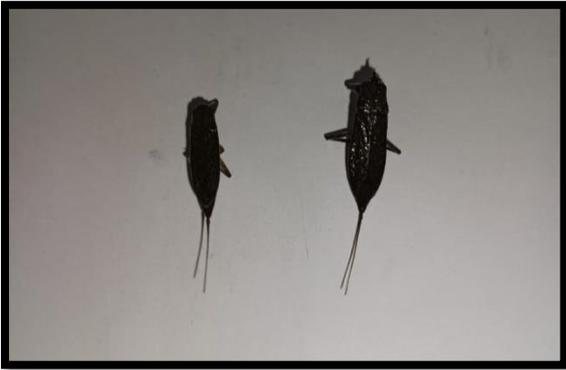
abundant family followed by Sagittoidea, Protozoa and Amphipoda whereas Cladocera has the least abundancy (Figure 2 & 3).

4.4 Benthic Macroinvertebrates:

Freshwater Bio monitoring and Benthic Macro invertebrates presents a state-of-the-art look at the use of benthic macroinvertebrates (aquatic insects, odonates, molluscs, crustaceans, and worms) in the biological assessment of water quality in lakes and streams. Four sampling locations were studied for their biological quality on the basis of Saprobic and Diversity score (Table 11) but the bottom of site L3 identified for sampling by Team (U/S of Damodar river) was hosting no benthos, moreover various human activity like cremation activity etc was observed at the site.

Table: 11: Saprobic score calculation of Benthic Macroinvertebrates found at different sampling sites

S. No.	Site	Saprobic Score	Diversity Score	Water Quality	Water quality class	Indicator Colour
1.	L ₂ (At confluence point)	6.5	0.52	Slight pollution	B	Light Blue
2.	L ₄ (D/S of river Damodar, Budidih)	6.67	0.75	Slight pollution	B	Light Blue
3.	L ₅ (D/S of river Damodar, Jharia-Jambadoba)	5.4	0.55	Moderate pollution	C	Green

L ₂ (At confluence point)	
	
Odonata (Aschenidae)	Hemiptera (Nepidae)
L ₄ (D/S of river Damodar, Budidih)	
	
Crustacean (Paleamonidae)	Mollusca (Thiaridae)
	
Odonata (Aschenidae)	
L ₅ (D/S of river Damodar, Jharia-Jambadoba)	



Mollusca (Uninoidae)

Mollusca (Sphaeridae)



Mollusca (Thiaridae)



Mollusca (Viviparidae)



Crustacean (Paleamonidae)

Plate 9: Identification of Benthic - macroinvertebrates

The detailed study of one season of Damodar River is given in **Table 11**. From the table it was observed that the saprobic index was maximum at D/S of Damodar river point (6.7), revealing the water body as relatively good in terms of biological diversity, carrying huge quantity of water leading to dilution of pollutants and favoring more species richness and thus increasing the biological productivity at this point. Apart from this, at L2, the confluence point of drain coming from CTPS meeting Damodar river was also found to be less polluted through benthos monitoring. It was also observed that the site was hosting various fingerlings of fishes. The sampling station L5 (Downstream at Jharia) showed only moderate pollution represented mainly by Molluscan species.

The results of benthos monitoring at 3 sampling points revealed slight to moderate pollution. The overall species was represented by different members of groups viz. Mollusca, Odonata, and Crustaceae (Table 10 & Plate 9).

Conclusion on Ecological assessment:

Soils along the course of river Damodar within impact zone is rich in organic carbon and have sufficient N, P, K and hence, soil fertility is good showing no impact of oils spill on soil fertility at present. Also, hydrocarbon was found at the oil spillage point only and not at any other site in soils. Moreover, hydrocarbon traces found at a few places in drains (L1 and L2) and river (L4) shows that oil residue is there in sediment. But, Biological analysis shows optimum diversity indices, for instance in phytoplankton and zooplanktons, the diversity indices at most of the sites indicated minimum impact of pollution. In addition, saprobic and diversity scores obtained for benthic invertebrate animals showed moderate to slight pollution which could be due to anthropogenic activities observed during the site visit. The condition factor also indicated good growth conditions of fishes. Hence, the river and river sediment do not show any adverse impact of oil spill on aquatic biodiversity at present.

