MEJA URJA NIGAM (P) LIMITED

(A JV of NTPC Ltd & UPRVUN Ltd)

Ref: MUNPL/Y/MEJA-I/EC Comp/24-25/Apr-Sep25 Date: 31.12.2025

To,
Regional Officer
MoEF&CC, Kendriya Bhawan
Sector – H, Sector A, Ali Ganj,
Lucknow, Uttar Pradesh,
India-226010

Subject: Submission of Half Yearly Environment Clearence Compliance Report of Stage-I (2x660 MW) MEJA Thermal Power Plant for the period 1st April 2025 to 30th September 2025-Reg.

Dear Sir,

Please find enclosed herewith the Half Yearly Environment Clearence Compliance Report of Stage-I (2x660 MW) MEJA Thermal Power Plant for the period 1st April 2025 to 30th September 2025.

Thanking You

Yours Faithfully,

31.12.2025

Bappaditya Sarkar
AGM-Environment Management Group

Annexure-A: Half yearly Environment Clearance Compliance Report for the period 1st April 2025 to 30th September 2025 of Stage-I (2x660 MW) Meja Thermal Power Plant.

Corporate Identity No. U74900DL2008PTC176247
पंजीकृत कार्यालय: एनटीपीसी भवन, कोर-7, स्कोप कॉम्प्लेक्स, इंस्टिट्यूशनल एरिया, लोधी रोड, नई दिल्ली-110 003
Regd. Office: NTPC Bhawan, Core-7, SCOPE Complex, Institutional Area, Lodhi Road, New Delhi-110 003
यूनिट: मेजा थर्मल पावर प्रोजेक्ट, पी. ओ. कोहड़ार, तहसील-मेजा, जिला-प्रयागराज-212301
Unit: Meja Thermal Power Project, P.O. Kohdar, Tehsil-Meja, Distt. Prayagraj-212301
Phone No: 0532-2693300 / 2693333, Fax – 0532-2693178

ANNEXURE-A

ENVIRONMENT CLEARENCE COMPLIANCE REPORT (ECCR)

of

STAGE-I (2x660 MW), MEJA URJA NIGAM (P) LTD.

(A Joint Venture of NTPC Limited & U.P.R.V.U N. Ltd.)

For the period 1st April 2025 to 30th Sep 2025.

By

Environment Management Group

MEJA THERMAL POWER PLANT

P.O- Kohdar, Tehsil- Meja, Distt-Prayagraj (UP)-212301

Name of the Project: Stage-I (2 x 660MW) Meja Thermal Power Plant

Project Code: F.No. IV/ENV/UP/TH-41/319/2010

Clearance Letter No.: J-13012/03/2008- IA II (T) dated 10.01.2011

Period of Compliance Report: From 01st April 2025 to 30th September 2025

Specific conditions:

<table>
<tr><th>Sl.</th><th>Item Description</th><th>Status as on 30.09.2025</th></tr>
<tr><td>i</td><td>Primary survey of flora and fauna in the study area shall be carried out and report submitted to the ministry within six months.</td><td>Primary survey of flora and fauna at MEJA TPP was carried through Centre for Social Forestry and Eco-Rehabilitation (ICFRE-Dehradun) Allahabad from November 2011 to April 2012.
Complied.</td></tr>
<tr><td>ii</td><td>A Wildlife conservation plan (especially with regard to Black buck) shall be prepared in consultation with the office of the chief wildlife concerned and reputed wildlife expert/ institute and submitted to the ministry within six months along with a road map for implementation. The plan shall specify budget earmarked for activities to be undertaken. The conservation plan shall be implemented prior to the commissioning of the power plant and the status of implementation shall be submitted to the regional office of the ministry from time to time.</td><td>Wildlife Conservation Plan (WCP) was prepared in consultation with Forest Dept. WCP is implemented and works are completed.
Complied.</td></tr>
<tr><td>iii</td><td>Land requirement shall be restricted to 1100 acres (445.15 Ha) (including ash pond)</td><td>During conceptualization of MEJA TPP in 2008, construction of both the stages was considered. Accordingly, Govt of Uttar Pradesh has allocated land to MUNPL for Stage-I and Stage-II. Some common facilities have been developed considering both Stage-I and Stage-II. Land breakup is given in table below:
<table>
<tr><th>Description</th><th>Land area for Stage-I (Ha)</th><th>Land area for Stage-II already taken with Stage-I (Ha)</th></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Sl.</th><th>Item Description</th><th>Status as on 30.09.2025</th></tr>
<tr><td></td><td></td><td>Further, the clarification about the land under the possession was presented during MEJA Stage-II expansion for consideration. EC for MEJA TPP Stage-II expansion was granted by MoEF&CC vide letter dt 30.04.2025.</td></tr>
<tr><td>iv</td><td>Provision for installing of FGD shall be provided for the future use.</td><td>As per the MoEF&CC notification dated 05.09.2022, MEJA Project falls in Category C. The cutoff timeline for compliance w.r.t. SO_2 emission is 31st December 2026.
Flue Gas Desulphurization (FGD) erection & commissioning works for MEJA Stage-I for both units of are completed. Trial run completed in January-February 2024. Both FGD utilities are kept in service from 28.02.2025.
Complied.</td></tr>
<tr><td>v</td><td>High efficiency Electrostatic precipitators (ESPs) shall be installed to ensure that particulate emission does not exceed 50 mg/Nm^3. Adequate dust extraction system such as cyclones/bagfilters and water spray system in dusty areas such as coal handling and ash handling points, transfer areas and other vulnerable dusty areas shall be provided</td><td>Electrostatic precipitators (ESP) have been provided and are in operation. PM emission is maintained within 30 mg/Nm^3. Adequate dust extraction system and water spray system have also been provided in CHP and ash handling areas to control fugitive emission.
Being Complied.</td></tr>
<tr><td>vi</td><td>Sulphur and ash contents in the coal to be used in the project shall not exceed 0.5% and 34 % respectively at any given time. In case of variation of coal quality at any point of time fresh reference shall be made to MOEF for suitable amendments to environmental clearance condition wherever necessary.</td><td><table><tr><th>Coal Sample</th><th>Concentration</th></tr><tr><td>Sulphur in Coal (%)</td><td>Unit #1– 0.46% by wt.
Unit #2– 0.45% by wt.</td></tr><tr><td>Ash (%)</td><td>23 to 40</td></tr></table>Noted for compliance.</td></tr>
<tr><td>vii</td><td>Stack height of 275 m height shall be installed and provided with continuous online monitoring equipment for SOx, NOx and $PM_{2.5}$& PM_{10}. Exit velocity of flue gases shall not be less than 22 m/sec. Mercury emissions from stack may also be monitored on periodic basis.</td><td>275 meter high stack with continuous online monitoring for SO_2, NO_x, PM. Exit velocity of flue gas is being maintained more than 22m/sec and monitoring of Hg emission is carried out quarterly.
Amendment regarding $PM_{2.5}$ taken and mentioned in condition no. (iv) of EC Amendment dated 08.08.2019.</td></tr>
</table>

Sl.	Item Description	Status as on 30.09.2025
xi	No ground water shall be extracted for the use in operation of the power plant even in lean season.	storage for minimum 15 days plant requirement needs to be ensured, to maintain the minimum flow in the river during lean period. 2. MUNPL, Meja has a reservoir with a total capacity of approximate 29 lac cubic meter to cater water requirement of 30.5 days on 100% PLF for both the units. 3. The condition mentioned in the GoUP water allocation letter is being conformed. In lean season, Irrigation Dept, GoUP maintains minimum required environmental flow in River Ganga and MUNPL regulates its water drawl based on the directions given by Irrigation Dept., GoUP
xii	No water bodies (including natural drainage system) in the area shall be disturbed due to activities associated with the setting up/ operation of the power plant.	No water body in the area is disturbed. Being Complied.
xiii	Minimum required environmental flow suggested by the competent authority of state government shall be maintained in the channel/ river (as applicable) even in lean season.	1. As per GoUP water allocation letter dated 10.01.2008, water storage for minimum 15 days plant requirement needs to be ensured, to maintain the minimum flow in the river during lean period. 2. MUNPL, Meja has a reservoir with a total capacity of approximate 29 lac cubic meter to cater water requirement of 30.5 days on 100% PLF for both the units. 3. The condition mentioned in the GoUP water allocation letter is being conformed. In lean season, Irrigation Dept, GoUP maintains minimum required environmental flow in Ganga River and MUNPL regulates its water drawl based on the directions of Irrigation

<table>
<tr><th>Sl.</th><th>Item Description</th><th>Status as on 30.09.2025</th></tr>
<tr><td></td><td></td><td>The current ash utilization of MUNPL Stage-I for FY 2024-25 is 75.56%. The ash utilization status first ash compliance cycle i.e. from FY 2022 to 2026 is projected below:
<table>
<tr><th>Financial Year</th><th>Ash Production (LMT)</th><th>Total AU (LMT)</th><th>Total AU (%)</th></tr>
<tr><td>FY 2022-23</td><td>15.73</td><td>9.82</td><td>62.39</td></tr>
<tr><td>FY 2023-24</td><td>17.85</td><td>12.63</td><td>70.78</td></tr>
<tr><td>FY 2024-25</td><td>20.17</td><td>15.24</td><td>75.56</td></tr>
<tr><td>FY 25-26 (Projected)</td><td>20.17</td><td>37.00</td><td>183.40</td></tr>
<tr><td>Total (In first compliance cycle of 4yrs)</td><td>73.92</td><td>74.69</td><td>101.03</td></tr>
</table>
Monthly report of ash utilization are submitted to MoEF&CC's Regional Office-Lucknow and other statutory authority as per requirement & direction from time to time.</td></tr>
<tr><td>xvii</td><td>Fly ash shall be collected in dry form and storage facility (silos) shall be provided. Unutilized fly ash shall be disposed off in the ash pond in the form of slurry form. Mercury and other heavy metals (As, Hg, Cr, Pb etc.) will be monitored in the bottom ash as also in the effluents emanating from the existing ash pond. No ash shall be disposed off in low lying area.</td><td>DAES with 04 nos. dry fly ash silo each of 1200MT capacity and 3 nos. HCSD silos each of 535MT capacity are in operation. Heavy metal analysis is being monitored in bottom ash. There is no discharge from ash pond and also ash is not disposed in low lying areas. Heavy metal analysis report of ash decanted water is attached as Annexure 3.
Being Complied.</td></tr>
<tr><td>xviii</td><td>Ash pond shall be lined with HDP/LDPE lining or any other suitable impermeable media such that no leachate takes place at any point of time. Adequate safety measures shall also be implemented to</td><td>Bentonite layer has been applied in Bottom ash lagoons and HCSD slurry layering in other lagoons.

Being Complied.</td></tr>
</table>

Sl.	Item Description	Status as on 30.09.2025
		to the young students. Solar Powered Mini water scheme has been implemented at the neighboring villages. Out of the total 18 allocated units, 18 units have been made operational till date. 01 unit is expected to benefit around 25-30 families. 200 solar street lights installed in nearby villages.
xxii	Further an amount of Rs 37.10 Crores shall be earmarked as one time capital cost for CSR programme as committed by the project's proponent. Subsequently a recurring expenditure of Rs 7.40 Crores per annum shall be earmarked as recurring expenditure for CSR activities. Details of the activities to be undertaken shall be submitted within six months along with roadmap for implementation.	For CD works, as per RAP I (main plant) and RAP II (supplementary RAP), Rs. 3672 lakhs were approved and till 31.03.2025, Rs. 3532.77 lakhs have been utilized for the various Community Developmental works at the associated villages. For FY 2024-25, proposals for need based CD activities have been approved for the balance amount of Rs. 148.23 lakhs (out of 3672 lakhs) and are in progress. Recurring expenditure condition is amended in EC Amendment dated 08.08.2019. Its compliance report is incorporated in this report at EC Amendment dated 08.08.2019 condition no. vii. Being Complied.
xxiii	While identifying CSR activities it shall be ensured that need based assessment for the nearby Villages within study area shall be conducted to study economic measures with action plan which can help in upliftment of poor section of society. Income generating projects consistent with the traditional skills of the people shall be undertaken. Development of fodder farm, fruit bearing orchards, Vocational training etc. can form a part of such programmes. Company shall provide separate budget for community development activities and income generating programmes. Vocational training programmes for possible self-employment and jobs shall be imparted to identify villagers free of cost.	• Need based assessment survey along with Social Economic survey and Socio Impact Evaluation Study were undertaken in the year 2022. Based on the reports submitted by the external agency, CD/CSR plans are devised. • Under the approved CD Budget as well as annual CSR budget, CSR/CD activities had been undertaken focusing on infrastructure building, increasing employability & to overall uplift the standard of living of the villages in the vicinity. Some of the activities

Sl.	Item Description	Status as on 30.09.2025
		& 40 tarpaulin Sheets to families in the villages of Kona who were affected by the floods. 13. Distribution of 5,000 relief packets to families in Prayagraj affected by the floods. Being Complied
xxiv	It shall be ensured that in-built monitoring mechanism for the schemes identified is in place and annual social audit shall be got done from the nearest government institute of repute in the region. The project proponent shall also submit the status of implementation of the scheme from time to time.	A separate department (R&R) headed by an executive at the level of SM is monitoring R&R works. R&R works are further reviewed and monitored at different levels of Management, periodically. First Socio Economic Survey (SES study was conducted in 2009. First social audit of surrounding villages was completed, and report already submitted. Second social audit by GB Pant Social Science Institute, Jhunsi (GBPSSI) for the period Nov-12 to Mar-14 has also been completed and final report has been submitted. Third Social Audit for activities undertaken during April 2014-Mar 2016 has been completed and final report has been submitted by GBPSSI. Fourth social audit by GB Pant Social Science Institute, Jhunsi (GBPSSI) for the period Mar-14 to April – 2025 has also been completed. Final report is yet to be finalized. Social Impact Evaluation Study (SIES) has been undertaken by M/s GBPSSI, Jhunsi for the period of July-19 to Mar-21 & report has been submitted. Being Complied

General Conditions:

Sl.	Item Description	Status as on 31.03.2025
i	A well-designed rainwater harvesting shall be put in place before commissioning of the plant. Central Groundwater Authority/ Board shall be consulted for-finalization of	Water Reservoir is spread over an area of 75Ha and has a rainwater harvesting potential of 6865Lakh.Ltrs/annum. In addition, there are two Rainwater

	and other contract workers during construction phase.	First aid center running in plant. Being Complied.
vii	Noise levels emanating from turbines shall be so controlled such that the noise in the work zone shall be limited to 75 dB. For people working in the high noise area, requisite personal protective equipment like earplugs/earmuffs etc. shall be provided. Workers engaged in noisy areas such as turbine area, air compressors etc. shall be periodically examined to maintain audiometric record and for treatment for any hearing loss including shifting to non-noisy/ less noisy areas.	Workers engaged in noisy areas are provided with earplugs/earmuffs. For such workers, periodical audiometric examination is carried. Being Complied.
viii	Regular monitoring of ambient air ground level concentration of SO2, NOx, PM2.5 & PMIO and Hg shall be carried out in the impact zone and records maintained. If at any stage these levels are found to exceed the prescribed limits, necessary control measures shall be provided immediately. The location of the monitoring stations and frequency of monitoring shall be decided in consultation with SPCB. Periodic reports shall be submitted to the Regional Office of this Ministry. The data shall also be put on the website of the company.	4 Nos. AAQMS stations have been commissioned and online data is being transmitted to CPCB. Third party regular monitoring of ambient air for SO_2, NOx, $PM_{2.5}$ & PM_{10} and Hg is being carried out and report is submitted to regulatory authorities regularly. A copy of report is attached as **Annexure 5.** If at any stage these levels are found to exceed the prescribed limits, necessary control measures like cleaning of roads, water sprinkling along the road and other preventive measures are provided immediately. Being Complied.
ix	Provision shall be made for the housing of construction labour (as applicable) within the site with all necessary infrastructure and facilities such as fuel for cooking, mobile toilets, mobile STP, safe drinking water, medical health care, creche etc. The housing may be in the form of temporary structures to be removed after the completion of the project.	The project is under operation and at this stage the condition is Not Applicable.
x	The project proponent shall advertise in at least two local newspapers widely circulated in the region around the project, one of which shall be in the vernacular language of the locality concerned within seven days from the date of this clearance letter, informing that the project has been	Complied. It was published in United Bharat, Amar Ujala, Dainik Jagran newspaper on 18.1.2011 and Times of India on 15.01.2011.

<table>
<tr><td>xv</td><td>The project proponent shall submit six monthly reports on the status of the implementation of the stipulated environmental safeguards to the Ministry of environment and Forests, its Regional Office, Central Pollution Control Board and State Pollution Control Board. The project proponent shall upload the status of compliance of the environmental clearance conditions on their website and update the same periodically and simultaneously send the same by e-mail to the Regional Office, Ministry of Environment and Forests.</td><td>Six monthly reports are submitted to MoEF&CC IRO Office-Lucknow, Central Pollution Control Board and State Pollution Control Board.
The status of compliance of environment clearance condition has been uploaded in company website of https://munpl.co.in/environment-management.

Being Complied.</td></tr>
<tr><td>xvi</td><td>Regional Office of the Ministry of Environment & Forests will monitor the implementation of the stipulated conditions. A complete set of documents including Environmental Impact Assessment Report and Environment Management Plan along with the additional information submitted from time to time shall be forwarded to the Regional Office for their use during monitoring. Project proponent will upload the compliance status in their website and up-date the same from time to time at least six monthly basis. Criteria pollutants levels including NOx (from stack & ambient air) shall be displayed at the main gate of the power plant.</td><td>Environment clearance compliance report are being submitted on every six months.
The compliance report is being uploaded in website of the company (www.munpl.co.in).

Real time data of CEMS and CAAQMS is being displayed in LED screen at plant gate.

Being Complied</td></tr>
<tr><td>xvii</td><td>Separate funds shall be allocated for implementation of environmental protection measures along with item-wise break- up. These cost shall be included as part of the project cost. The funds earmarked for the environment protection measure shall not be diverted for other purposes and year wise expenditure shall be reported to ministry.</td><td>During the conceptualization of the project, all Environmental Protection Measures are installed.
Description<table><tr><td>Issues Raised</td><td>Action Plan Proposed</td><td>Compliance Status</td></tr><tr><td></td><td></td><td></td></tr></table></td></tr>
</table>

				shall be undertaken at all available spaces in plant and Township. Cost Provision: Rs. 2 Crores	around the plant is 10 Ha (10 KM x 100 meters) and the total number of tree plantation to be carried out considering 2500 saplings per Ha comes to 2,50,000. Till date greenbelt is developed in an area approximately of 200 Ha. with 4,17,370 saplings planted and with survival rate of around 81%. Further plantation shall be carried out continuously in a phased manner. Cost incurred till date: 6 Crores approximate.
				Setting up of high efficiency ESP for control of air pollution as per proposal within a maximum emission of 100 mg per	High efficiency ESP to control the emission of particulate matter to 100 mg/Nm3 have already	Electrostatic Precipitator (ESP's) have been provided and made operational to control the PM emission within

					measures a portable HDPE pipeline is also available to suppress fugitive dust emissions in ash pond. All lagoons are in operation. Decanted ash water from the lagoon is pumped back to the plant and reuse for ash disposal through a dedicated Ash Water Recirculation System (AWRS) Total cost incurred is Rs. 322 Crores (Rs. 125 Cr for Ash Pond and AWRS, Balance is land cost for Ash Pond.)