Assessment of the environmental damage caused by the oil spillage and the cost of restitution of the environment:

The oil spill cost Rs. 1 Cr. 48 Lacs 8 thousands) for 900 L furnace oil spill is calculated by the methodology adopted in the research publication "Oil spill & cleanup Costs by Cao Thi Thu Trang, Institute of Marine Environment & Resource, Vietnam" It is also available at Research Gate, <https://www.researchgate.net/publication/259272466>. The methodology of cost calculation is found to be acceptable as Vietnam is also a developing country. Also, cleanup cost values for 900 Litres of Furnace oil and various other oil types in Table 6 of the paper are in a similar range as calculated in this methodology.



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**5.0 Annexure 1: Interim report on
Environment Compensation Fixation for
CTPS Oil Spill**

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**Interim Report
on
Environment Compensation Fixation
for
CTPS Oil Spill**

(Spill Date: 15th October 2019)

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Expert Team Members:

Dr. Ajay Mandal, Professor and HoD, Petroleum Engineering,
IIT (ISM) Dhanbad

Nitish Kumar, IFS, Attached Officer, Dumka

Vikas Meena, IFS, Attached Officer, Chatra South

Submitted to:



Jharkhand State Pollution Control Board

Somendra
6.2.2020

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07/2/2020

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1. Executive Summary

A breach in hume pipe caused spillage of approximately 2700 liter (as reported) of furnace oil (FO) at early hours of 15th October, 2019. CTPS was able to recover 1800 liters (approximately) of the same spilled oil but 900 liters of it, found its way to Damodar river. This spill has major environmental impacts which is not only on river ecology but also affects society dependent on river directly or indirectly.

This report considers various circumstances leading to spill, fixes responsibility as well as also calculates environment compensation for spilled oil which could not be collected.

The total compensation for the spill in this case is calculated to be INR 1.5 crores. (which can be modified later depending on exact quantity of recovered spilled oil, which is to be reported)

2. Description of Event

2.1. Members of expert committee met with officers of M/S CTPS namely:

- Shri R.K. Sinha, CE and HOP
- Shri Asim Nandy, CE (O and M)
- Shri Subhash Singh, DCE (M), O&M
- Shri Abhay Srivastava, DGM (Adm)
- Shri Rabindra Kumar, DCE(C)
- Shri Raushan Kumar Singh, EE (M), EMPC
- Shri P C Sahu, SE (Fuel)
- Shri Pranav Kumar Mahapatra, SDE(M), Fuel

in presence of Shri R.N. Chaudhary, RO, Dhanbad, JSPCB and Shri Ashutosh Anand, Consulting Executive, JSPCB on 27th January, 2020.

2.2. After discussion with above officials and field visit, following sequence of events can be concluded:

2.2.1. There was malfunction in new system of fuel oil loading system from railway rake on 15th October, 2019.

2.2.2. This led to CTPS shifting of fuel oil loading to old system

2.2.3. Between this an amount of 2700 liter was found to have leaked onto the rake ground level collection system (See Fig.2)

2.2.4. This leaked fuel oil collected itself and flew to the pipe connecting to oil collection space. This pipe was leaking that day, leading to spilling over of the fuel oil.

2.2.5. This spilled over fuel oil collected in the water collection system present very close to the leaking pipe (See Fig. 3)

- 2.2.6. Thus, oil along with rain water flowed in the storm water drainage system and flew till oil catcher system established before a natural drain which joins to Damodar river (See Fig. 4 and 5).
- 2.2.7. Few hours passed before the spill was noticed by CTPS around 4 am on the same day. CTPS was also informed by Jamadoba Water Intake station, located downstream of the plant, that floating oil was observed.
- 2.2.8. CTPS started to stop flow of fuel oil further to river Damodar. Their main focus was stopping further flow of fuel oil from oil catcher system and from mouth of drain joining Damodar river.
- 2.2.9. CTPS mostly employed installing brushwood dams and flow barrier and then skimming of fuel oil from behind of these barriers (See Fig. 6).
- 2.2.10. Field inspection (See Fig. 7) could not reveal exact amount of collected oil. CTPS has officially informed that they were able to collect around 1800 liter of the spilled 2700 liter of fuel oil (preliminary estimates) (See Fig. 8). But this has to be confirmed, by draining all containers to a settling tank. **CTPS has been asked to report the exact quantity after separation of collected spilled oil from water.**

2.3. Responsibility Fixing

- 2.3.1. Leakage in hume pipe is non-compliance of CTO.
- 2.3.2. It is evident that the leakage in connecting hume pipe was not detected well in time to avoid the oil spill.
- 2.3.3. Late detection lead to spread of oil to Damodar river which has multiple inlets for drinking water supply.
- 2.3.4. Closeness of oil sump with inlet of drainage system led to flow of spilled oil towards river. This is a design issue.
- 2.3.5. Oil collection pipe was also found to be choked in oil catcher system made to collect oil in case of untoward incidences.
- 2.3.6. CTPS did not disseminate the information to management of nearby water intake wells, which supplies drinking water to nearby settlements. Rather, it was other way round.

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3. Environment Compensation

- 3.1. Environment compensation is term used for the process through which the financial responsibility for environmental damage is transferred back to those who cause the damage.
- 3.2. Environmental compensation is one of the means of making polluter pay (and take action more generally) for preventing, remediating or compensating environmental damage they cause. Therefore, environmental compensation is an important instrument of the implementation of Polluter Pays Principle.
- 3.3. Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 have been notified by Government of India exercising the powers conferred by Section 6, 8 and 25 of Environment (Protection) Act, 1986. Provision of paying financial penalty for any violation of the provisions under the rules have been stipulated. The same is reproduced as below:

"23. Liability of occupier, importer or exporter and operator of a disposal facility.-

(1) The occupier, importer or exporter and operator of the disposal facility shall be liable for all damages caused to the environment or third party due to improper handling and management of the hazardous and other waste. ..."

- 3.4. The figure below shows an indicative conceptual site model, depicting the different pathways and receptors that run the risk of being exposed to any contaminant in soil, groundwater and surface water due to impact from hazardous waste dumping/leakages.