Additional EC conditions added in EC amendments:		
	EC conditions added vide letter dt 21.07.2017	
xxv	Air and water quality equipment shall be set up for periodic environment monitoring	There are 4 Ambient air monitoring station and 01 Effluent quality stations are installed and online data are being transmitted to pollution control board. Being Complied.
xxvi	Global Positioning System GPS positioning system to be installed on all the truck carrying coal	Presently coal is being transported through railway rakes. At-this moment, this condition is Not Applicable.
xxvii	MOEF&CC notification S.O. 3305(E) dated 7.12.2015 and subsequent notification issued time to time shall be implemented with respect to specific water consumption zero liquid discharge and emission standards.	Electrostatic precipitators (ESP) have been provided and made operational. PM emission is maintained within 30 mg/Nm^3. MEJA Stage-I, erection & commissioning works of both units of Flue Gas Desulphurization (FGD) are completed. Both these utilities are kept in regular services from 28.02.2025. Low NOx burner are installed and in operation. Specific Water Consumption for FY 25-26 till 30th September 2025 is 2.7 m^3/KwHr (Std. 3.0 m^3/KwHr). All effluents are treated & recycled for further reuse. There is no discharge from plant premises except during monsoon period. Being Complied.
xxviii	Trucks shall be covered with tarpaulin and properly stamped to ensure that tarpaulin is property tied with help of rope and truck is fully covered so that there is no slippage of coal and/or emission of dust during transportation.	Presently coal is being transported through railway rakes. At-this moment, this condition is Not Applicable.
xxix	Water sprinkling to be carried through out the route for control of fugitive dust emissions.	Presently coal is being transported through railway rakes. At-this moment, this condition is Not Applicable.
xxx	Railway siding shall be constructed before the expiry of validity of EC that is before 09.01.2018	Complied. Amendment in this EC condition was granted vide 21.07.2017 and further extended in 24.09.2018 till 31.03.2019. Railway side was completed within the timelines provided. Being Complied.

iii.	The trucks used for transportation of coal shall be in compliance with the latest vehicular emission norms.	Presently coal is being transported through railway rakes. At-this moment, this condition is Not Applicable.
	EC Amendment dated 08.08.2019	
i	The extension of environment clearance is only for continuing the construction activities of the unit 2. however, the operation of both units shall be started only when new pollution control equipment is installed and made ready to meet the revised emission norms issued vide dated 7.12.2015. Otherwise, an extension from the CPCB shall be obtained and submitted to the Ministry	New pollution control equipment's are installed to meet the revised emission norms. Electrostatic precipitators (ESP) have been provided and made operational. PM emission is maintained within 30 mg/NM^3. MEJA Stage-I, erection & commissioning works of both units of Flue Gas Desulphurization (FGD) are completed. Unit#1 and Unit #2 are kept in regular service. Being Complied.
ii	The average weekly emissions of flue gas for PM SO2 and NOx shall be submitted as a part of the compliance report. Further the mercury emission report shall also be submitted.	Average emission of flue gas is attached as **Annexure 7**. Being Complied.
iii.	The progress of the installation of FGD, De-Nox systems along with financial expenditure shall be submitted along with six monthly compliance report.	MEJA Stage-I, erection & commissioning works of both units of Flue Gas Desulphurization (FGD) are completed. Both these utilities are kept in regular services. Total financial expenditure of amount Rs.579Cr made till date for installation of FGD system. Low NOx burner are installed and are in use. Being Complied.
iv	Specific condition no. (xii): Bi-flue stack of 275 m height with flue gas velocity not less than 22 meter per second shall be installed and provided with continuous online monitoring equipment for Sox, Nox and PM.	275m height stack is provided with continuous online monitoring for SO_2, NOx, PM. Exit velocity of flue gas shall be maintained more than 22m/sec. Being Complied.
v	While commissioning the proposed unit the compliance of revised emission norms issued wide notification dated 07.12.2015 shall be achieved along with specific water consumption as per notification dated 28.06.2018. The FGD system and NOx control measures such as SCR/SCNR/De-	Electrostatic Precipitators (ESP) have been provided and made operational. PM emission is maintained within 30 mg/Nm^3. MEJA Stage-I, erection & commissioning works of both units of Flue Gas

<table>
<tr><td></td><td>highest amount shall be submitted within three months.</td><td>is under progress.
Being Complied.</td></tr>
<tr><td>viii</td><td>With respect to the recurring CSR expenditure any condition stipulating the recurring amount per annum in the EC may be made redundant. The recurring amount shall be in line with section 135 of companies act, 2013 which states that companies shall spend (in every financial year) at least 2% of the average net profit of the company made during the 3 immediately preceding financial years, in pursuance of its corporate social responsibility policy</td><td>In compliance with Section 135 of Companies Act, 2013, the total amount allocated for CSR for FY 2025-26 is Rs. 11.51 crores (2% of the average net profit of 03 preceding FYs). Implementation of the activities planned is under progress.

Being Complied.</td></tr>
<tr><td>ix</td><td>The details of average net profit made during the last 3 years to be submitted including the amount earmarked for CSR activities at least 2 %) from this project and the detail of various activities undertaken along with expenditure, extent of village covered, benefitted population, the proximity to the project area etc. as a part of EC compliance report (October to March on 1st June and April to September on 1st Dec) on the Ministry and its regional office.</td><td><table><tr><th>Financial Year</th><th>Net profit (In Lakh)</th></tr><tr><td>2022-23</td><td>9180.67</td></tr><tr><td>2023-24</td><td>36995.94</td></tr><tr><td>2024-25</td><td>126606.11</td></tr><tr><td>Avg of Net Profit for past 03 FY</td><td>57594.24</td></tr><tr><td>CSR Budget 25-26 (2% avg of the 03 FY)</td><td>1151</td></tr></table>Details of the CSR activities is Attached as Annexure 8.

Being Complied.</td></tr>
</table>

31.12.2025

Bappaditya Sarkar

AGM (Environment Management Group)

Project No.: CS-219/2021-23/SWHD

Final Report

on

Hydrogeological Study in Meja Prayagraj, UP

Sponsored by:

MEJA URJA NIGAM PRIVATE LIMITED
Meja village, Prayagraj district,
Uttar Pradesh

मेजा ऊर्जा निगम प्रा० लिमिटेड
MEJA URJA NIGAM (P) LIMITED
(A Joint Venture of NTPC Ltd. & UPRVUN Limited)
Corporate Identity No. U74900DL2008PTC176247

Prepared by:

NATIONAL INSTITUTE OF HYDROLOGY (NIH)

(An ISO-9001:20015 Certified Organization)

Roorkee – 247 667, Uttarakhand

NATIONAL INSTITUTE OF HYDROLOGY
NIH
राष्ट्रीय जलविज्ञान संस्थान
आपो हि ष्ठा मयोभुवः

August, 2024

PROJECT TEAM

Dr. A.K. Lohani	**Scientist 'G' & Head, Surfacewater Hydrology Division**
Dr. Gopal Krishan	**Scientist 'E', Hydrological Investigations Division**

Abstract

In order to fulfill the requirements of MOEF&CC as well as MUNPL, MEJA's concern towards conservation of surface and ground water resources for the benefit of the project as well as general population, a detailed Hydro-geological Study is proposed to be undertaken by National Institute of Hydrology, Roorkee. After getting the idea of the concerns, the National Institute of Hydrology (NIH), Roorkee agrees to undertake the investigation as a consultancy with the following objectives and scope of work.

The study surface water, hydrogeology and groundwater flow dynamics; surface water and groundwater quality; rainwater harvesting potential; to assess the impact of plant areas on the groundwater and its quality in the nearby areas. Analysed results of different components and their interpretations have been presented in 11 chapters. Chapter-1 presents introduction; Chapter-2 describes the study area details; Chapter-3 drainage, topography and landuse; Chapter-4 geological settings; Chapter -5 climate and rainfall pattern; Chapter -6 hydrogeology and groundwater level variation; Chapter-7 water quality assessment; Chapter-8 rain water harvesting potential Chapter 9- source sustainability; Chapter 10 describes a critical appraisal and remedial measures and Chapter -11 elaborates the conclusions and recommendations.

The bore hole drilling data reveals that the lithology of the region is basically, Sandstone of various grade and composition. The water bearing zone in the area is comprises of fractured sandstone basically between 200-240, 260-280 ft bgl. The infiltration rate varies from 0.3 (Ladiyari) to 7 mm/hour (Basahih) in various parts of the study area indicating low infiltration rates. Thesis's Time-drawdown curve matching method show Transmissivity value of the piezometer around 0.40 m^2/day, whereas, Theis's recovery method the Transmissivity of the aquifer is coming approx. to 0.37 m^2/day. Depth to water level ranges from 2.4 to 8.6 mbgl, during the survey period in September 2023.

In post monsoon 2021, Fluoride and Chloride are found within the acceptable limit at 66 and 93% of locations while all other samples including surface water samples are found within permissible limit at all the locations. Concentration of fluoride in 33% groundwater samples; sulphate and nitrate in 22 % groundwater samples are found beyond the permissible limit.
For arsenic, all samples are found within the permissible limit (50 ppb) for all the sampling locations. The influence of MUNPL, MEJA effluents was analysed in multiple ways through water sampling from MUNPL, MEJA project area and a buffer zone of 25 km.

The values of various groundwater quality parameters are of geogenic nature and no impact of MUNPL, MEJA effluents has been observed on the surface and ground water quality of the study area. However, it is advised to review the groundwater quality status after every three years.

ACKNOWLEDGEMENTS

Thermal power projects consume large quantities of water for their operation, which is obtained from the surface water sources, which may affect the surface water hydrology of the area. In addition, there are certain structures and activities which may affect the ground water hydrology also such as # dewatering during construction of the project construction of water impoundment structure on streams to draw water, construction of raw water reservoir inside main plant area, construction and operation of ash dyke area etc Further fresh water becoming a scarce resource day by day, MUNPL, MEJA understand its responsibility towards conservation of surface and ground water resources for the benefit of the project as well as general population within the study area, i.e. within 25 km from the boundary of the project.

First of all, we express our sincere and humble gratitude to Dr. J.V. Tyagi, Dr Sudhir Kumar and Dr. M.K. Goel Directors NIH, for providing all kind of cooperation and support, We would like to thank Dr. Nitesh Patidar, Sc. 'C' for soil analysis.

We, on behalf of the Institute and study team thankfully acknowledge the MUNPL, MEJA especially Sh. Anurag Khare, Sh. Saurabh Pathak, Sh. Shiv Prakash Srivastava who took keen interest in this study since its inceptation. Thanks to all the support received from other staff members of MUNPL, MEJA.

Thanks to all helping us in this project work successfully and for their valuable advice and support, which we received from them from time to time. My gratitude would be incomplete without mentioning the names of Mr. Anij Dwivedi, Mr. Vikas Dabral, Mr. Satya Prakash for the field work and critical observations, Thanks to Soil and water Lab for heavy metal analysis.

We also take this opportunity to thank all the staff of Surface water Hydrology Division, Groundwater Hydrology division, finance and bill section during the project work.

Dated: August 31, 2024

Place: Roorkee **(A K Lohani & Gopal Krishan)**

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1. Introduction

Meja, a joint venture incorporated in 2008 between NTPC and UPRVUNL in District Prayagraj of Uttar Pradesh. The present capacity of TPP is 1320 MW (2×660 MW) and the same is under commercial operation. This coal based thermal power plant is located in Meja tehsil of Prayagraj district (Fig. 1.1). It has its own 28-km freight corridor that helps in bringing critical materials, such as coal, to plant by rail. The plant is also connected to river Ganga at Bijora village, through a network of about 30 km pipeline, to transport water for industrial purposes. Meja Thermal Power Station is the first supercritical power plant (SCPP) of Uttar Pradesh.

It uses 20 per cent less coal compared to them. It generates less carbon emissions. A supercritical coal plant is a coal-fired power plant with more modern designs. It differs from traditional coal power plants as the water running through it works as a supercritical fluid. This reduces the amount of heat transfer to the water which in normal cases is needed in a conventional coal plant. Therefore, less coal is used to heat the same amount of water.

In order to fulfill the requirements of MOEF&CC as well as MUNPL, MEJA's concern towards conservation of surface and ground water resources for the benefit of the project as well as general population, a detailed Hydrological Study is being undertaken by National Institute of Hydrology, Roorkee

After getting the idea of the concerns, the National Institute of Hydrology (NIH), Roorkee agreed to conduct a detailed hydrogeological study entitled "*Hydrogeological Study in Meja Prayagraj, UP*" constitutes the required framework of tasks referred by the MUNPL, MEJA to the NIH.

The study is referred to investigate and address the following objectives and scope of work:

1.1 Objectives:

Thermal power projects consume large quantities of water for their operation, which is obtained from the surface water sources, which may affect the surface water hydrology of the area. In addition, there are certain structures and activities which may affect the ground water hydrology also such as # dewatering during construction of the project construction of

water impoundment structure on streams to draw water, construction of raw water reservoir inside main plant area, construction and operation of ash dyke area etc Further fresh water becoming a scarce resource day by day, MUNPL, MEJA understand its responsibility towards conservation of surface and ground water resources for the benefit of the project as well as general population within the study area, i.e. within 25 km from the boundary of the project.

In view of the above, the study will be carried out with main aim to assess impact of ash ponds on hydrological regime with special emphasis on the geo-hydrological conditions of the ash pond area to appraise the risk of contamination of ground water due to ash disposal to achieve the following objectives:

1.1.1 Surface Water Hydrology:

a) To study on water availability from the identified source - availability, allocation, downstream users, trends in water utilization in past decade.

b) To study the drainage pattern of the study area.

c) Identity the surface water bodies (including degenerated water bodies) within the study area (25 km radius from the plant boundary) their status, exploitation and potential for development of degenerated water bodies.

d) To study the surface water quality and current of contamination, if any.

e) To study the overall impact of construction on intake structures and drawl of water for operation of power project on surface water hydrology.

g) To develop a plan for annual review and monitoring of surface water systems in the study area.

1.1.2 Ground Water Hydrology

a) To define the present hydro - geological scenario of the study area through water contour map.

b) to identify aquifers, their characteristics (geometry, sections, status of groundwater storage, seasonal, fluctuations, direction of flow of groundwater etc.) and present levels of exploration, assessment of groundwater depletion if any.

c) To establish hydraulic characteristics of aquifers present in project area, especially ash pond area through pump test.

d) Estimation of annual recharge and utilization of ground water in pre –project and post project conditions, as per GEC Norms.

e) To study on groundwater quality and current sources of contamination, if any.

g) To develop a monitoring network for annual review and monitoring of ground water levels and quality.

1.2 Scope of work:

The scope of work for this part shall broadly cover the following:

a) Geological Investigations

- To provide the geological maps of the ash ponds and surrounding regions.
- To draw geological cross-sections of ash pond region and to provide stratigraphic details.

b) Geohydrological Investigations

c) Drilling and Logging

- To carry out drilling and logging at suitable sites
- To evaluate the hydraulic characteristics of aquifers like porosity, permeability, transmissivity, isotropism, yield etc through pump test around the existing and proposed ash ponds
- To use suitable logging methods for study of rock properties

d) Infiltrations Studies

To evaluate infiltration capacity of the soils around the existing and proposed ash ponds

e) Water Quality

- To assess the quality of groundwater in and around the present ash pond.
- To assess impact on surface water and ground regime especially around ash dyke. In case any deterioration is observed specific mitigation measures shall be suggested.
- To develop a plan for annual review and monitoring of surface water systems in the study area.

f) Leachate Studies

- To evaluate the concentration of various elements that are leached from ash as a function of variable leaching conditions, through experimental simulations.

- Recommendation for installation/fixation of the Piezometers on the basis of the leachates study.

Prior to this study, some studies and reports already done on various aspects in the area were also consulted. CGWB also published its periodicals on the hydro-geological investigations of the Prayagraj district which have been consulted while carrying out this study.

This report deals with comprehensive analysis of data related to meteorology, hydrogeology, topography, drainage network, geological formations, groundwater scenarios and direction, groundwater quality, etc. The data support for carrying out the analysis of different components have been obtained from India Meteorological Department (IMD), Geological Survey of India (GSI), downloading of Shuttle Radar Topography Mission (SRTM)/ Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data, groundwater related data from NWIC (National Water Informatics Centre) and reports, reports published by other organizations, and also from the field measurement and investigations conducted by the NIH team.

To bring conformity with the actual field conditions, all spatially varying databases have been analysed with reference to the geographic coordinate system by their latitudes and longitudes such that the analysed results can easily be verified with the actual field conditions. The report provides the analyses on the scope of work provided by the sponsoring agency, data collected from various sources, and by field investigations. The findings and observations are based on the comprehensive analysis of different components present in the report.

The report deals with the analysis on the following:

i. Delineation of the MUNPL, MEJA core zone area, buffer zone area, drainage network and drainage area characterization describing surface drainage pattern of the area,
ii. Land-use, habitat settlements, water bodies, in and around the study area,
iii. Hydro-meteorological characteristics of the area,
iv. Hydro-geological characterization, groundwater scenarios, groundwater fluctuation and flow direction, etc.
v. Soil characteristics determination based on field tests.
vi. Hydro-chemical characterization of groundwater in and around the MUNPL, MEJA area.
vii. Recommendations for future measures and adaptations.

Based on the analysis of above components, a section summarizing the analysis, findings and recommendations has been exclusively presented in the report.

2. Study Area

2.1 Location

Meja Tehsil is situated in Prayagraj district, Uttar Pradesh, India and it is characterized by Active Flood Plains, Older Alluvial Plain and Rocky Surface (Denudational hills). The active flood plain is quite localized and confined only to the river system, whereas the older alluvial plain is characterized by depositional and erosional terraces found in patches along the active plain. The denudational hills found prominent in trans Yamuna area formed mainly of quartzite.

As of the 2001 census, its total population was 471,851. Meja is primarily an agricultural dominated area; the main crops are wheat and rice. Some areas are cultivated with pulses also like Arhar, Urd and Chana. The principal sources of irrigation are canals and tubewells. Meja is 8 km from Meja Road railway station and connects with Koraon from the south and Manda from the east. The wildlife conservation reserve come up on over 126 hectares in Meja forest division known for its rocky, undulating and arid terrain.

The core zone area is comprised of the '*Meja Project Area*' measuring about 6400 ha **(**64 sq**.** km**)** that lies between the latitudes 25° 06' 45" to 25° 11' 33"N and longitudes 81° 52' 30" to 82° 00' 00"E, and the **'***Buffer Zone***'** of 25 km from the *Meja Project Area* measuring about 19,5900 ha **(**1959 sq**.** km**)** that lies between the latitudes 24^{o} 50' to 25^{o} 25' N and longitudes 81^{o} 40' to 82^{o} 15' E (Figure 2.1). The extended buffer zone area all around the *Meja Project Area* has been taken for analysis to investigate the physiography of the surrounding area particularly to see the connectivity of the surface drainage pattern, settlements, water bodies, groundwater, etc. All these areas lie in the Survey of India Toposheet No. 63G16,. A satellite image of the study area as seen from the '*Google Earth*' along with digitized features of the '*Meja Project Area*', and the '*Buffer zone*' is shown in Figure 2.3.

2.2 Hydrogeology and Climate

The location map of the MUNPL, MEJA project area and the buffer zone area is shown below in Figure 2.3. The climate is characterized by Humid Sub-tropical climate with distinct hot summer (March-July), cold winter (December-February) and rainy monsoon (July to September). The highest temperature goes above 42°C in May-June and the lowest up to 9°C in December-January.

January is the coldest month with mean daily minimum temperature at 9.1ºC and mean daily maximum temperature at 23.7ºC. May is the hottest month with mean daily maximum temperature at 42.1ºC and mean daily minimum temperature at 27.4ºC with the advance of the south-west monsoon about middle of June the the Day temperature drops appreciably, but night temperature is a little higher than May. The mean monthly maximum temperature is 32.8ºC and means monthly minimum temperature is 19.5ºC.