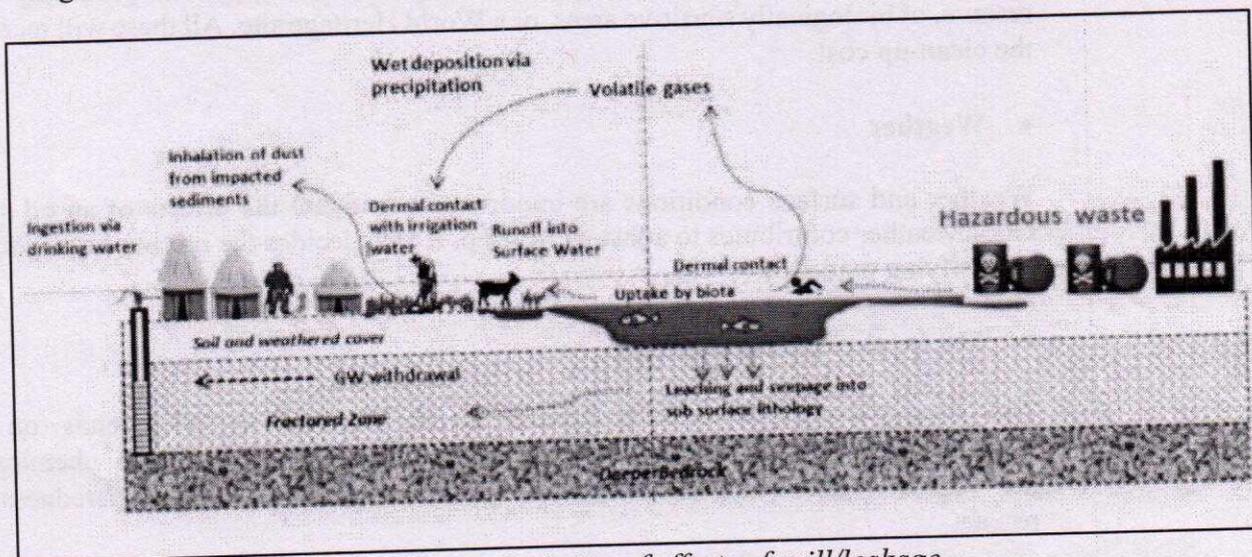


Figure 1. Simplistic depiction of effects of spill/leakage

4. Considerations in case of Oil Spill

4.1. The following factors affect the estimation of the environmental costs and damage caused by oil spills¹

- **Oil type**

Oils are complex mixtures with a wide variety of properties. When oil is spilled on the surface of the sea or river, it undergoes physical and chemical changes. These processes include evaporation, dispersion, dissolution and sedimentation. They result in the disappearance of the oil from the surface. On the other hand, the formation of an oil-water emulsion and the increase of viscosity promote the persistence of the oil in the ecosystem. The marine environment assimilates oil through the long - term process of biodegradation. In general, light oil and light crude oils do not persist on the surface of the sea for long, as a result of the fast evaporation of the volatile components and the easy dispersion. But, other types of oil such as heavy crude, emulsified crude and heavy fuel oils are persistent in the environment, because they contain a high ratio of non-volatile components and they have a high viscosity. Clean - up of these oils in the environment is difficult and the cost may be very high.

- **Location of the oil spill**

The location of an oil spill has an important effect on the clean-up cost. The location is decisive for the response a rescue team can provide and for the damage to natural and social resources, the economy and the environment. The location also influences the behavior of the oil and the way it relates to the hydro meteorological characteristics (wind direction, currents, waves, tides, and water depth) of the area. Also, the type of the coast affects the clean-up cost. Influencing factors include the proximity of a reserve, of biologically sensitive areas, or a World Heritage site. All these will increase the clean-up cost.

- **Weather**

Weather and surface conditions are important to mitigate the effects of an oil spill. Good weather contributes to a faster clean-up. It also decides the mixing response and emulsifying tendency.

- **The local response capacity**

The response capacity of the Rescue Center for oil spills depends on its equipment (buoy, airplane, oil containment, ship, rescue boat, and chemicals), the rescue teams (trained and skilled professionals) and the preparedness to rescue.

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5. Environment Compensation Calculation

5.1. The clean-up cost of an oil spill is the sum of the response costs, the value of the socioeconomic damage and the environmental cost¹.

• Response Cost

Total response cost = base per-gallon response cost (based on oil type/volume/response method) x medium modifier x spill amount

The base per-gallon response cost is the cost to eliminate 1 gallon of oil from the environment. The base per-gallon response cost depends on the response methods such as mechanical cleaning, dispersing, in-situ treatment or manual removal approaches. The effectiveness of the response methodology is shown in table 3.

The base per-gallon response cost to remove different amounts of different oil types is shown in annex 1.

The medium modifier is a value that differs for an oil spill in open water, wetland, mudflat, soil, or sand. Medium modifier values are listed in annex 3.

• Socio-economic Cost

Total socioeconomic damage cost = per-gallon socioeconomic cost x socioeconomic cost modifier x spill amount

The per-gallon socioeconomic cost corresponds with the impact of 1 gallon of oil to the local and regional tourism, commercial fishing, recreational facilities, national parks, marine resources, seascapes, private property and waterway and port operation impacts. This cost depends on the oil type and the spill size. Unit price estimations are listed in annex 2.

The socioeconomic cost modifier differs according to the socioeconomic sector that is impacted. A list of values is shown in annex 4.

• Environmental Cost

Total environmental damage cost = per-gallon environment cost x 0.5 (freshwater + wildlife modifier) x spill amount

The per-gallon environment cost corresponds with the cost of the damage caused by 1 gallon of oil. Damage costs are estimated by the amount of money that is necessary to repair the environmental damage. This cost is shown in annex 2.

Detailed calculations, according to above methodology are shown in section 5.2.

5.2. Calculations for CTPS Case

Heads	Values	Remarks
Amount of Oil Spill (liters)	900	
Amount of Oil Spill (Gallons)	237.75	
Oil Type	Furnace oil	Heavy oil
Total Response cost		Total response cost = base per-gallon response cost (based on oil type/volume/response method) x medium modifier x spill amount
Medium modifier	1.3	Considering Average for Open water (1) and Wetland (1.6)
base per gallon response cost (USD)	310	50% effectiveness
Total Response Cost (USD)	95815.18	mechanical method
Total Socioeconomic cost		
Socioeconomic base cost Per-Gallon (USD)	80	Total socioeconomic damage cost = per-gallon socioeconomic cost x socioeconomic cost modifier x spill amount
Cost Modifier Value	0.3	
Total socio economic cost (USD)	5706.12	Minimal value rank
Total Environmental cost		
Environment base cost. Per Gallon (USD)	85	Total environmental damage cost = per-gallon environment cost x 0.5 (freshwater + wildlife modifier) x spill amount
Cost Modifier value (Freshwater Vulnerability)	0.9	
Cost Modifier value (Habitat and Wildlife sensitivity)	1.5	Non specific
Total Environmental cost (USD)	24250.99	River
Total of all Total cost (USD)	125,772	
Market Exchange Rate	44	Average exchange rate from USD to INR in 2005
Inflation adjusted cost (INR)	14,807,826	100 rupees in 2005 are equivalent to 267.58 rupees in 2019 (See Annex 7)
Total Compensation Cost of 900 litres of Oil Spill in Damodar (INR)	14,807,826	1 crore 48 lakhs 8 thousand
Scenario of 1000 liters	16,453,140	1 core 64 lakh 53 thousand

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6. Recommendations

- 6.1. CTPS should do design changes and modify present arrangement so as to avoid overflow of industrial effluent to storm water or other miscellaneous collection system, which joins directly to surface drainage, like rivulets and rivers.
- 6.2. CTPS should repair oil catcher and arrange for its restricted entry.
- 6.3. CTPS should design a Disaster Management Plan whereby an information dissemination system is triggered as soon as some untoward event happens. Drinking water intake should be stopped as soon as some effluent is discharged in the river.
- 6.4. Proper documentation of all spills (small or large) should be done at level of individual power plants and communicated to JSPCB officials.

7. References

- 7.1. "Oil Spills and Cleanup Costs", *Trang, Cao Thi Thu*, 2006
- 7.2. "Development of Oil Spill Response Cost-Effectiveness Analytical Tool", *Etkin, Dagmar Schmidt, Welch, Jeff*, 2005