The average annual rainfall is 1042 mm and about 90% of rainfall takes place during south-west monsoon season commences from middle of June to September. During monsoon surplus water is available for deep percolation to ground water. During the monsoon season the air is very humid and after onset of the monsoon season humidity decreases progressively. The mean monthly morning relative humidity is 64% and means monthly evening relative humidity is 48%. During the monsoon season the air is very humid and after onset of the monsoon season humidity decreases progressively. The mean monthly morning relative humidity is 64% and means monthly evening relative humidity is 48%. Winds are generally high throughout the year with some increase in force in summer and monsoon season. The mean wind velocity is 5.1 kmph. The potential evapotranspiration is 1537.5 mm.

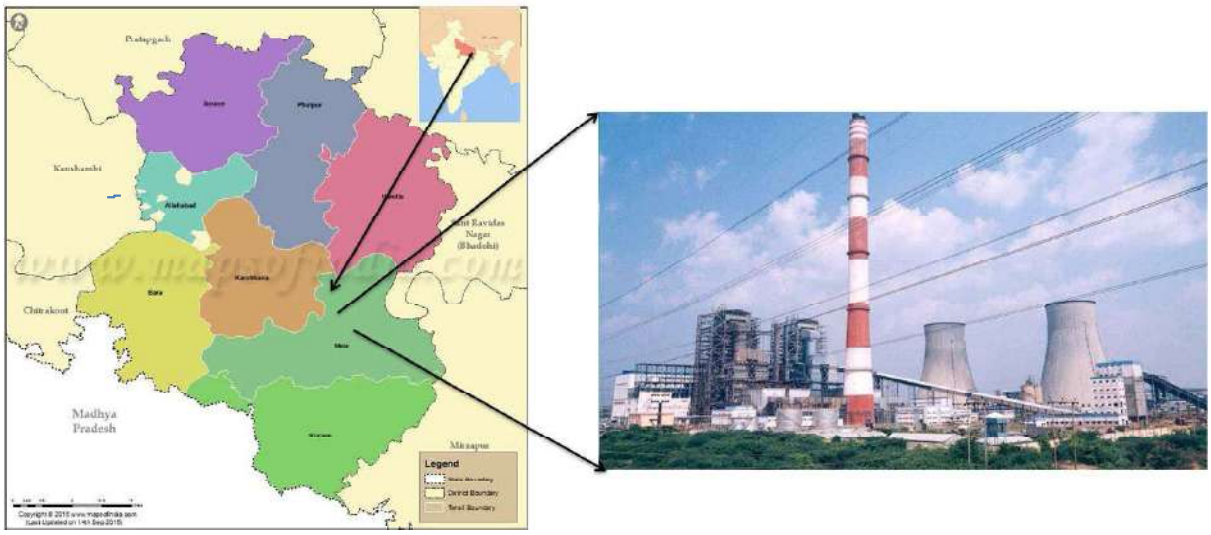


Figure 2.1. Location map of the MUNPL, MEJA, Meja, Prayagraj.

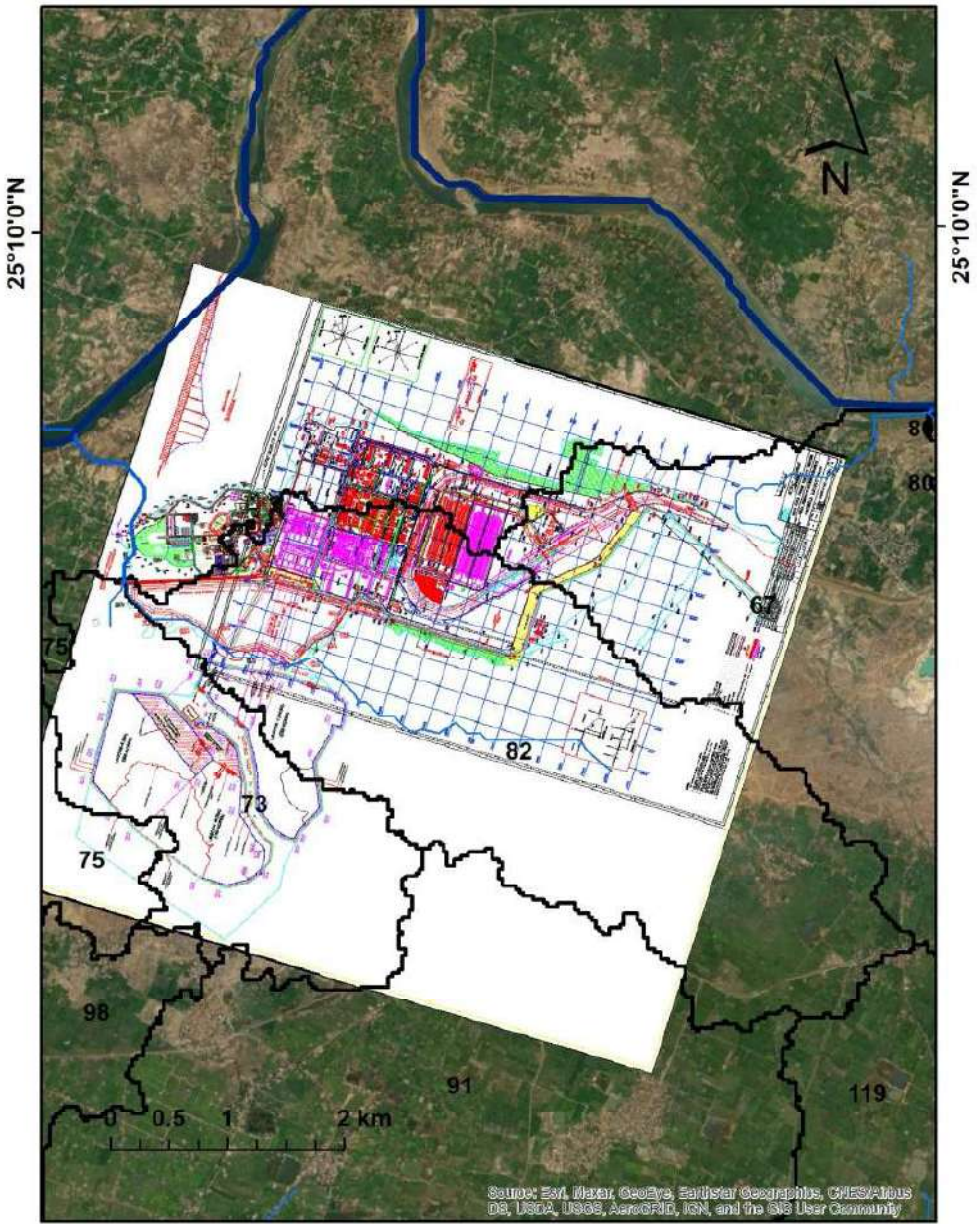


Figure 2.2. Snapshot of the study area seen from the '*Google Earth*' showing boundaries of the MUNPL, MEJA area .

Physiography of study area

Physiography of the lease area is characterized by almost flat country with isolated few low ridges. Prayagraj is located at 25.45°N 81.84°E in the southern part of the Uttar Pradesh at an elevation of 98 meters (322 ft) and stands at the confluence of two, the Ganges and Yamuna. The region was known in antiquity as the Vats country. To its south and southeast is the Bagelkhand region; to its east is middle Ganges valley of North India, or Purvanchal; to its southwest is the Bundelkhand region; to its north and northeast is the Awadh region and to its west along with Kaushambi it forms the part of Doab i.e the Lower

Doab region.In the north Pratapgarh, in the south Rewa (M.P.), in the east Sant Ravi Das Nagar and in the west Kaushambi districts are located.

The study area is characterized by Active Flood Plains, Older Alluvial Plain and Rocky Surface (Denudational hills). The active flood plain is quite localized and confined only to the river system, whereas the older alluvial plain is characterized by depositional and erosional terraces found in patches along the active plain. The denudational hills found prominent in trans Yamuna area formed mainly of quartzite10 and the core area of the Meja power plant is situated on the denudational hills. The district is well connected by rail and road network. The nearest airports are at Prayagraj and Lucknow. Administratively, Prayagraj town is the Head Quarter of the district.

Groundwater occurs in alluvium and in the weathered and joint sandstones in areas which are underlain by the hard rocks. Two broad hydrogeological units, namely, unconsolidated (Alluvium) and consolidated (hard rock) are the major components. The Alluvial formations occur in the Trans-Ganga and Doab region. Occurrence of consolidated formations is restricted primarily to Trans Yamuna tract. In the study area, the thickness of alluvium is more than 300 m with the discharge rates of 2000-3000 lpm.

3.0 Drainage, Topography and Land Use Mapping

3.1 General

MUNPL, MEJA project area, along with the buffer zone of 25 km radius, 1959.50 sq. Km, has been digitized in the ArcGIS framework with reference to the geographic coordinate system by their latitudes and longitudes. The MUNPL, MEJA area comprises of various plant units and flourishing plantations; while the buffer zone represents the surrounding area measuring 25 km distance either side from the edge of the MUNPL, MEJA premises.

Making use of the downloaded Shuttle Radar Topography Mission (SRTM)/ data from internet, **a** Digital Elevation Model (DEM) has been prepared. The habitat settlements area, agricultural lands, existing water bodies, etc. have also been delineated from the Copernicus Global Land Cover (CGLS-LC100 Collection 3).

3.2 Area-Drainage Network Map

The area-drainage network map has been prepared using the 90-meter Shuttle Radar Topography Mission (SRTM) data from internet and is shown in Figure 3.1.

The Northern half of the district occupies part of Ganga basin and Southern part of the district occupies the part of Yamuna and Tons Sub- basin. The rivers of the district belong to the main drainage system of the Ganga. The most important tributaries are Yamuna and Tons while those of minor systems include Sai and Yamuna. The Ganga enters the district in the Kaurihar Block. It maintains a meandering course. Yamuna, the second major river, enters the district in the extreme west in the Sankargarh block and flows narrowly before joining to the Ganga at Sangam in the proximity of Prayagraj city. Yamuna has more channel constant and steeper banks. Yamuna has a more rapid stream and flowing fast down a greater bed slope than the Ganga. Its water is comparatively cleaner than Ganga most streams water of the joining the Yamuna are mere drainage channels or ravines.

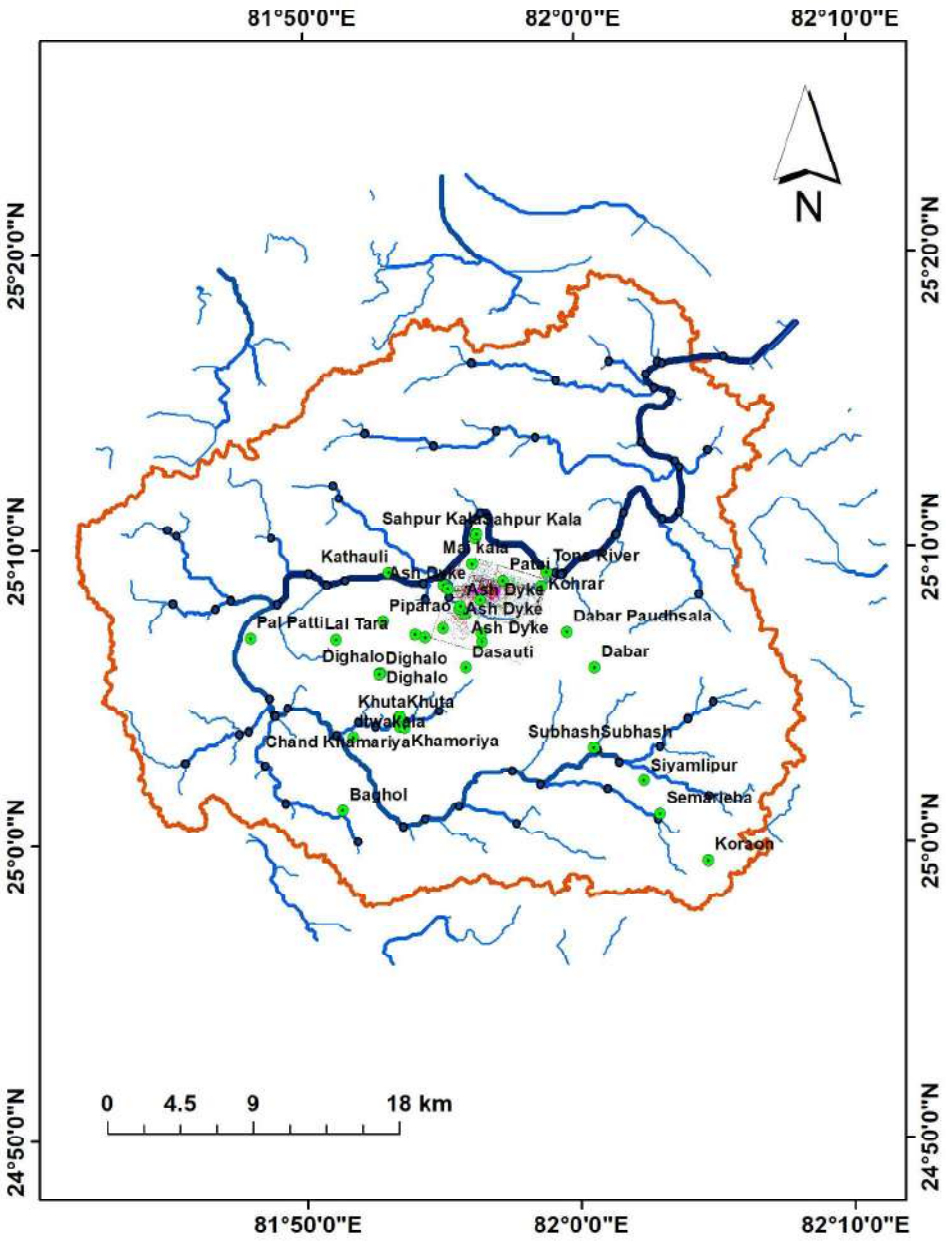


Figure 3.1. Discretized drainage map with canal and small streams in the buffer zone.

3.3 Surface Topography and Contours

Google Earth Terrain data, downloaded from internet, was used to prepare the surface topography of the MUNPL, MEJA area and the buffer zone area (Figure 3.2) and district information taken from CGWB. The study area has slope range of 0 to 30.30 degrees.

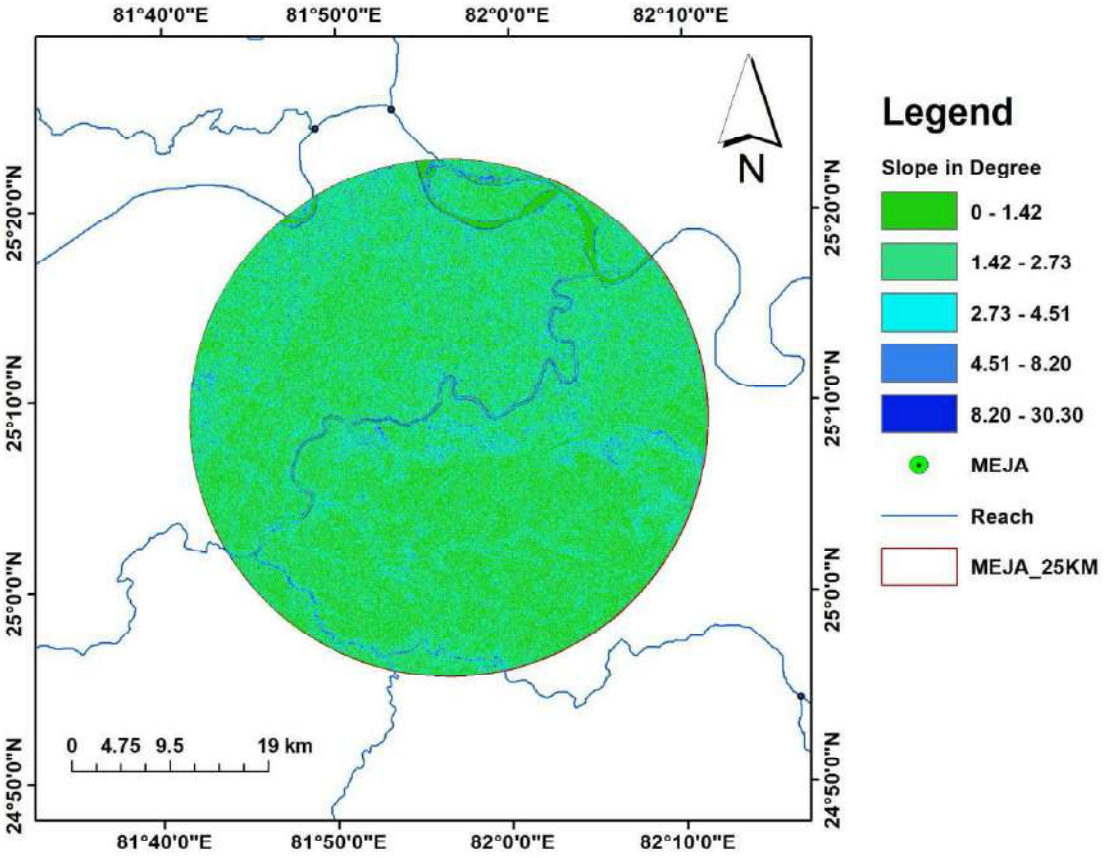


Figure 3.2. Slope map of the study area.

3.4 Land Use

A land use map is prepared for 2020 showing agricultural land, settlement, forest, shrubs, water bodies, etc. in the study area (Figure 3.3). Most of the area in the buffer zone comes under agricultural land, followed by bare/sparse vegetation. From Figure 3.3, it can be seen that there are many small and medium size recognizable water bodies present in the buffer zone (Figure 3.3).

3.4.1 Land use Break-up of the Study Area

The land use area break-up details are given in Table 3.1. It is seen that maximum area lies under the agricultural land in the buffer zone followed by the bare/sparse vegetation.

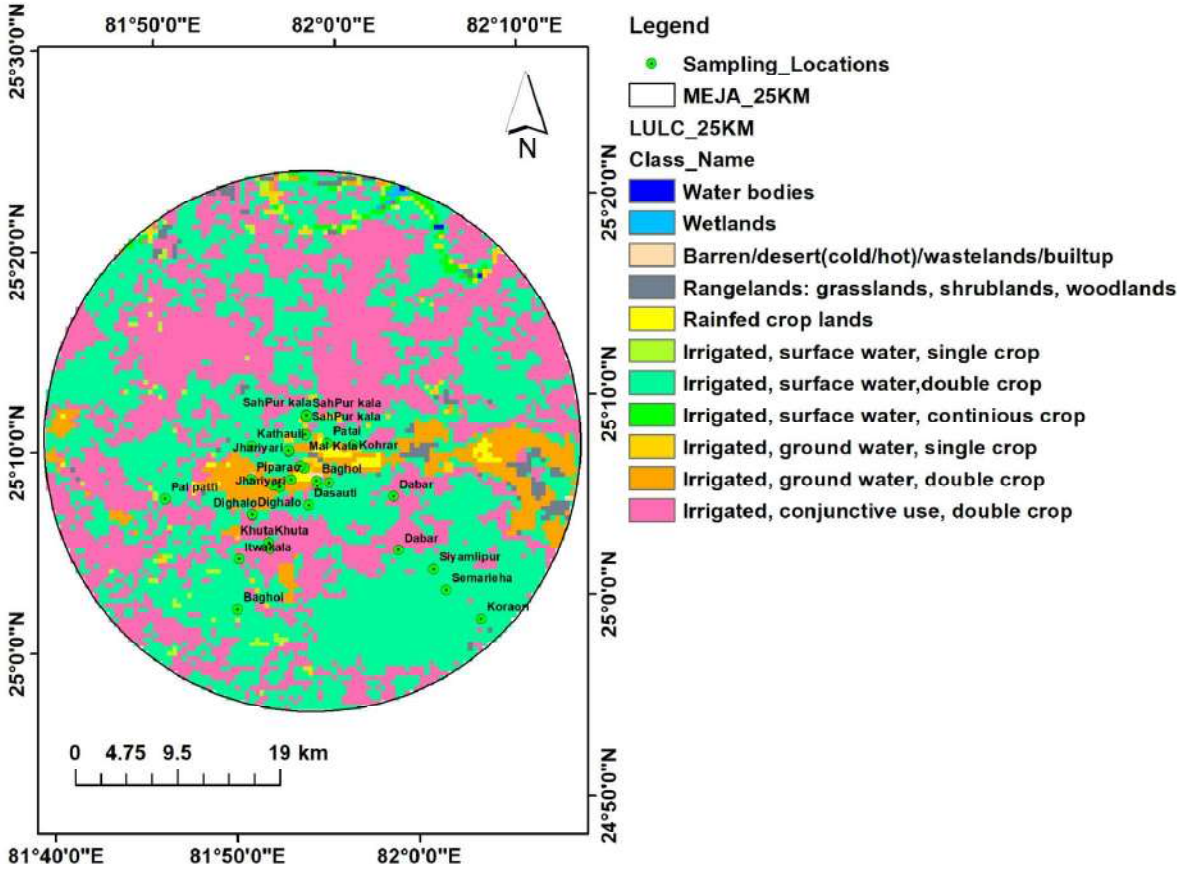


Figure 3.3. Land use map of the study area.

Table 3.1: Land use details for the study area

S. No.	Land use	Area (Ha)	Percentage
1	Water bodies	0.810	0.041
2	Wetlands	2.228	0.114
3	Barren/desert(cold/hot)/ wastelands/builtup	1.556	0.079
4	Rangelands: grasslands, shrublands, woodlands	27.671	1.412
5	Rainfed crop lands	12.063	0.616
6	Irrigated, surface water, single crop	16.695	0.852
7	Irrigated, surface water,double crop	963.421	49.167
8	Irrigated, surface water, continious crop	12.323	0.629
9	Irrigated, ground water, single crop	17.354	0.886

10	Irrigated, ground water, double crop	112.078	5.720
11	Irrigated, conjunctive use, double crop	793.304	40.485

3.5 Summary

(i) The MUNPL, MEJA project area is occupying part of Ganga basin and another part of Tons Sub- basin. The seasonal rivers as well as tributaries are ephemeral and flow only in response to heavy precipitation.

(ii) The area shows large variations in the topography, with a slope range of 0 to 30.30 degrees

(iii) A number of large and small recognizable size habitat settlements are found scattered in the buffer zone area.

(iv) Most of the area in the buffer zone comes under the agricultural land followed by the bare/sparse vegetation.

4.0 Geological Setting

4.1 Regional Geological Setting

The district represents a complex geology with the formation belonging to Quaternary (Alluvium – Sand, silt, clay and Kankar, Laterite.) period covering major part in the northern side of the district overlying the Vindhyan formations (Sand stone and shale -Kaimur sandstone and Bijaigarh Shale) in the southern plateau (CGWB, 2019). The oldest formations exposed are Bijaigarh Shale in the edge of the district around Hanumangunj in Koraon block. Further to the north the sandstone and quartzites, representing the uppermost part of the Kaimur series, are seen as isolated part of the district covering the blocks of Meja,,Manda, Koraon and Shankargarh, The Vindhyans forms the floor of the younger sediments in the Cis-Yamuna area. The Laterite normally overlies Vindhyans at certain places. It is reddish brown to chocolate in color, highly ferruginous, and perforated mass. Alluvium found in the whole of Trans-Ganga, Doab and Part of Trans – Yauna tract of Quaternary age. The alluvium detritus of Vindhyan is found at some places in the southern part of the Doab. In Trans – Yamuna tract, The Vindhyan detritus merges with the Yamuna sand and silt. The thickness of the alluvial sediments gradually increases in the north and maximum thickness is encountered within the flood plain area of river Ganga and Yamuna. Greater thickness is encountered within the Trans – Ganga area where it exceeds 300 meters followed by doab region where it is less than 250 meters and ultimately less than 50 meters in the Trans-Yamuna region. The alluvial sediments essentially composed sands of various grades, clay and silts within the unconsolidated granular mass assemblage of nodular concretions of Calcium Carbonate have been recorded at different depths (CGWB, 2019).

4.2 Surface and Sub-surface geology of MUNPL, MEJA area and Buffer zone

Surface and sub-surface geology guide us about the control of water flow on/in the surface and sub-surface geological formations. Therefore, characterization of the surface and sub-surface geology and their hydraulic properties is essentially required for appraisal of fate of surface water and groundwater. It is in those contexts, surface and sub-surface geology of the area is analysed in detail.

4.3 Surface Soil Features

A soil map for the core zone and buffer zone is prepared based on the soil data available from the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP). The scanned image was geo-10referenced in the ArcGIS software. The geo-referenced was then used to digitize various types of soil polygons falling in the study area. The classified soil map is presented in Figure 4.1. It is seen that most of the area under the buffer zone falls under loamy soils in texture

with dense sub-surface layer, followed by clayey soils where clay content increases with depth, moderately to slightly acidic in reaction.

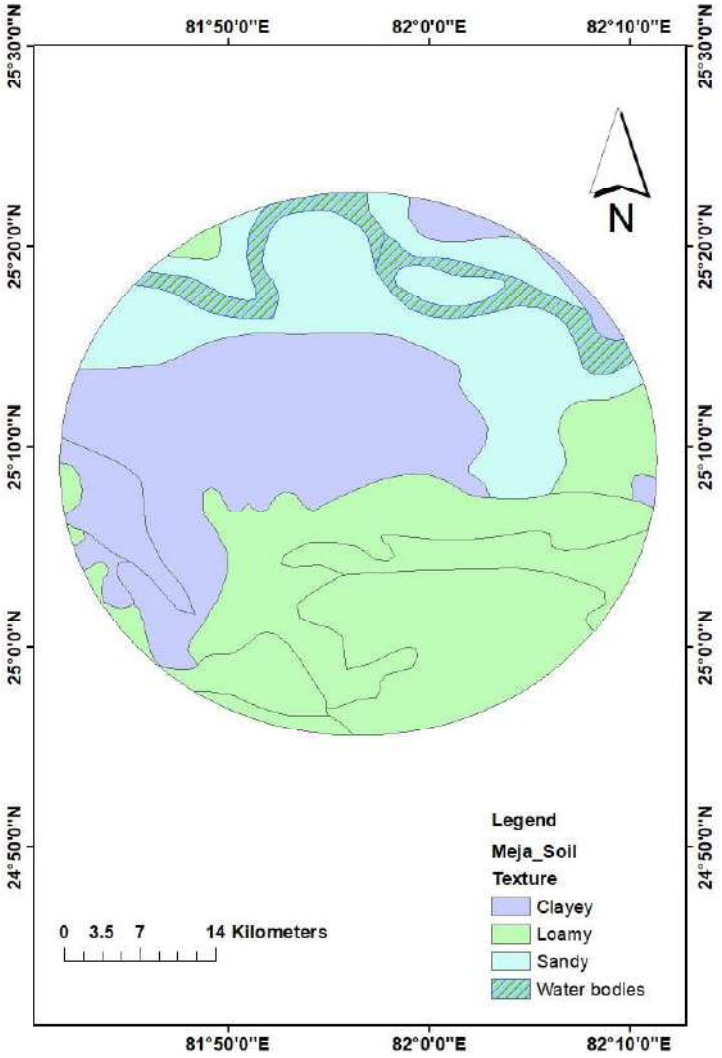


Figure 4.1. Map showing general variation of soil types in the buffer zone.

To identify the rates of infiltration in the study area, infiltration tests were carried out at ten locations, as shown in Figure 4.2. Infiltration is the process by which water on the ground surface enters the soil. The velocity or speed at which water enters into the soil is called the Infiltration rate. Infiltration is the measure of the ability with which soil is able to absorb water. Technically, the Infiltration rate is the volume flux of water flowing into the soil profile per unit of soil surface area. Infiltration is usually measured by the depth (generally in mm) of the water layer that can enter the soil in a specified time (generally one hour). Thus, an Infiltration rate of 15 mm/hour means that a water layer of 15 mm on the soil surface will take one hour to infiltrate.

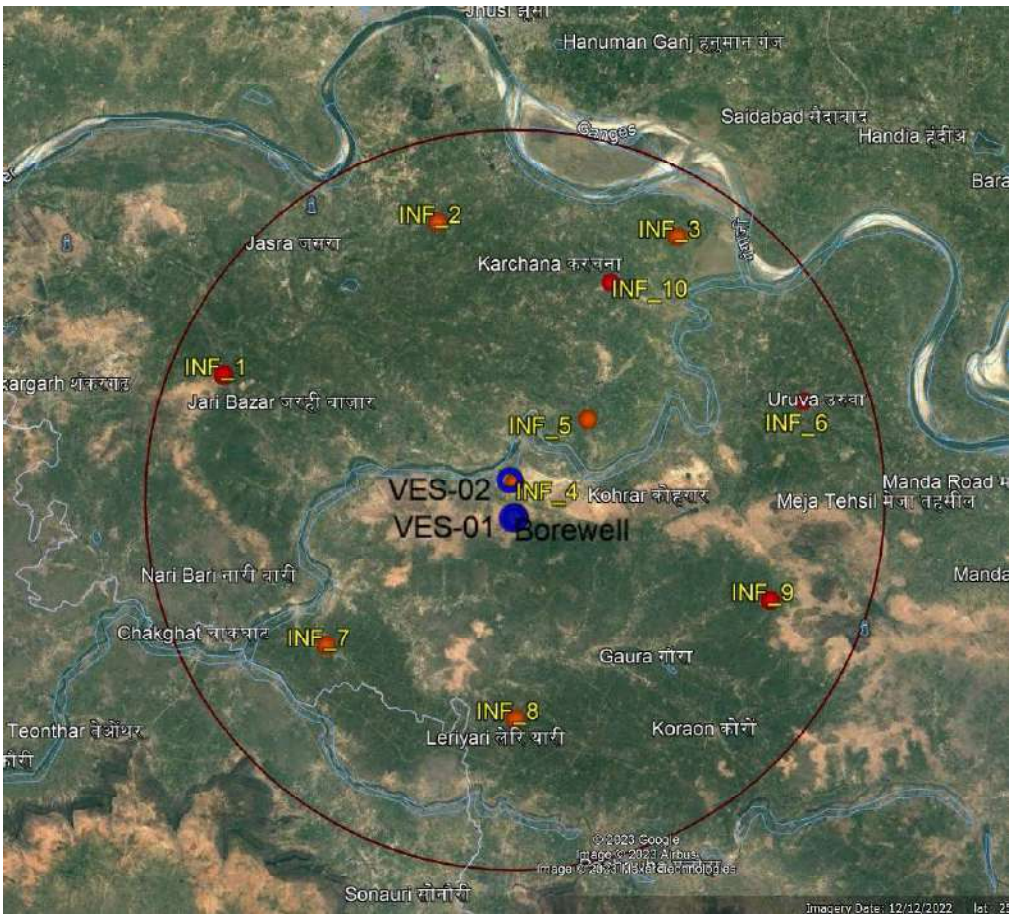


Figure 4.2. Map showing infiltration test sites in the study area buffer zone of 25km radius from the NTPC Meja

In dry soil, water infiltrates rapidly. This is called the initial Infiltration rate. As more water replaces the air in the pores, the water from the soil surface infiltrates more slowly and eventually reaches a steady rate. The Infiltration rate decreases to a steady or quasi-steady state as the soil becomes saturated. Therefore, the Infiltration rate curve shows a sharp decline with time. The constant rate approached after a sufficiently large time is referred to as the steady-Infiltration rate. Some water that infiltrates will remain in the shallow soil layer, where it will gradually move vertically and horizontally through the soil and subsurface material. Some of the water may infiltrate deeper, recharging groundwater aquifers.

Infiltration rate is an important component of the hydrologic cycle. It helps to determine how rainfall is divided between recharging the groundwater and running off over the surface as sheet wash and in streams. Infiltration process is responsible for modifying precipitation and converting it to runoff and additions to soil moisture storage. The infiltration and other processes are interrelated through a common dependence on soil moisture conditions. In general, the lower the Infiltration rate, the greater the surface runoff, and thus the greater the potential for soil erosion. A high Infiltration rate lets most of the rain water soak into the soil and make its way downward to the aquifer.

Soils with low infiltration can be responsible for runoff and flooding and can become saturated during rain events. It, in turn, decreases soil strength and increases erosion potential. It can also cause nutrient deficiencies in plants and generate anaerobic conditions. Soils that have reduced infiltration have an increase in the overall amount of runoff water. This excess water can contribute to local and regional flooding of streams and rivers or result in accelerated soil erosion of fields or stream banks.

A typical variation of infiltration capacity for different soils for different initial conditions is shown in Figure 4.3, It is clear from the figure that the infiltration capacity for a given soil decreases with time from the start of rainfall; it decreases with the degree of saturation and depends upon the type of soil. As discussed earlier, the infiltration capacity values of soils are subjected to wide variation depending upon a large number of factors.

There are a number of available methods which can be used to measure the Infiltration rate in the field. Single Ring and Double Ring Infiltrometer, Mariotte-Double ring Infiltrometer, Disc Permeameter, Rainfall Simulator, Runoff-on-Ponding, Runoff-on-out and Percolation test are the common methods used for Infiltration rate determinations. The Percolation test is the most popular and convenient method for Infiltration rate determination because of its simple experimental setup and straightforward mathematical calculation.

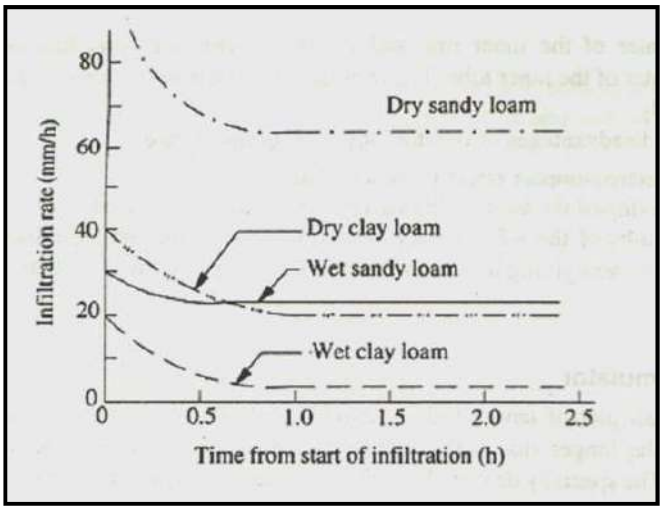


Figure 4.3: Variation of Infiltration capacity (Source: Subramanya, 2013)

(Subramanya K, Engineering Hydrology, Copyright © by McGraw Hill Education (India) Private Limited, Fourth Edition, pp 98-121, 2013)

Figure 4.4: Field set up of double ring infiltrometer

In the present investigation, the double ring infiltrometer method has been used for the measurement of infiltration rates. The Double Ring Infiltrometer consists of two rings; an inner and outer ring. The purpose in having two rings is to create a one-dimensional flow of water from the inner ring, as the analysis of data is simplified. If water is flowing in one dimension at steady-state condition, and a unit gradient is present in the underlying soil, and the infiltration rate is approximately equal to the saturated hydraulic conductivity. The inner ring is driven into the ground, and there is a second bigger ring around that to help control the flow of water through the first ring. The rings are driven to about 12 cm deep in the soil by using a heavyweight hammer striking on a wooden plank placed on the top of the ring uniformly, without undue disturbance to soil surface. Water is poured into the rings at regular time intervals either with a constant or falling head condition, and the operator records how much water infiltrates from the inner ring into the soil over a given time period. The observations of infiltration rate are carried out in the inner ring with field type point gauge and stopwatch. Figure 4.4 shows the field setup of the double-ring infiltrometer. The results from the double ring infiltrometer (constant head) test sites are shown in Table 4.2a to 4.2h and Figure 4.6a to 4.6h.

Figure 4.5: The field setup of the double-ring infiltration inside the NTPC Meja Plant and 25 Km radius buffer zone.

The result obtained from the infiltration test indicates very low final infiltration rates varying from 0.3 (Lediyari village) to 7.0 (Basahih) mm/hr of the soil near the plant premises. This indicates that the surface and sub-surface rate of infiltration is low, due to which there are chances of low recharge or high surface runoff.

Table 4.1a: Infiltration test analysis at location-01

Client:		NTPC Meja			**Date**	December-2021	
Location:		Puraniya			Landmark:		
Latitude:		25.266520N			**Longitude:**	81.991197E	
Time (min)	**Time (Sec)**	**Cumulative Time (min)**	**Vol (cm^3)**	**Depth (cm)**	**Cumulative (mm)**	**Infil. Rate cm/sec**	**Infil. Rate mm/hr**
0.5	30	0.5	180	0.011	0.1	0.0004	13.3
0.5	30	1	130	0.008	0.2	0.0003	9.6
1	60	2	180	0.011	0.3	0.0002	6.7
1	60	3	150	0.009	0.4	0.0002	5.6
1	60	4	110	0.007	0.5	0.0001	4.1
2	120	6	80	0.005	0.5	0.0000	1.5
2	120	8	130	0.008	0.6	0.0001	2.4
2	120	10	160	0.010	0.7	0.0001	3.0
2	120	12	190	0.012	0.8	0.0001	3.5
2	120	14	170	0.010	0.9	0.0001	3.1
2	120	16	140	0.009	1.0	0.0001	2.6
2	120	18	140	0.009	1.1	0.0001	2.6

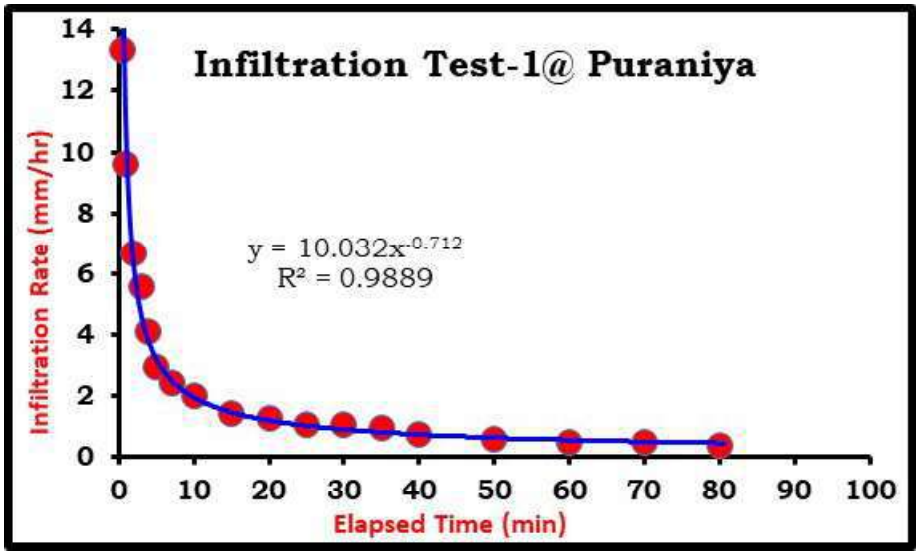


Figure 4.6a: Infiltration rate vs elapsed time graph for location 01

Table 4.1b: Infiltration test analysis at location-02

Client:		NTPC Meja			**Date**	08-09-2023	
Location:		Jhari Bazar			Landmark: Near Hanuman Mandir		
Latitude:		25.200896N			**Longitude:**	81.734189E	
Time (min)	**Time (Sec)**	**Cumulative Time (min)**	**Vol (cm^3)**	**Depth (cm)**	**Cumulative (mm)**	**Infil. Rate cm/sec**	**Infil. Rate mm/hr**
0.5	30	0.5	180	0.011	0.1	0.00	13.3
0.5	30	1	130	0.008	0.2	0.00	9.6
1	60	2	180	0.011	0.3	0.00	6.7
1	60	3	150	0.009	0.4	0.00	5.6
1	60	4	110	0.007	0.5	0.00	4.1
1	60	5	80	0.005	0.5	0.00	3.0
2	120	7	130	0.008	0.6	0.00	2.4
3	180	10	160	0.010	0.7	0.00	2.0
5	300	15	190	0.012	0.8	0.00	1.4
5	300	20	170	0.010	0.9	0.00	1.3
5	300	25	140	0.009	1.0	0.00	1.0
5	300	30	140	0.009	1.1	0.00	1.0
5	300	35	130	0.008	1.2	0.00	1.0
5	300	40	100	0.006	1.2	0.00	0.7
10	600	50	160	0.010	1.3	0.00	0.6
10	600	60	130	0.008	1.4	0.00	0.5
10	600	70	120	0.007	1.5	0.00	0.4
10	600	80	100	0.006	1.5	0.00	0.4