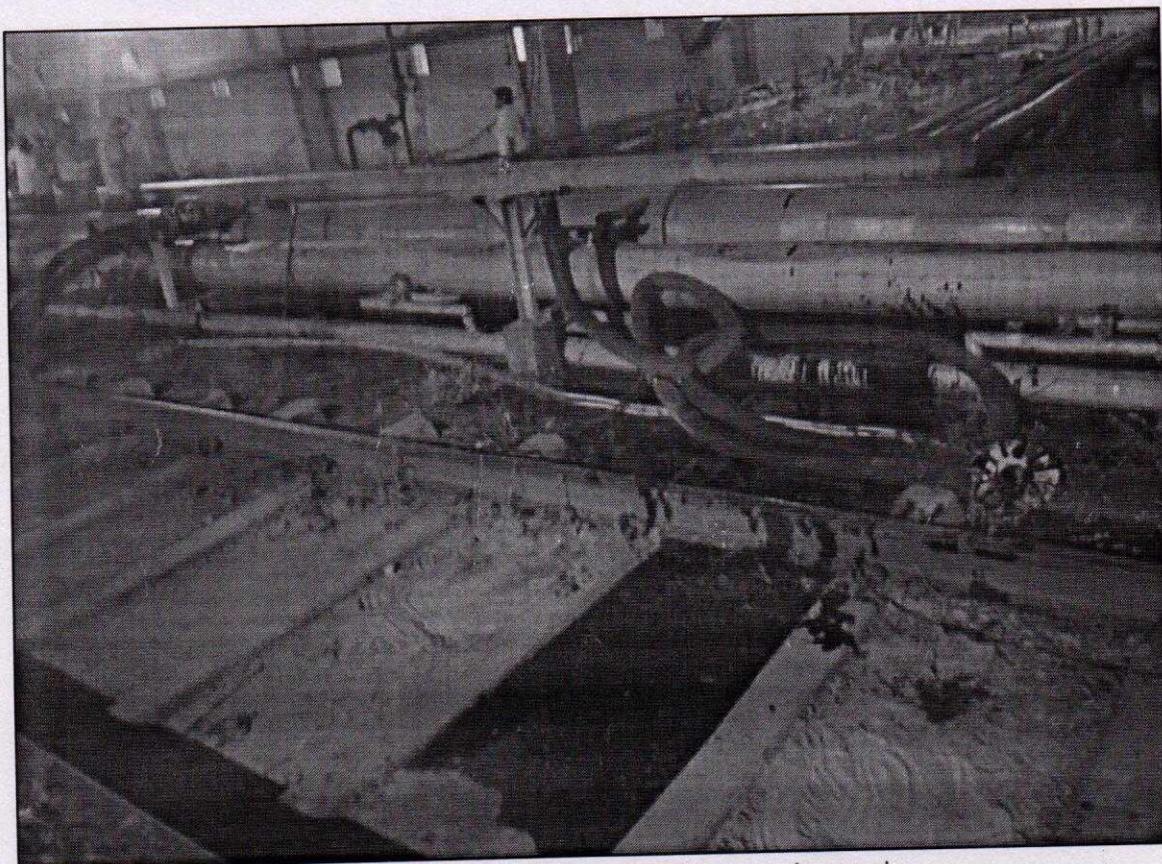


Figure 2. Spillage of Furnance Oil onto the tracks

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Figure 3. Breached pipe leading to oil spill which got collected in nearby water drainage inlet



Figure 4. Spilled oil seen in oil catcher system

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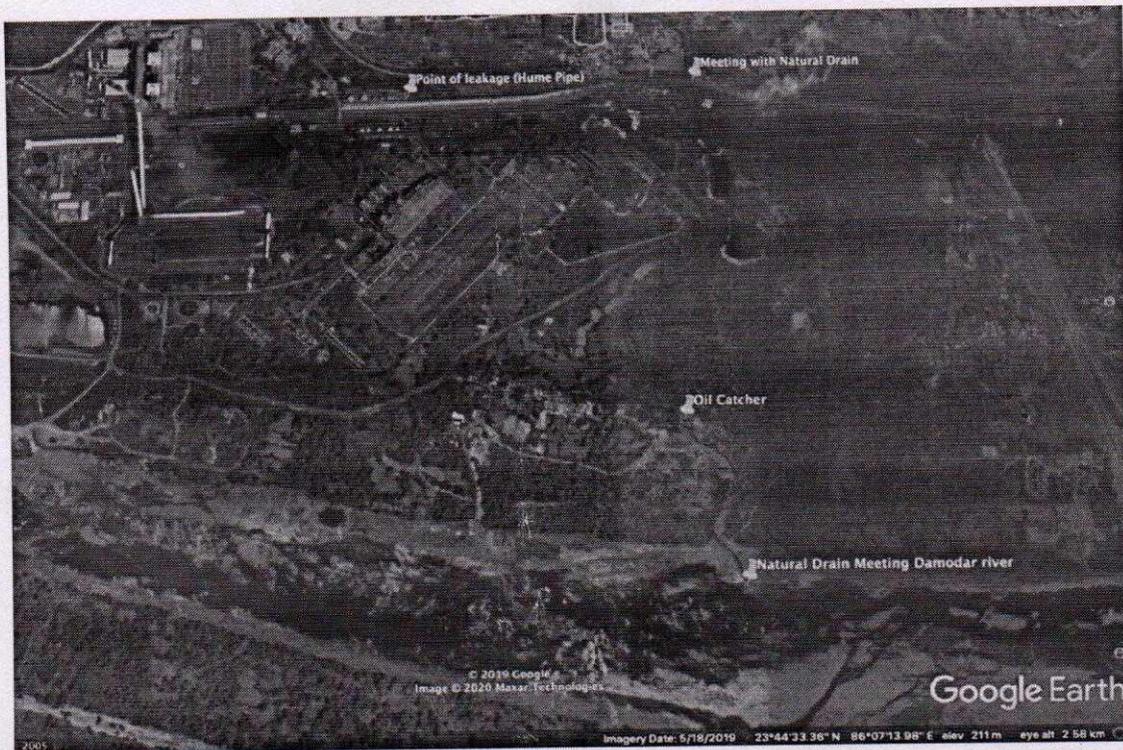


Figure 5. Google map showing spill location and its connection to Damodar river via drain



Figure 6. Temporary empoundment of water and oil using brushwood

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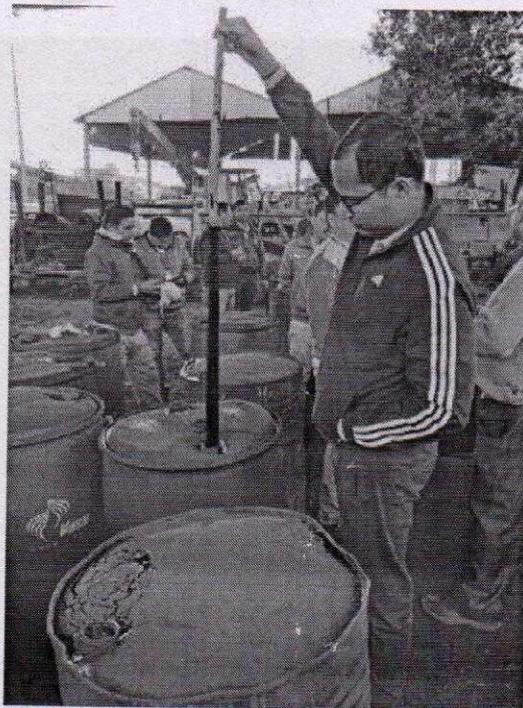


Figure 7. Checking of oil levels inside containers

DT	NEW PLANT		KL	OLD PLANT			KL	KL
	F0.Sto-1	F0.Sto-2	Total (New)	OP#2	OP#3	OP#7	Total (Old)	TOTAL STOCK(Old+new)
14.10.2019	0.17	0.23	85.4864	0.5	0.5	0.4	124.6	210.09
15.10.2019	0.17	0.63	170.9728	7	5.2	3.4	1388.4	1559.37
Difference in levels								1349.29 KL
RECEIVED BY RAKE								1351.99 KL
Shortfall qty								-2.70 KL

No of drums of capacity 200 Lts present at site = 18
 Considering average oil qty in each drum as 100 Ltrs
 So the total Qty in each drum to be = 1800

Shotage Quantity = 2700-1800= 900 Liter (Approx)

SDE (M), CTPS
 21-01-2020

Figure 8. Quantity of spilled oil collected by CTPS (as reported)

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8. Annexures

Annex 1: Per-gallon Oil Spill Response Cost as used in EPA BOSCEM (in USD) (Etkin, 2005)

Oil type	Volume (gallons)	Mechanical				Dispersants		In-situ Burn	
		0%	10%	20%	50%	Low	High	50%	80%
Light fuel	<500	100	85	70	57	36	25	26	13
	500-1,000	98	83	68	55	35	24	25	12
	1,000-10,000	97	82	67	54	34	23	24	11
	10,000-100,000	87	72	59	41	26	18	18	9
	100,000-1,000,000	74	62	49	26	17	10	10	5
	>1,000,000	31	26	17	12	11	6	7	3
Heavy oils	<500	440	386	335	310	140	89	125	64
	500-1,000	438	385	334	309	139	88	124	63
	1,000-10,000	436	384	333	308	138	87	123	62
	10,000-100,000	410	359	308	267	103	62	103	51
	100,000-1,000,000	179	154	128	103	59	54	72	41
	>1,000,000	87	77	67	36	53	49	56	26
Crude oils	<500	220	199	189	153	85	53	75	48
	500-1,000	218	197	187	151	84	52	74	47
	1,000-10,000	215	195	185	149	82	51	72	46
	10,000-100,000	195	185	174	138	74	31	62	31
	100,000-1,000,000	123	118	113	92	49	29	36	16
	>1,000,000	92	82	76	64	58	13	22	11
Volatile distillates	<500	-	103	-	-	-	-	-	-
	500-1,000	-	102	-	-	-	-	-	-
	1,000-10,000	-	100	-	-	-	-	-	-
	10,000-100,000	-	55	-	-	-	-	-	-
	100,000-1,000,000	-	23	-	-	-	-	-	-
	>1,000,000	-	7	-	-	-	-	-	-

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Annex 2: Socioeconomic and Environmental Base Per-Gallon Coast as used in EPA BOSCEM (Etkin, 2005)