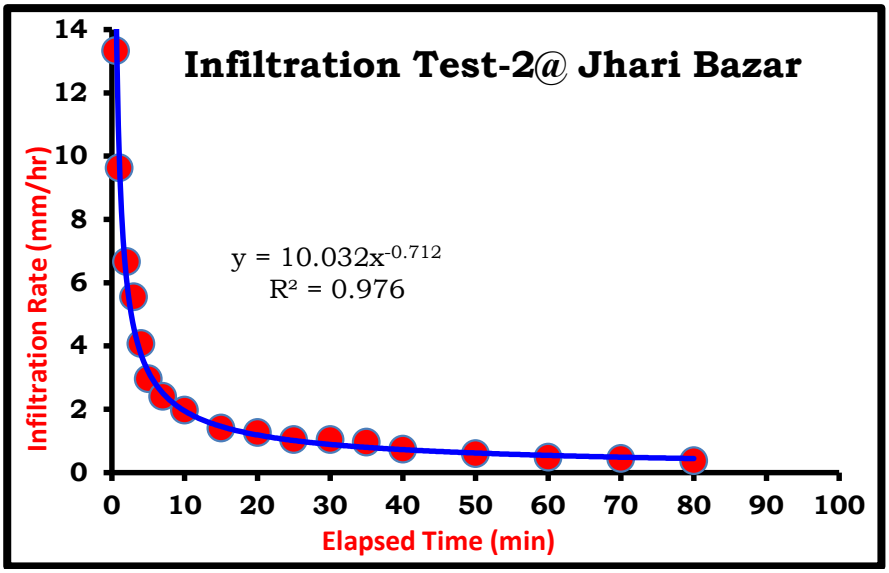


Figure 4.6b: Infiltration rate vs elapsed time graph for location 02

Table 4.1c: Infiltration test analysis at location 03

Client:		NTPC Meja			**Date**	04-09-2023	
Location:		Chinbana			Landmark: Opps. Shiv Mandir		
Latitude:		25.295730N			**Longitude:**	82.034743E	
Time (min)	**Time (Sec)**	**Cumulative Time (min)**	**Vol (cm^3)**	**Depth (cm)**	**Cumulative (mm)**	**Infil. Rate cm/sec**	**Infil. Rate mm/hr**
0.5	30	0.5	160	0.010	0.1	0.00	11.9
0.5	30	1	90	0.006	0.2	0.00	6.7
1	60	2	110	0.007	0.2	0.00	4.1
1	60	3	70	0.004	0.3	0.00	2.6
1	60	4	60	0.004	0.3	0.00	2.2
3	180	7	140	0.009	0.4	0.00	1.7
3	180	10	110	0.007	0.5	0.00	1.4
5	300	15	120	0.007	0.5	0.00	0.9
5	300	20	100	0.006	0.6	0.00	0.7
5	300	25	90	0.006	0.6	0.00	0.7
5	300	30	80	0.005	0.7	0.00	0.6
5	300	35	80	0.005	0.7	0.00	0.6
5	300	40	90	0.006	0.8	0.00	0.7
10	600	50	160	0.010	0.9	0.00	0.6
10	600	60	130	0.008	1.0	0.00	0.5
10	600	70	110	0.007	1.0	0.00	0.4
10	600	80	100	0.006	1.1	0.00	0.4
10	600	90	100	0.006	1.2	0.00	0.4

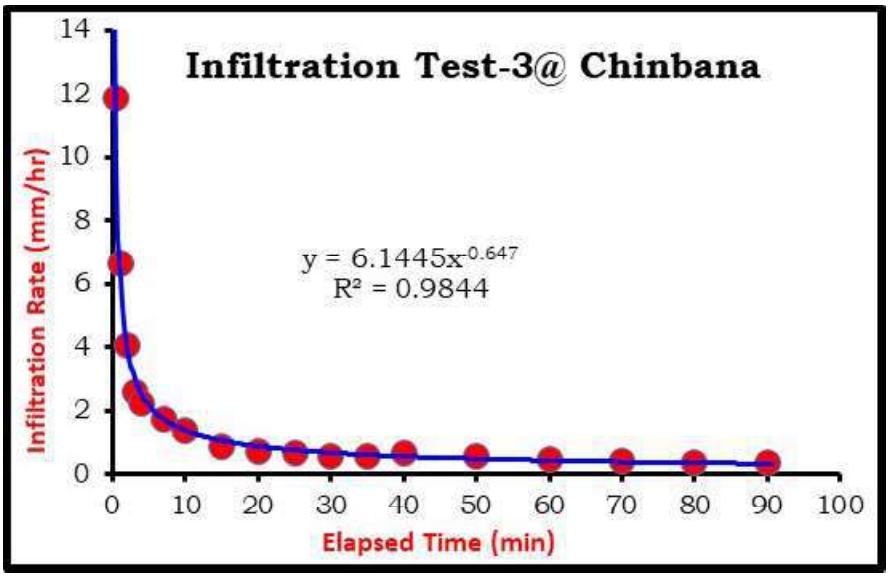


Figure 4.6c: Infiltration rate vs elapsed time graph for location 03

Table 4.1d: Infiltration test analysis at location 04

Client:		NTPC Meja			**Date**	04-09-2023	
Location:		Basahi			Landmark: Water Supply Tank		
Latitude:		25.295730N			**Longitude:**	82.034743E	
Time (min)	**Time (Sec)**	**Cumulative Time (min)**	**Vol (cm^3)**	**Depth (cm)**	**Cumulative (mm)**	**Infil. Rate cm/sec**	**Infil. Rate mm/hr**
0.5	30	0.5	750	0.046	0.5	0.00	55.6
0.5	30	1	420	0.026	0.7	0.00	31.1
1	60	2	580	0.036	1.1	0.00	21.5
1	60	3	540	0.033	1.4	0.00	20.0
1	60	4	430	0.027	1.7	0.00	15.9
1	60	5	380	0.023	1.9	0.00	14.1
2	120	7	670	0.041	2.3	0.00	12.4
2	120	9	710	0.044	2.8	0.00	13.1
3	180	12	930	0.057	3.3	0.00	11.5
3	180	15	780	0.048	3.8	0.00	9.6
5	300	20	1290	0.080	4.6	0.00	9.6
5	300	25	1230	0.076	5.4	0.00	9.1
5	300	30	1210	0.075	6.1	0.00	9.0
5	300	35	1110	0.069	6.8	0.00	8.2
5	300	40	1050	0.065	7.5	0.00	7.8
5	300	45	1080	0.067	8.1	0.00	8.0
5	300	50	1090	0.067	8.8	0.00	8.1
5	300	55	1060	0.065	9.5	0.00	7.9
5	300	60	1030	0.064	10.1	0.00	7.6
5	300	65	990	0.061	10.7	0.00	7.3
5	300	70	1000	0.062	11.3	0.00	7.4
5	300	75	1010	0.062	11.9	0.00	7.5
5	300	80	990	0.061	12.5	0.00	7.3
5	300	85	950	0.059	13.1	0.00	7.0
5	300	90	950	0.059	13.7	0.00	7.0

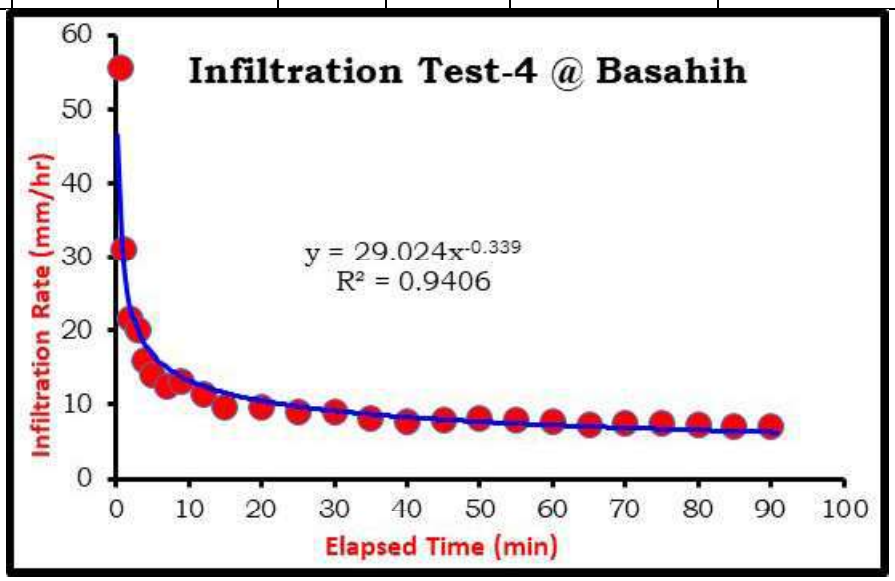


Figure 4.6d: Infiltration rate vs elapsed time graph for location 04

Table 4.1e: Infiltration test analysis at location 05

Client:		NTPC Meja			**Date**	04-09-2023	
Location:		NTPC Township			Landmark: Market DTDC Courier		
Latitute:		25.142788N			**Longitude:**	81.932318E	
Time (min)	**Time (Sec)**	**Cumulative Time (min)**	**Vol (cm^3)**	**Depth (cm)**	**Cumulative (mm)**	**Infil. Rate cm/sec**	**Infil. Rate mm/hr**
0.5	30	0.5	240	0.015	0.1	0.0005	17.8
0.5	30	1	200	0.012	0.3	0.0004	14.8
1	60	2	210	0.013	0.4	0.0002	7.8
1	60	3	190	0.012	0.5	0.0002	7.0
1	60	4	160	0.010	0.6	0.0002	5.9
2	120	6	290	0.018	0.8	0.0001	5.4
2	120	8	310	0.019	1.0	0.0002	5.7
2	120	10	250	0.015	1.1	0.0001	4.6
2	120	12	220	0.014	1.3	0.0001	4.1
3	180	15	270	0.017	1.4	0.0001	3.3
3	180	18	310	0.019	1.6	0.0001	3.8
3	180	21	250	0.015	1.8	0.0001	3.1
3	180	24	260	0.016	2.0	0.0001	3.2
3	180	27	230	0.014	2.1	0.0001	2.8
3	180	30	180	0.011	2.2	0.0001	2.2
5	300	35	350	0.022	2.4	0.0001	2.6
5	300	40	330	0.020	2.6	0.0001	2.4
5	300	45	290	0.018	2.8	0.0001	2.1
5	300	50	270	0.017	3.0	0.0001	2.0
5	300	55	270	0.017	3.1	0.0001	2.0
5	300	60	260	0.016	3.3	0.0001	1.9
5	300	65	250	0.015	3.5	0.0001	1.9
5	300	70	250	0.015	3.6	0.0001	1.9

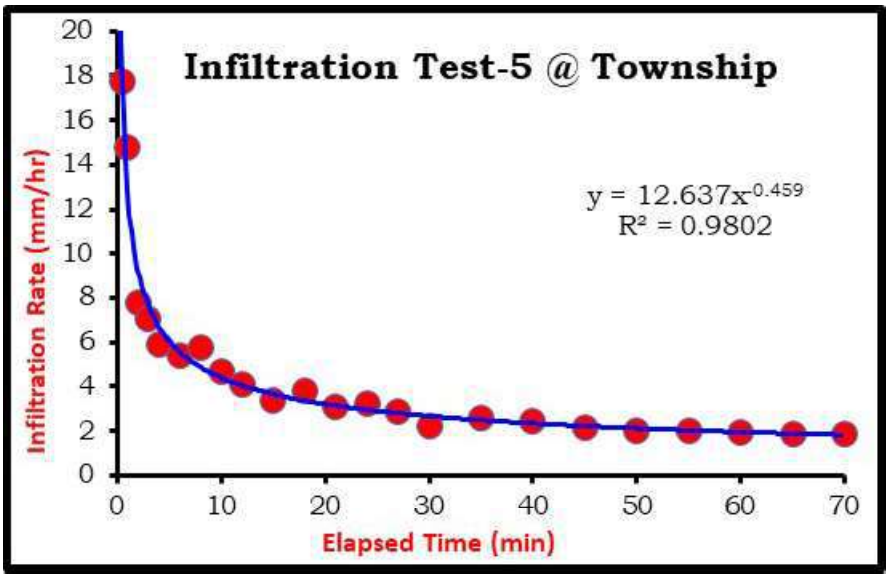


Figure 4.6e: Infiltration rate vs elapsed time graph for location 05

Table 4.1f: Infiltration test analysis at location 06

Client:		NTPC Meja			**Date**	04-09-2023	
Location:		Dharwara			Landmark: Upper Primary School		
Latitude:		25.182847N			**Longitude:**	81.979608E	
Time (min)	**Time (Sec)**	**Cumulative Time (min)**	**Vol (cm^3)**	**Depth (cm)**	**Cumulative (mm)**	**Infil. Rate cm/sec**	**Infil. Rate mm/hr**
0.5	30	0.5	710	0.044	0.4	0.00	52.6
0.5	30	1	530	0.033	0.8	0.00	39.3
1	60	2	550	0.034	1.1	0.00	20.4
1	60	3	510	0.031	1.4	0.00	18.9
1	60	4	440	0.027	1.7	0.00	16.3
1	60	5	350	0.022	1.9	0.00	13.0
1	60	6	230	0.014	2.0	0.00	8.5
2	120	8	190	0.012	2.2	0.00	3.5
2	120	10	150	0.009	2.3	0.00	2.8
5	300	15	260	0.016	2.4	0.00	1.9
5	300	20	180	0.011	2.5	0.00	1.3
10	600	30	240	0.015	2.7	0.00	0.9
10	600	40	210	0.013	2.8	0.00	0.8
10	600	50	200	0.012	2.9	0.00	0.7
10	600	60	190	0.012	3.0	0.00	0.7
10	600	70	190	0.012	3.2	0.00	0.7

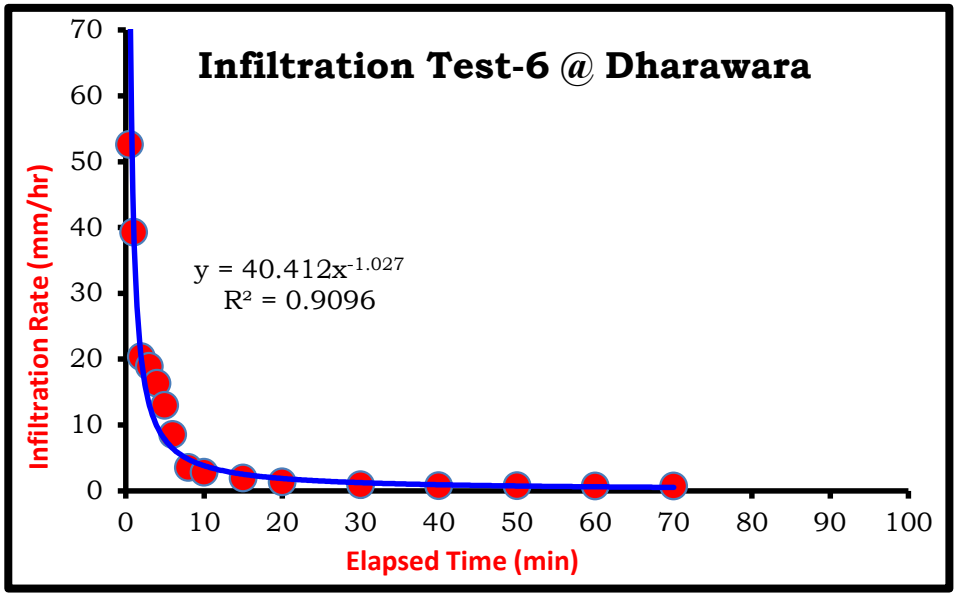


Figure 4.6f: Infiltration rate vs elapsed time graph for location 06

Table 4.1g: Infiltration test analysis at location 07

Client:		NTPC Meja			**Date**	03-09-2023	
Location:		Uruva village			Landmark: Near Bus Stand		
Latitude:		25.199252N			**Longitude:**	82.123701E	
Time (min)	**Time (Sec)**	**Cumulative Time (min)**	**Vol (cm^3)**	**Depth(cm)**	**Cumulative (mm)**	**Infil. Rate cm/sec**	**Infil. Rate mm/hr**
1	60	1	390	0.024	0.2	0.0004	14.4
1	60	2	300	0.019	0.4	0.0003	11.1
1	60	3	260	0.016	0.6	0.0003	9.6
1	60	4	300	0.019	0.8	0.0003	11.1
2	120	6	350	0.022	1.0	0.0002	6.5
2	120	8	340	0.021	1.2	0.0002	6.3
2	120	10	330	0.020	1.4	0.0002	6.1
5	300	15	660	0.041	1.8	0.0001	4.9
5	300	20	550	0.034	2.1	0.0001	4.1
5	300	25	530	0.033	2.5	0.0001	3.9
5	300	30	500	0.031	2.8	0.0001	3.7
5	300	35	460	0.028	3.1	0.0001	3.4
5	300	40	420	0.026	3.3	0.0001	3.1
5	300	45	380	0.023	3.6	0.0001	2.8
5	300	50	370	0.023	3.8	0.0001	2.7
5	300	55	360	0.022	4.0	0.0001	2.7
5	300	60	360	0.022	4.2	0.0001	2.7
10	600	70	700	0.043	4.7	0.0001	2.6
10	600	80	690	0.043	5.1	0.0001	2.6
10	600	90	690	0.043	5.5	0.0001	2.6

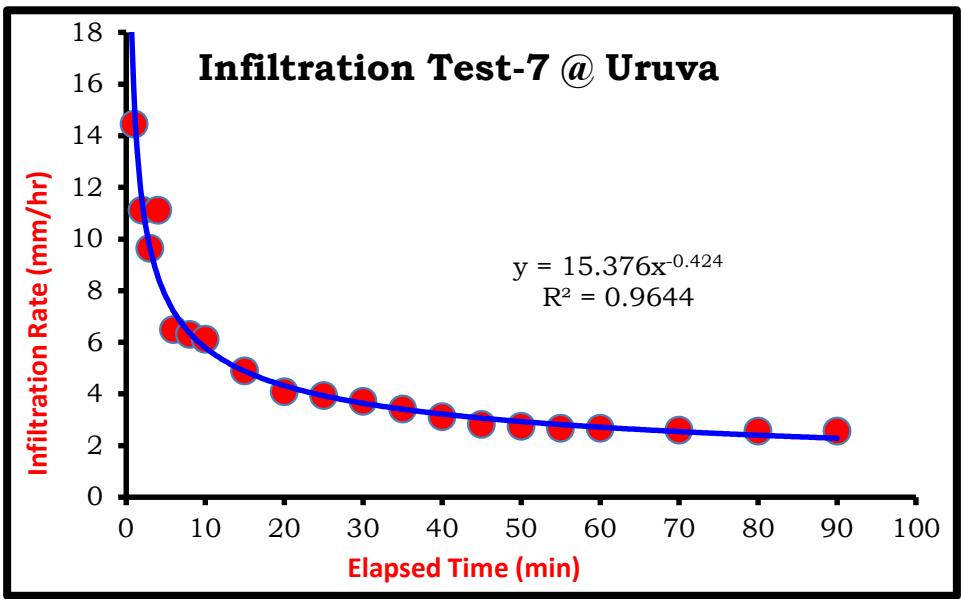


Figure 4.6g: Infiltration rate vs elapsed time graph for location 07

Table 4.1h: Infiltration test analysis at location 08

Client:		NTPC Meja			**Date**	03-09-2023	
Location:		Kheri Village			Landmark: Upper Primary School		
Latitude:		25.038937N			**Longitude:**	81.810725 E	
Time (min)	**Time (Sec)**	**Cumulative Time (min)**	**Vol (cm^3)**	**Depth (cm)**	**Cumulative (mm)**	**Infil. Rate cm/sec**	**Infil. Rate mm/hr**
0.5	30	0.5	360	0.022	0.2	0.000741	26.7
0.5	30	1	270	0.017	0.4	0.000556	20.0
1	60	2	200	0.012	0.5	0.000206	7.4
1	60	3	160	0.010	0.6	0.000165	5.9
1	60	4	120	0.007	0.7	0.000123	4.4
2	120	6	110	0.007	0.8	0.000057	2.0
2	120	8	100	0.006	0.8	0.000051	1.9
2	120	10	110	0.007	0.9	0.000057	2.0
5	300	15	200	0.012	1.0	0.000041	1.5
5	300	20	160	0.010	1.1	0.000033	1.2
5	300	25	130	0.008	1.2	0.000027	1.0
5	300	30	110	0.007	1.3	0.000023	0.8
10	600	40	190	0.012	1.4	0.000020	0.7
10	600	50	140	0.009	1.5	0.000014	0.5
10	600	60	120	0.007	1.5	0.000012	0.4
10	600	70	120	0.007	1.6	0.000012	0.4
10	600	80	110	0.007	1.7	0.000011	0.4

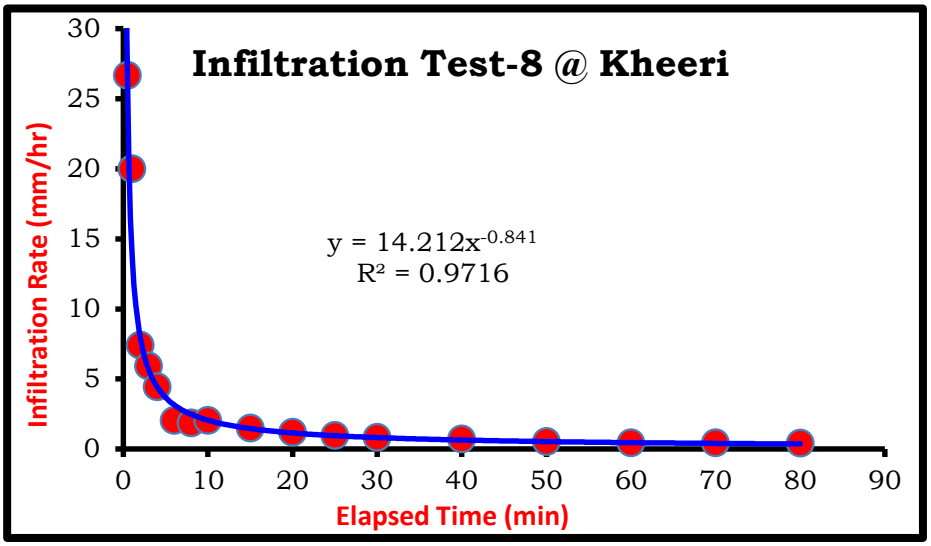


Figure 4.6h: Infiltration rate vs elapsed time graph for location 08

Table 4.1i: Infiltration test analysis at location 09

Client:		NTPC Meja			**Date**	03-09-2023	
Location:		Leriyari village			Landmark: Opposite Inter college		
Latitude:		24.999414N			**Longitude:**	81.939330E	
Time (min)	**Time (Sec)**	**Cumulative Time (min)**	**Vol (cm^3)**	**Depth (cm)**	**Cumulative (mm)**	**Infil. Rate cm/sec**	**Infil. Rate mm/hr**
1	60	1	910	0.056	0.6	0.000936	33.7
1	60	2	800	0.049	1.1	0.000823	29.6
1	60	3	600	0.037	1.4	0.000617	22.2
1	60	4	440	0.027	1.7	0.000453	16.3
1	60	5	310	0.019	1.9	0.000319	11.5
1	60	6	200	0.012	2.0	0.000206	7.4
2	120	8	360	0.022	2.2	0.000185	6.7
2	120	10	290	0.018	2.4	0.000149	5.4
5	300	15	440	0.027	2.7	0.000091	3.3
5	300	20	310	0.019	2.9	0.000064	2.3
5	300	25	230	0.014	3.0	0.000047	1.7
5	300	30	160	0.010	3.1	0.000033	1.2
10	600	40	130	0.008	3.2	0.000013	0.5
10	600	50	110	0.007	3.3	0.000011	0.4
10	600	60	90	0.006	3.3	0.000009	0.3
10	600	70	80	0.005	3.4	0.000008	0.3
10	600	80	90	0.006	3.4	0.000009	0.3

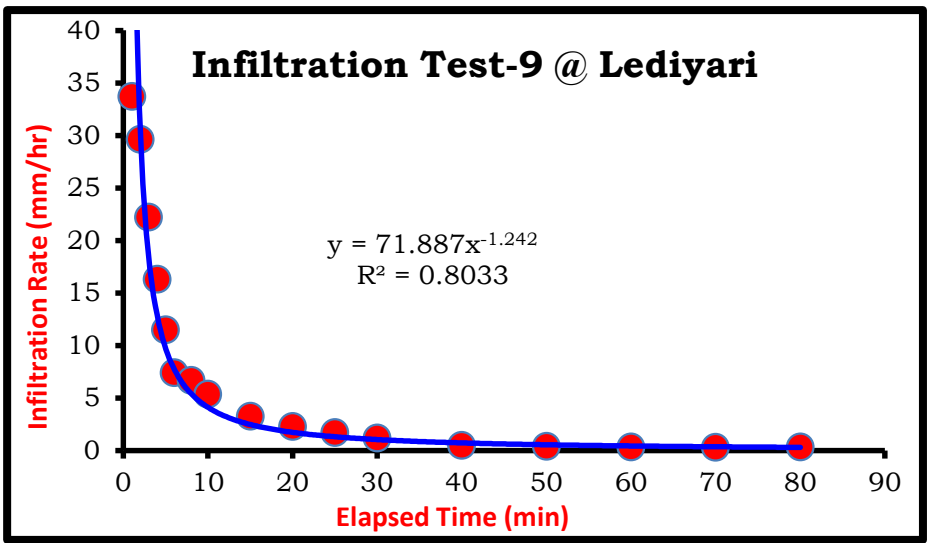


Figure 4.6i: Infiltration rate vs elapsed time graph for location 09

Table 4.1j: Infiltration test analysis at location 10

Client:		NTPC Meja			**Date**	03-09-2023	
Location:		Pasana village			Landmark: Kisan smaridhi Kendra		
Latitude:		25.077290N			**Longitude:**	82.106697E	
Time (min)	**Time (Sec)**	**Cumulative Time (min)**	**Vol (cm^3)**	**Depth (cm)**	**Cumulative (mm)**	**Infil. Rate cm/sec**	**Infil. Rate mm/hr**
1	60	1	450	0.028	0.3	0.000463	16.67
1	60	2	310	0.019	0.5	0.000319	11.48
1	60	3	170	0.010	0.6	0.000175	6.30
1	60	4	110	0.007	0.6	0.000113	4.07
1	60	5	90	0.006	0.7	0.000093	3.33
2	120	7	160	0.010	0.8	0.000082	2.96
3	180	10	200	0.012	0.9	0.000069	2.47
5	300	15	140	0.009	1.0	0.000029	1.04
5	300	20	100	0.006	1.1	0.000021	0.74
5	300	25	80	0.005	1.1	0.000016	0.59
5	300	30	60	0.004	1.2	0.000012	0.44
5	300	35	70	0.004	1.2	0.000014	0.52
5	300	40	60	0.004	1.2	0.000012	0.44
10	600	50	110	0.007	1.3	0.000011	0.41
10	600	60	100	0.006	1.4	0.000010	0.37
10	600	70	100	0.006	1.4	0.000010	0.37

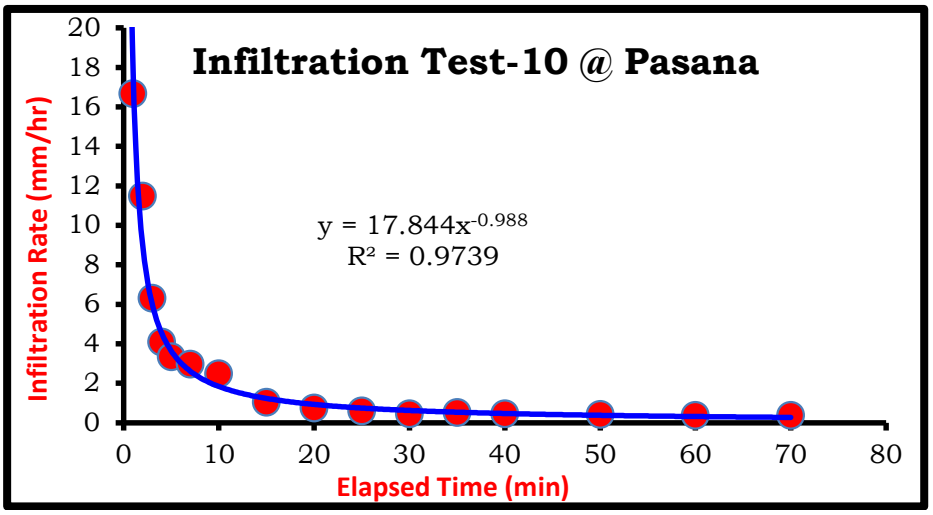


Figure 4.6j: Infiltration rate vs elapsed time graph for location-10

Table 4.1k: Location of the infiltration tests conducted near NTPC, MEJA along with the initial and final soil infiltration rate:

S. No.	Grid No.	Location	Latitude (N)	Longitude (E)	Initial Infiltration rate (mm/hr)	Steady Infiltration rate (mm/hr)
1	Infiltration-01	Purania	25.266520	81.991197	13.3	2.6
2	Infiltration-02	Jhari Bazar	25.200896	81.734189	13.3	0.4
3	Infiltration-03	Chinbana	25.295730	82.034743	11.9	0.4
4	Infiltration-04	Basahih	25.29573	82.034743	55.6	7.0
5	Infiltration-05	NTPC Township	25.142788	81.932318	17.8	1.9
6	Infiltration-06	Dharawara	25.182847	81.979608	52.6	0.7
7	Infiltration-07	Uruva village	25.199252	82.123701	14.4	2.6
8	Infiltration-08	Kheeri Village	25.038937	81.810725	26.7	0.4
9	Infiltration-09	Lediyari village	24.999414	81.93933	33.7	0.3
10	Infiltration-10	Pasana village	25.07729	82.106697	16.7	0.4

4.4 Sub-surface Geology

Geologically, the rock formations exposed in the study area belong to Dhandraul Formation of Kaimur group of Vindhyan Super group comprising medium to coarse grained, white to greyish and white sandstone in the study area. The rock exhibits sedimentary structure like ripple marks and cross bedding. The rocks were moderately jointed. The deposition of horizontal and vertical joints has given the blocky nature to the rock (Fig. 4.7). Also, the area exposes quaternary sediments represented by Banda Alluvium (Older Alluvium). The area is covered with thick overburden comprising yellowish brown variegated silty clay with ubiquitous kankar and coarse to fine sand and reddish-brown silt. Porous alluvial formation occurring in the alluvium plain area, forms the most prolific aquifer system, whereas the sedimentary semi-consolidated formations and hard rocks, form aquifer of low yield prospect in the denudational hilly region.

Two broad hydrogeological units, namely, unconsolidated (Alluvium) and consolidated (hard rock) are the major components in the district. Groundwater occurs in alluvium and in the weathered and joint sandstones in areas which are underlain by the hard rocks such as in Salaiya Khurd, Salaiya Kalan and Jhadiyahi denudational hilly region. The drill hole data revealed that the thickness of overburden varies from 0.5 to 34.25 m,bgl in the study area. However, near VES-01 village Salaiya Khurd around 1.65 m,bgl overburden was observed.

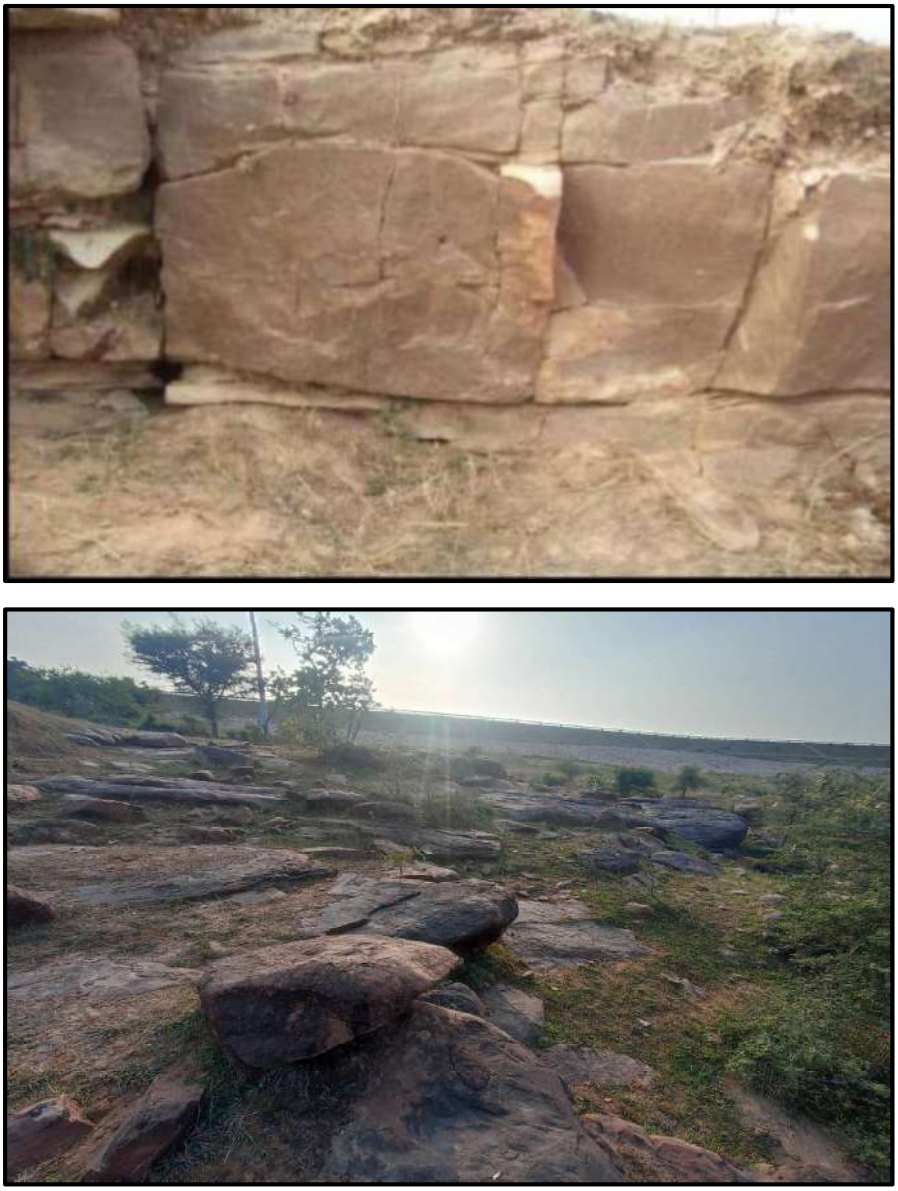


Figure 4.7: Blocky nature of rock due to deposition of horizontal and vertical joint sets near Ash dyke of NTPC Meja

In the study area wells and tube wells are the main ground water abstraction structures. Ground water is being developed in the area by medium to deep tube wells, dug wells, dug-cum bored wells. Based on 3 exploratory wells data in the area CGWB observed yield at Pipraon village was about 770 lpm (good to excellent on groundwater prospective) whereas yield of 107 lpm encountered at Saliya Khurd village belongs to very poor prospective area. Depth to water level ranges from 2.4 to 8.6 mbgl, during the survey period (September 2023).

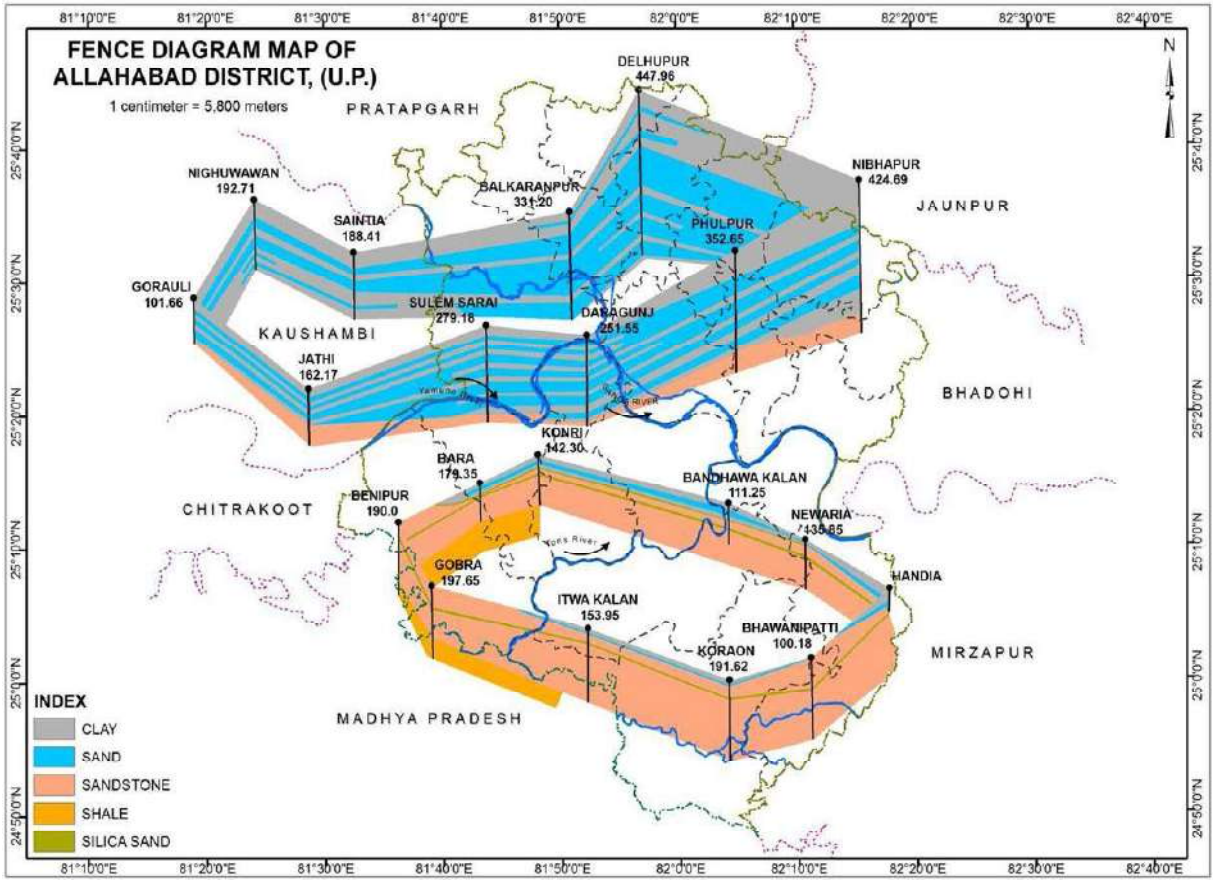


Figure 4.8. 3D lithological model showing hydro-geological condition in the Prayagraj (Allahabad) district (CGWB)