Oil type	Volume (gallons)	Base Cost (USD/gallon)	
		Socioeconomic	Environmental
Light fuel	<500	65	48
	500-1,000	256	45
	1,000-10,000	400	35
	10,000-100,000	180	30
	100,000-1,000,000	90	15
	>1,000,000	70	10
Heavy oils	<500	80	85
	500-1,000	330	80
	1,000-10,000	500	70
	10,000-100,000	200	65
	100,000-1,000,000	100	30
	>1,000,000	90	25
Crude oils	<500	150	95
	500-1,000	600	90
	1,000-10,000	900	85
	10,000-100,000	500	75
	100,000-1,000,000	200	40
	>1,000,000	175	35
Volatile distillates	<500	50	90
	500-1,000	200	87
	1,000-10,000	300	80
	10,000-100,000	140	73
	100,000-1,000,000	70	35
	>1,000,000	60	30

Annex 3: EPA BOSCEM Response Cost Modifiers for Location Medium Type Categories (Etkin, 2005)

Category	Cost Modifier value
Open Water/Shore*	1.0
Soil/Sand	0.6
Pavement/Rock	0.5
Wetland	1.6
Mudflat	1.4
Grassland	0.7
Forest	0.8
Taiga	0.9
Tundra	1.3

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Annex 4: EPA BOSCEM Socioeconomic and Cultural Value Rankings (Etkin, 2005)

Value Rank	Soil Impact Site(s) Description	Examples	Cost Modifier Value
Extreme	Predominated by areas with high socioeconomic value that may potentially experience a large degree of <i>long-term</i> impact if oiled.	Subsistence/ commercial fishing, aquaculture areas	2.0
Very High	Predominated by areas with high socioeconomic value that may potentially experience some <i>long-term</i> impact if oiled.	National park/reserves for ecotourism/nature viewing; historic areas	1.7
High	Predominated by areas with medium socioeconomic value that may potentially experience some <i>long-term</i> impact if oiled.	Recreational areas, sport fishing, farm/ranchland	1.0
Moderate	Predominated by areas with medium socioeconomic value that may potentially experience <i>short-term</i> impact if oiling occurs.	Residential areas; urban/suburban parks; roadsides	0.7*
Minimal	Predominated by areas with a small amount of socioeconomic value that may potentially experience <i>short-term</i> impact if oiled.	Light industrial areas; commercial zones; urban areas	0.3
None	Predominated by areas already moderately to highly polluted or contaminated or of little socioeconomic or cultural import that would experience little short- or long-term impact if oiled.	Heavy industrial areas; designated dump sites	0.1

Annex 5: EPA BOSCEM Freshwater Vulnerability Categories (Etkin, 2005)

Category	Cost Modifier value
Wildlife Use	1.7
Drinking	1.6
Recreation	1.0
Industrial	0.4
Tributaries to drinking/recreation	1.2
Non-specific	0.9

Annex 6: EPA BOSCEM Habitat and Wildlife Sensitivity Categories (Etkin, 2005)

Category	Cost Modifier value
Urban/Industrial	0.4
Roadside/Suburb	0.7
River/Stream	1.5
Wetland	4.0
Agricultural	2.2
Dry grassland	0.5
Lake/Pond	3.8
Estuary	1.2
Forest	2.9
Taiga	3.0
Tundra	2.5
Other sensitive areas	3.2

Annex 7: Calculation of Time Value of Money

There are several ways to calculate the time value of money. Depending on the data available, results can be obtained by using the compound interest formula or the Consumer Price Index (CPI) formula.

Using the compound interest formula

Given that money changes with time as a result of an inflation rate that acts as a compound interest, the following formula can be used: $FV = PV(1 + i)^n$, where:

- FV: Future Value
- PV: Present Value
- i: Interest rate (inflation)
- n: Number of times the interest is compounded (i.e. # of years)

In this case, the future value represents the final amount obtained after applying the inflation rate to our initial value. In other words, it indicates how much are \$100 worth today. There are 14 years between 2005 and 2019 and the average inflation rate has been 6.7839%. Therefore, we can resolve the formula like this:

$$FV = PV(1 + i)^n = \$100 * (1 + 0.07)^{14} = \$266.54$$

Using the CPI formula

When the CPI for both start and end years is known, the following formula can be used:

$$\text{Final value} = \text{Initial value} * \frac{\text{CPI final}}{\text{CPI initial}}$$

In this case, the CPI in 2005 was 43.2 and the CPI today is 115.63. Therefore,

$$\text{Final value} = \text{Initial value} * \frac{\text{CPI final}}{\text{CPI initial}} = \$100 * \frac{115.14}{43.2} = \$266.54$$

End of Report