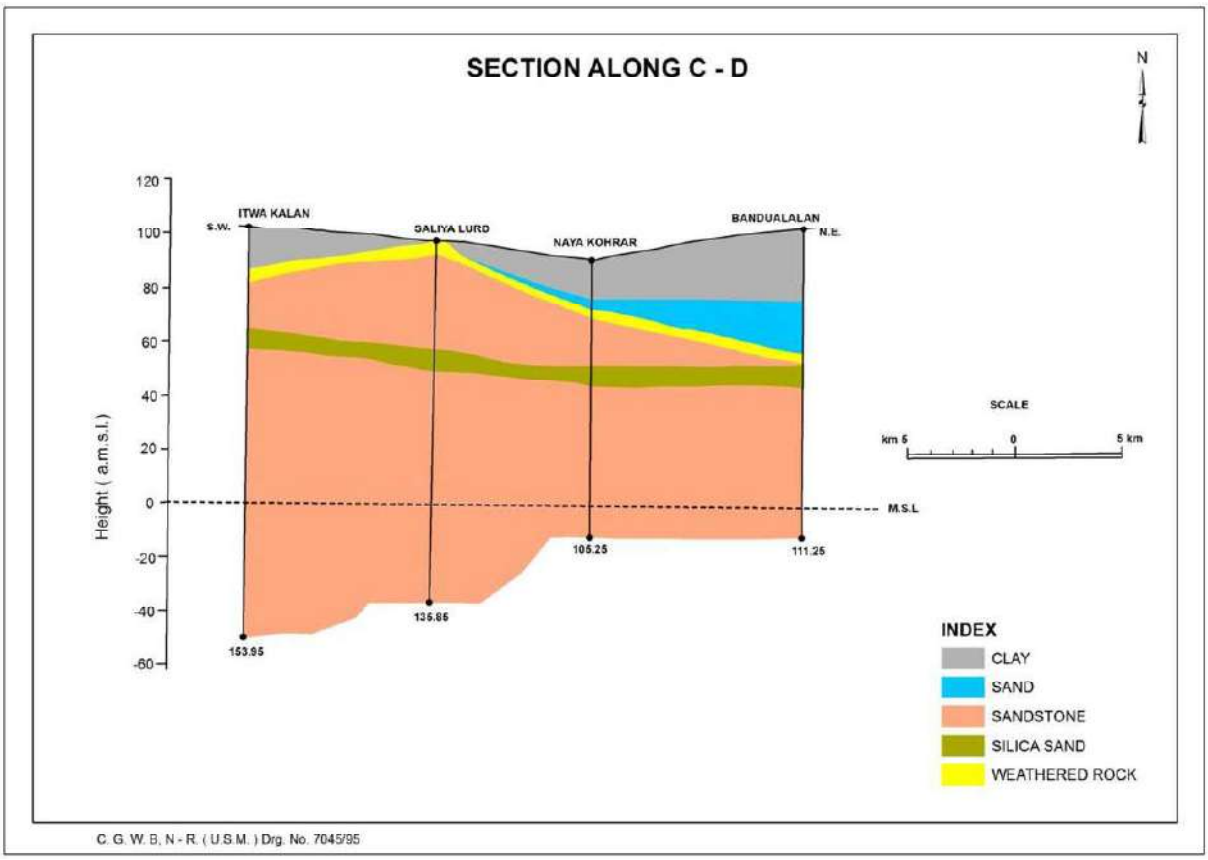


Figure 4.9. Map showing sectional view of hydro-geological variation along section C-D′. (CGWB)

4.5 Summary

(i) Geology of the district exposes rocks belonging to the Dhandraul Formation of Kaimur group of Vindhyan Super group.

(ii) The rock exhibits sedimentary structure like ripple marks and cross bedding. The rocks were moderately jointed. The deposition of horizontal and vertical joints has given the blocky nature to the rock. Also, the area exposes quaternary sediments represented by Banda Alluvium (Older Alluvium).

(iii)The area is covered with thick overburden comprising yellowish brown variegated silty clay with ubiquitous kankar and coarse to fine sand and reddish-brown silt. Porous alluvial formation occurring in the alluvium plain area, forms the most prolific aquifer system, whereas the sedimentary semi-consolidated formations and hard rocks, form aquifer of low yield prospect in the denudational hilly region.

(iv)Groundwater occurs in alluvium and in the weathered and joint sandstones in areas which are underlain by the hard rocks such as in Salaiya Khurd, Salaiya Kalan and

Jhadiyahi denudational hilly region. The drill hole data revealed that the thickness of overburden varies from 0.5 to 34.25 m,bgl in the study area.

(v) The infiltration rate varies from 0.3 (Ladiyari) to 7 mm/hour (Basahih) in various parts of the study area indicating low infiltration rates.

Geological Setting

5. Climate and Rainfall Pattern

5.1 General

The district Prayagraj experiences humid sub-tropical climate. January is the coldest month and May is the hottest. Peak temperature in summer reaches to 40.4°C. In winter, the minimum temperature falls up to 9.1°C. The humidity is the highest in the month of August with mean daily relative humidity at 82%. Winds are generally high throughout the year with some increase in force in summer and monsoon season. The mean wind velocity is 5.1 kmph. The potential evapotranspiration is 1537.5 mm. Normal rainfall of the district is 1042 mm. Almost 90% of the total annual rainfall is received during the southwest monsoon which enters the district in the second or third week of June and withdraws in the mid of September.

5.2 Rainfall Analysis

The gridded rainfall and temperature data for the study area are collected from the India Meteorological Department (IMD), Pune. Long series of gridded (0.25° x 0.25°) daily rainfall records of 36 years from 1985 to 2021 for the study area grids 24.75° to 25.00° N latitude and 74.00° to 74.25° E longitude from the IMD are used in the analyses. Similarly, long series of gridded (1° x 1°) daily temperature records of 37 years from 1986 to 2022 for the grid 24.50° N latitude and 80.50° E longitude are used. The annual rainfall of different years from 1985 to 2021 shown in Figure 5.1 depicts that the rainfall varied from year to year that ranges between 379. mm to 1300 mm with an average of 858 mm. The long-term daily average rainfall for the area is shown in Figure 5.2 indicating most of the rainfall (90%) during the monsoon period. It is also seen that rainfall is visible in most of the days which is because of averaging of daily rainfall of 36 years' period. The probability density function of the rainfall data, which is determined based on the different class intervals of rainfall events and their frequency distribution, is also carried out to find out the best fitted distribution of the rainfall pattern. After obtaining the best fitted distribution (in the present case it is observed to be normally distributed as shown in Figure 5.3, the pattern of the daily rainfall distribution estimated based on the mean and standard deviation value of the best fitted frequency distribution (Figure 5.3) is thereafter redefined, and the distribution is shown in Figure 5.3. The mean and the standard deviation of the fitted normal frequency distribution, which has the following mathematical form (Equation 1) are found to be 857 and 235, respectively.

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}}\, exp\left[-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2\right] \quad \ldots \quad (5.1)$$

where f(x) is the probability density function; μ is the mean; σ is the standard deviation; and x is the class interval value.

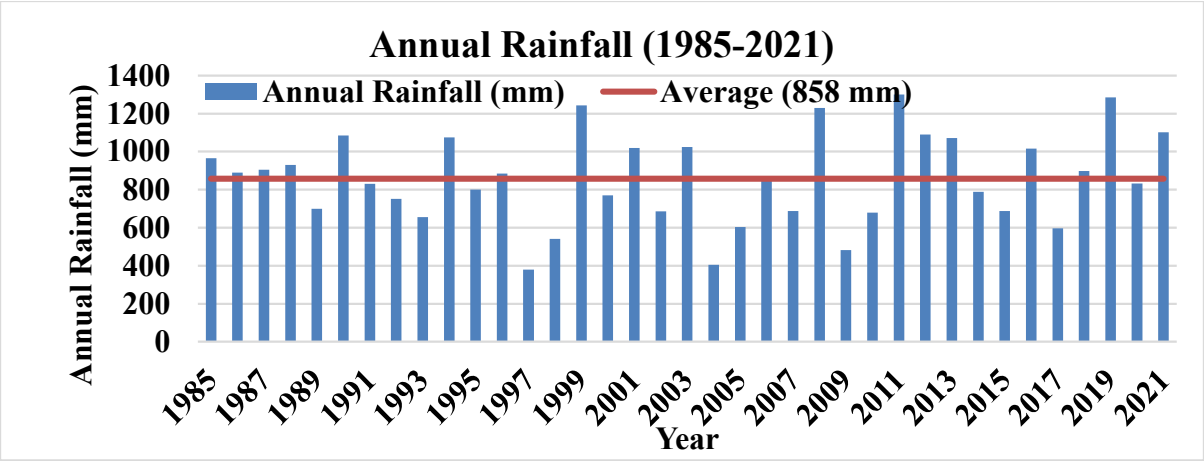


Figure 5.1. Variation of annual rainfall in the study area.

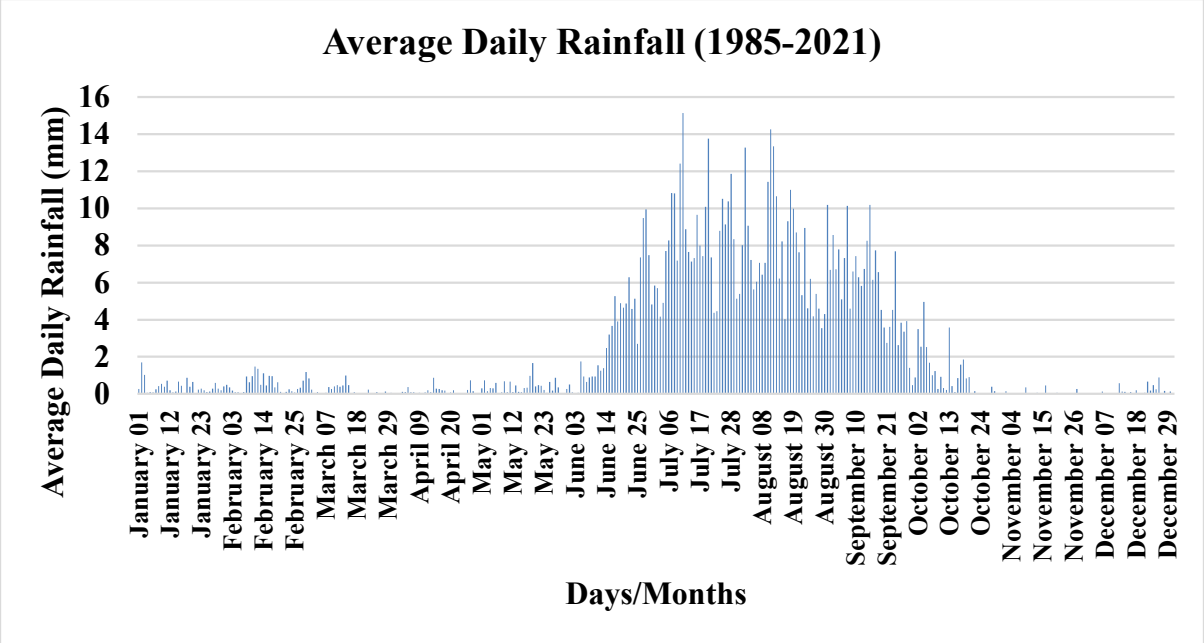
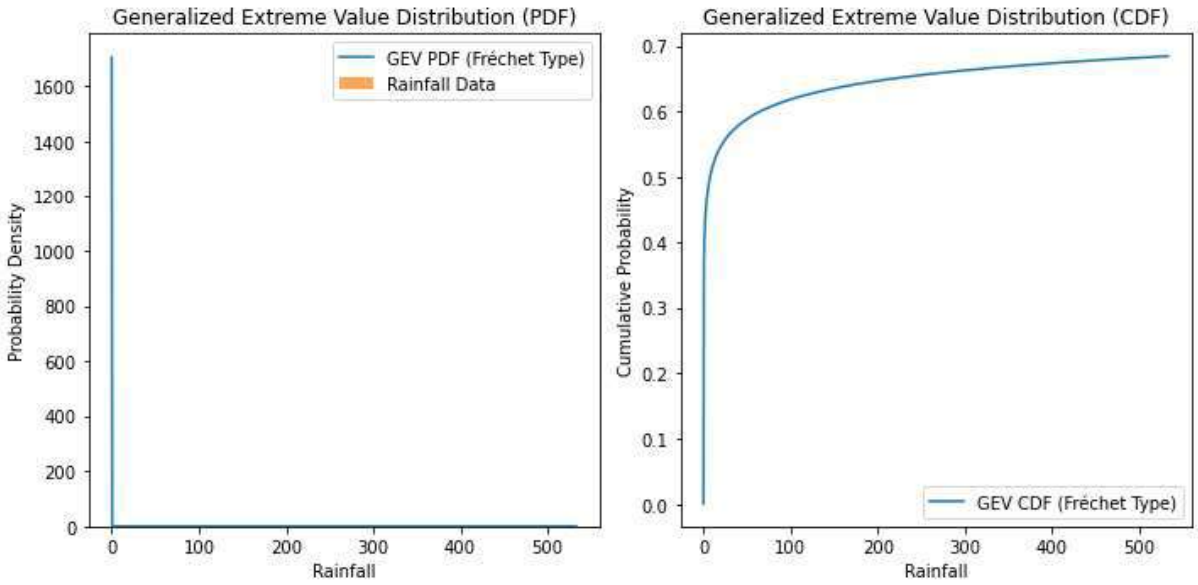


Figure 5.2. Average daily rainfall distribution in the study area derived from the analysis of 36 years (1985-2021) rainfall data.

Estimated Mean (μ): 2.348705154802776, Estimated Standard Deviation (σ): 8.23416394388357



Best fitted frequency distribution of 36 years' **Monthly** rainfall data for the study area

Estimated Mean (μ): 71.48739068019081, Estimated Standard Deviation (σ): 113.36208576851793

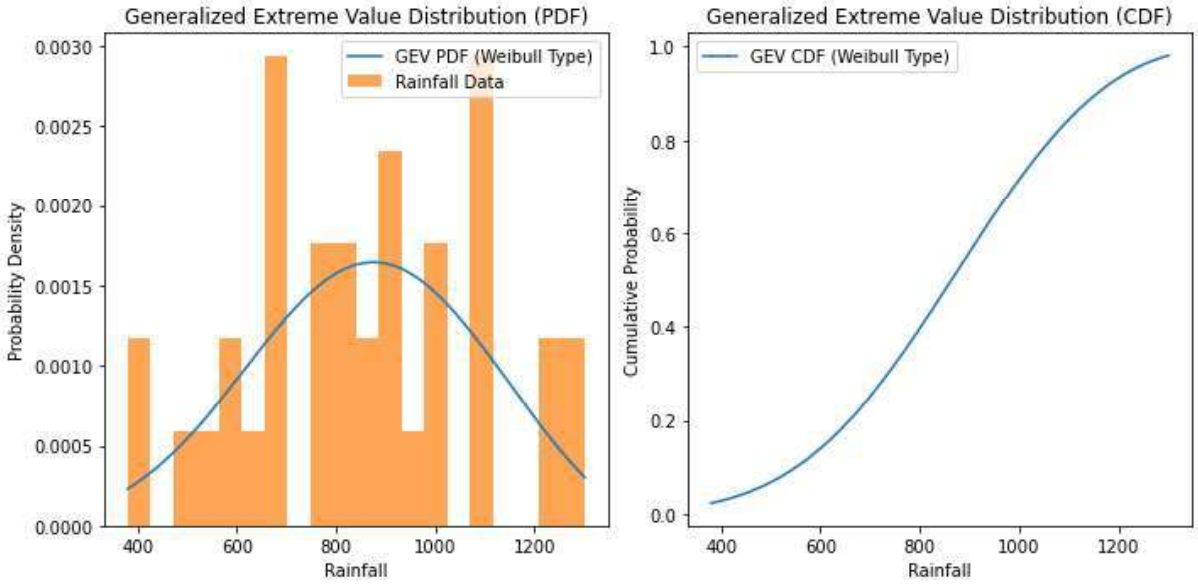


Figure 5.3. Best fitted frequency distribution of 36 years daily rainfall data for the study area. The Probability Density Function (pdf) showed a normally distributed curve with mean of 857 and standard deviation of 235.

Estimated Mean (μ): 857.8486881622896, Estimated Standard Deviation (σ): 235.16427171094404

We have taken the sign of the shape parameter into estimations and correctly identifies the type of GEV distribution (Weibull, Fréchet, or Gumbel). The plots display the GEV PDF and CDF with the appropriate type based on the estimated shape parameter.

The annual average rainfall of the study area is found to be 858 mm. Trend analysis is carried out on the annual rainfall time series covering 36 years' period from 1985 to 2021. Mann-Kendall's trend analysis was performed to see whether there is any trend in the annual rainfall. The analysis indicated S_{stat} as 208, Z_{comp} as 2.707, and Z_{tab} as 1.96 at 5 % significance level. The trend analysis results show the significant rising trend in the annual rainfall in the area under investigation.

The distribution of the average monthly rainfall is given in Table 5.1, which indicates that June through September is the wettest months. In the wettest months (monsoon season) about 921 mm (89.07 % of the annual rainfall) is received. Table 5.1 indicates that as if in every month, the area receives some amount of rainfall, which may not be true physically in every area. This is because of the averaging of 36 years daily rainfall.

Table 5.1: Estimated average monthly rainfall in the area

Month	**Average monthly rainfall (mm)**
January	17
February	20
March	11
April	7
May	10
June	137
July	332
August	275
September	187
October	36
November	4
December	6
Total	**1042**

In order to ascertain the certainty of rainfall that may occur, the probability analysis of the rainfall data for the period from 1985 to 2021 is also carried out for different probability levels. Lower probability indicates less assurance to the occurrence of rainfall, while higher probability indicates that rainfall has more chance to occur. For doing the analysis, average daily rainfall data has been converted to the average monthly data. The monthly rainfall data has thereafter been analysed for different probability levels. The probability of annual rainfall at different percentage of probability is shown in Figure 5.4. The probability of monthly rainfall for different probability of exceedance is shown in Figure 5.5. Figures 5.4 and 5.5 showed that as the probability increases the magnitude of rainfall events (Figure 5.4) and the quantity of annual rainfall decrease implying more assurance in the occurrence of the corresponding rainfall events. The rainfall distribution at various probabilities with desired assurance can be used for planning water usages and manage the water resources during low rainfall years.

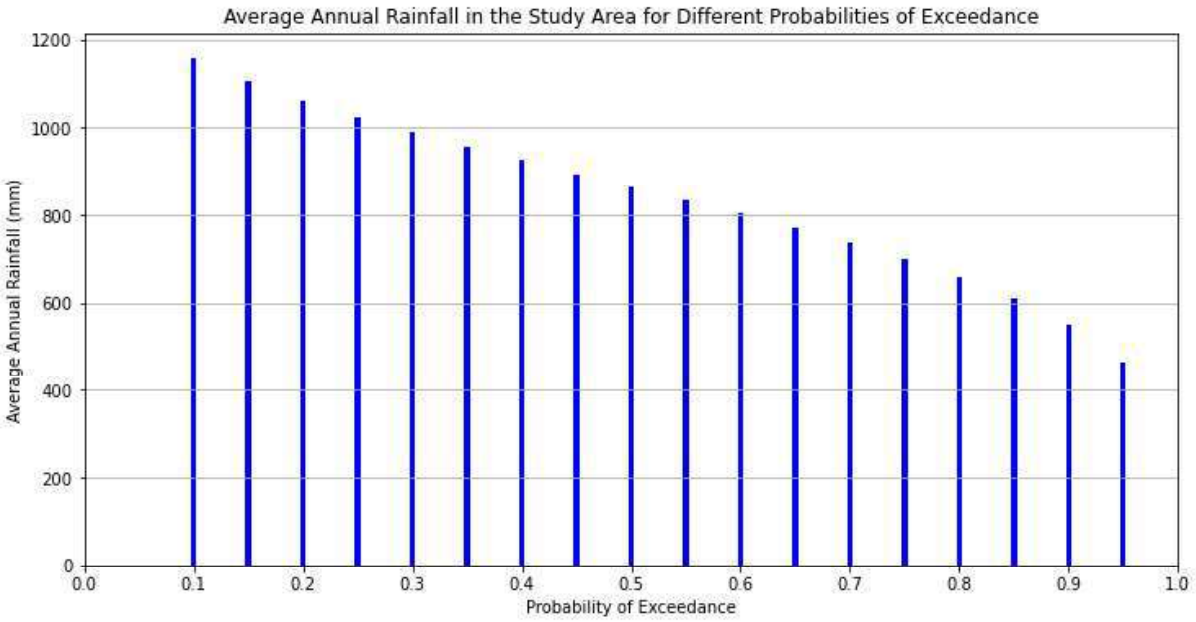


Figure 5.4. Average annual rainfall in the study area at different probability of exceedance.

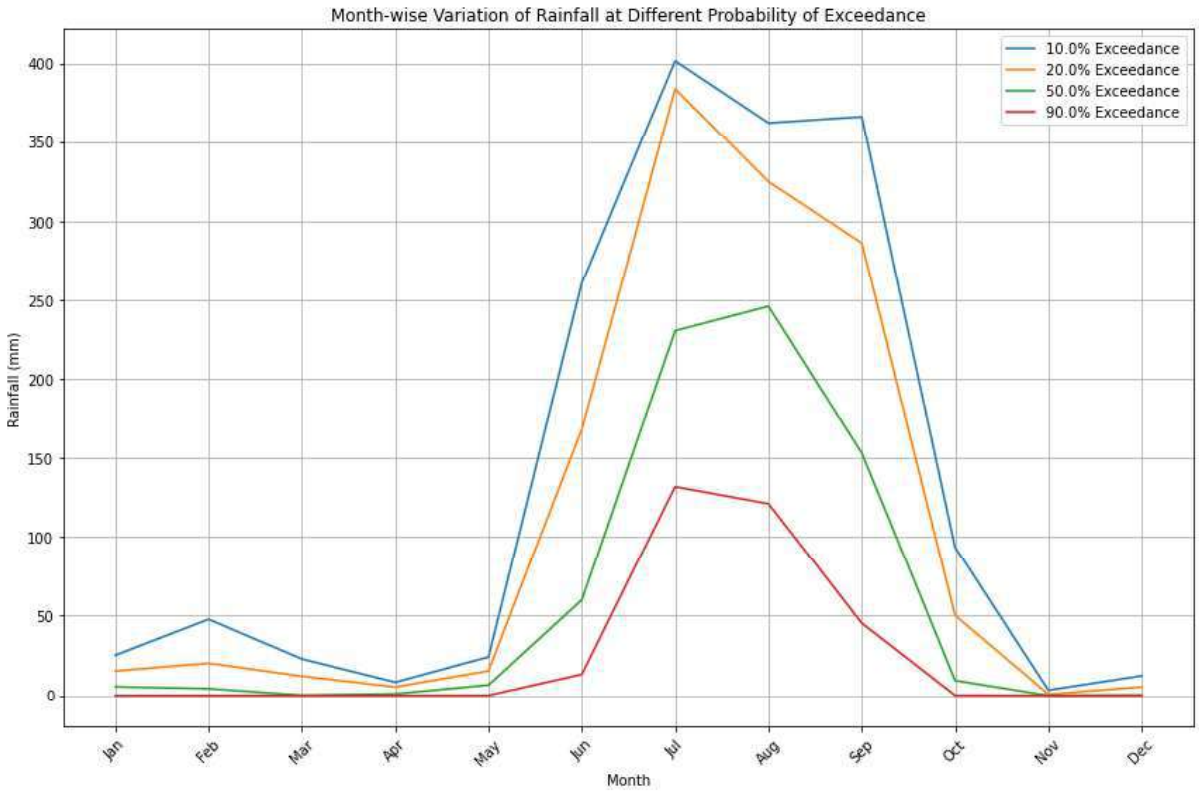


Figure 5.5. Month-wise variation of rainfall of the study area at different probability of exceedance.

5.3 Temperature Analysis

The variation of minimum, average and maximum temperature on monthly basis is shown in Figure 5.6. It is seen that the monthly average temperature varies from 8.5 ºC in January to 40.8 ºC in May. January and December are the coldest months while May and June are the hottest months.

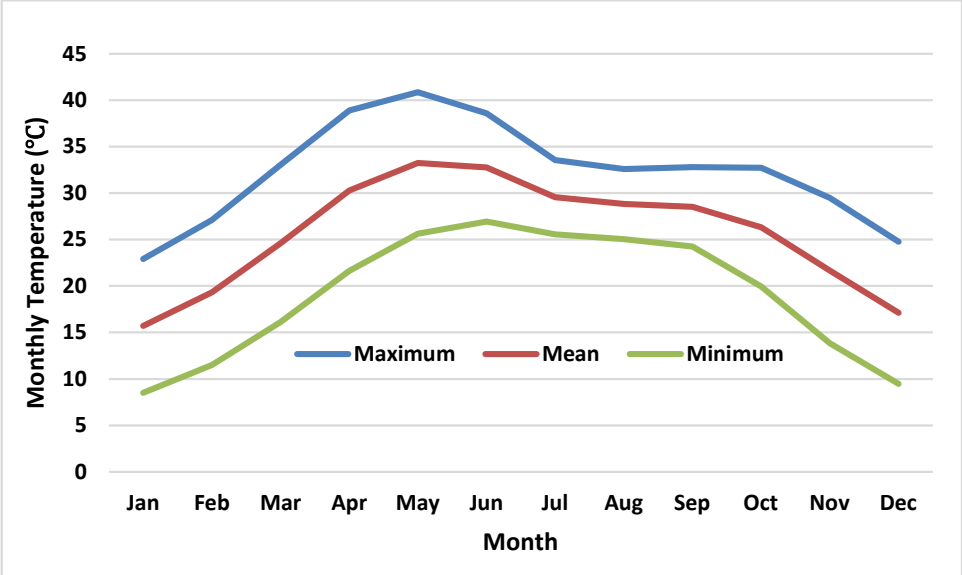


Figure 5.6. Variation of minimum, average and maximum average temperatures.

The variation of minimum, average and maximum temperature on weekly basis is shown in Figure 5.7. It is seen that the weekly average temperature varies from 8.3 ºC in the 1st week (January) to 41 ºC in the 20th week (May).

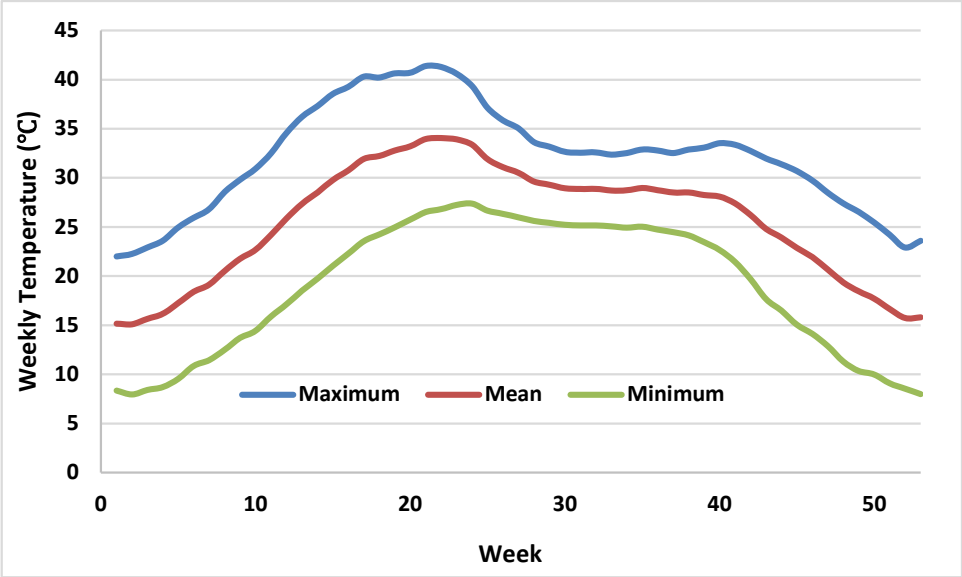


Figure 5.7. Variation of minimum, average and maximum weekly temperatures**.**

5.4 Summary

(i) Analysis of long series daily rainfall data of 36 years (1985-2021) of the study area showed that annual rainfall varied from year to year ranging between 379. mm to 1300 mm with an average of 858 mm.

(ii) About 921 mm (89.07 % of the annual rainfall) is received during the monsoon months, June through September.

(iii)Probability analysis of the annual rainfall data carried out at various dependability levels showed that the quantity of rainfall at 20%, 50%, and 90% probability of exceedance is 370, 250, and 130 mm, respectively.

(iv)The trend analysis carried out on the annual rainfall time series covering 36 years' period from 1985 to 2021 indicated the significant rising trend in the annual rainfall of the area.

(v) The monthly average temperature varies from 9.1 ºC in January to 40.8 ºC in May. January is the coldest month while May is the hottest month. The weekly average temperature varies from 8.3 ºC in the 1st week (January) to 41 ºC in the 20th week (May).

6. Hydrogeology, Groundwater, geophysical survey and pump test

6.1 General

Analysis of hydrogeology will help to understand how water interacts with geological systems. Groundwater flow direction will help delineate movement of groundwater. Hydrogeology together with its hydraulic properties and groundwater flow direction will help assess the groundwater potential.

To characterize the hydrogeology, groundwater level variation and groundwater flow direction of the study area, these aspects are first analysed in the regional scale and thereafter analysis is focused to local scale. For analysis of the above components, groundwater level data available from the Central Ground Water Board (CGWB, 2021-22), Govt. of India were used.

6.2 Hydrogeology

Occurrence of ground water in the district is mainly controlled by the topographic and structural features present in geological formations. Ground water occurs mainly under water table conditions in all formations. Ground water in the district occurs both in alluvium and the weathered and jointed sandstone in area which are underlain by hard rocks. Two-broad based hydrogeological units namely unconsolidated (Alluvium) and consolidated (Hard Rock) have been identified. The unconsolidated or alluvial formations occur in the Trans-Ganga and Doab region. Localized patches of Trans Yamuna region are also covered by the unconsolidated formations. Occurrence of consolidated formations is restricted primarily Trans – Yamuna tract and this sizable area flanks the southernmost segment of the district. In the Alluvium Area, ground water occurs within the primary porosity of alluvial sediments in the north, the aquifer materials are medium to coarse grained sands. The shallow aquifer materials are medium to coarse grained sands. The shallow aquifer occurs under unconfined condition while deeper aquifers are under semi confined to confined conditions.

Ground water occurs in the pore spaces of the unconsolidated alluvial sediments in the zone of saturation. The sediments consist of fine to medium sand with intercalated pockets of clayey material within, and a thin layer of clayey sediments at the top. Alluvial formations have also been encountered in Trans Yamuna area but has limited extension adjacent to river Yamuna. Vindhyan plateau is characterised by jointed and faulted hard rock formation which have limited ground water potential. Fissured formations are only found in

Trans Yamuna area and particularly dominant in southern part of Trans Yamuna area. It has developed secondary porosity and has limited yield prospects. Sandstone and Quartzites are important formations with layer of silica sand which forms the fissured formations for ground water withdrawal and act as potential horizons. Infiltration from rainfall is the main source of ground water recharge in the area. Influent seepage from the surface water bodies is also responsible for recharge to the ground water reservoir

Ground water is being developed in the area by medium to deep tube wells, dug wells, dug-cum bored wells. Based on 3 exploratory wells data in the area CGWB (2023) observed yield at Pipraon village was about 770 lpm (good to excellent on groundwater prospective) whereas yield of 107 lpm encountered at Saliya Khurd village belongs to very poor prospective area. Depth to water level ranges from 2.4 to 8.6 mbgl, during the survey period (September 2023). There is rise of 2-4 mbgl observed in post monsoon season as compared to pre-monsoon season which depicts a good infiltration and recharge of precipitation.

Groundwater level in May, 2021 was 4.94 mbgl, rise in ground water level observed in August, 2021 (1.35 mbgl); decreased to 3.86 mbgl in November, 2021 and slight rise was observed in January, 2022 (3.69 mbgl). Groundwater rise was found in pre monsoon was 0.1013 m/year and in post-monsoon was 0.0485 m/year (CGWB, 2022) with minimum water level fluctuation. Ground water flow is towards the river Ganga in the north and river Yamuna in the south.

Some of the observations of the groundwater levels are given in Table 6.1:

Table 6.1: Ground water level seasonal variations

Sr. No.	Location	Total depth of well (m)	Water level (mbgl) year 2022		
			Pre-Monsoon	Monsoon	Post-monsoon
1	Salaiya Khurd (well 1)	6.50	5.50	0.91	1.80
2	Salaiya Khurd (well 2)	7.30	5.80	1.60	2.50
3	Jhariyahi	14.50	13.75	11.80	12.50
4	Mai kalan	12.00	10.50	5.00	5.75
5	Salaiya kalan	16.00	14.50	7.75	8.65

6.3 Geophysical Investigation

Varieties of methods are available to assist in the assessment of geological sub-surface conditions. The main emphasis of the fieldwork undertaken was to determine the thickness and composition of the sub-surface formations and to identify water-bearing zones. This information was principally obtained in the field using vertical electrical soundings (VES). This method is described below.

Vertical electrical soundings (VES) were carried out to probe the condition of the sub-surface and to confirm the existence of deep groundwater. The electrical properties of rocks in the upper part of the earth's crust are dependent upon the lithology, porosity, the degree of pore space saturation and the salinity of the pore water. Saturated rocks have lower resistivities than unsaturated and dry rocks. The higher the porosity of the saturated rock, or the higher the salinity of the saturating fluids, shows the lower resistivity. The presence of clays and conductive minerals also reduces the resistivity of the rock. The resistivity of earth materials can be studied by measuring the electrical potential distribution produced at the earth's surface by an electric current that is passed through the earth. The resistance R of a certain material is directly proportional to its length L and cross-sectional area A, expressed as:

$$R = Rs * L/A \text{ (in Ohm)}$$

where Rs is known as the specific resistivity, characteristic of the material and independent of its shape or size. With Ohm's Law,

$$R = dV/I \text{ (Ohm)}$$

where dV is the potential difference across the resistor and I is the electric current through the resistor. The specific resistivity may be determined by:

$$Rs = (A/L) * (dV/I) \text{ (in Ohm m)}$$

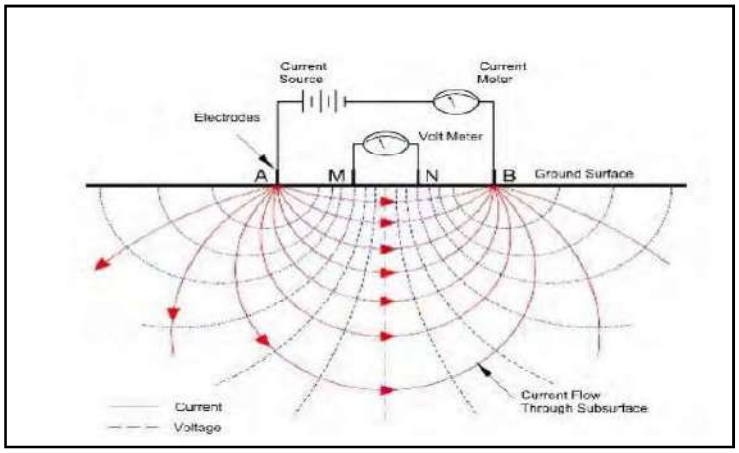


Figure 6.1: Electrical Circuit for Resistivity Survey

6.3.1 Vertical Electrical Sounding (VES)

When carrying out a resistivity sounding, current is led into the ground by means of two electrodes. With two other electrodes, situated near the centre of the array, the potential field generated by the current is measured. From the observations of the current strength and the potential difference, and taking into account the electrode separations, the ground resistivity can be determined. During a resistivity sounding, the separation between the electrodes is step-wise increased (in what is known as a Schlumberger Array), thus causing the flow of current to penetrate greater depths. When plotting the observed resistivity values against depth on double logarithmic paper, a resistivity graph is formed, which depicts the variation of resistivity with depth. This graph can be interpreted with the aid of a computer, and the actual resistivity layering of the subsoil is obtained. The depths and resistivity values provide the hydrogeologist with information on the geological layering and thus the occurrence of groundwater.

Vertical electrical sounding (VES) method of geophysical investigation has been favourably applied in the areas of groundwater potential studies. Vertical electrical sounding is one of the best methods of investigating the electrical properties of the subsurface such as resistivity/conductivity variation with depth and is the best geophysical method known and applied for groundwater prospecting in many areas.

6.3.2 VES Field survey

Fieldwork was carried on 5rd Sep.to 7th Sep. 2023 to conduct VES survey at two locations in and around the NTPC MEJA plant premises (Table 6.1). The vertical electrical sounding (VES) was executed in order to unveil the hydro stratigraphy of the area. The subsurface stratigraphy and clay, sand-silt and gravels layer conditions of the investigated site in general are considered to be fairly non-uniform.

Figure 6.2: Conducting Geophysical Survey (VES Test) at two locations (1) Near Ash Dyke (2) Inside the NTPC Meja Plant.

Table 6.2: Latitude, longitude and elevation of the conducted VES tests near NTPC MEJA.

VES	Lat.	Long	Depth of Survey (m)
1	25.121049	81.933251	95 (~300ft)
2	25.143598	81.928773	70 (~225ft)

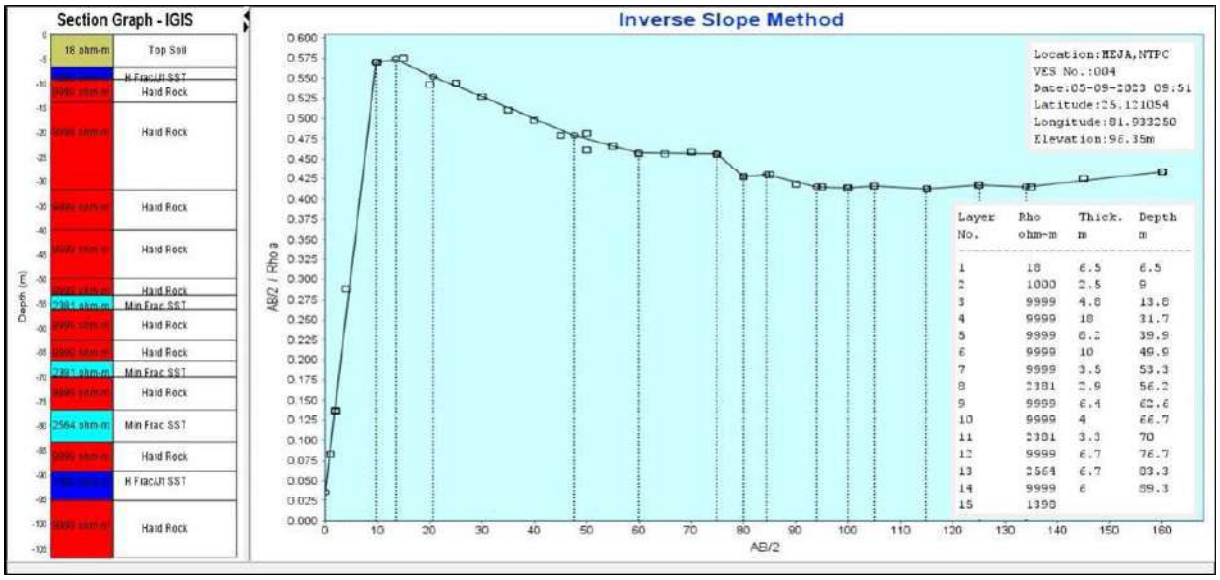


Figure 6.3: VES-01 Survey conducted at NTPC, MEJA.

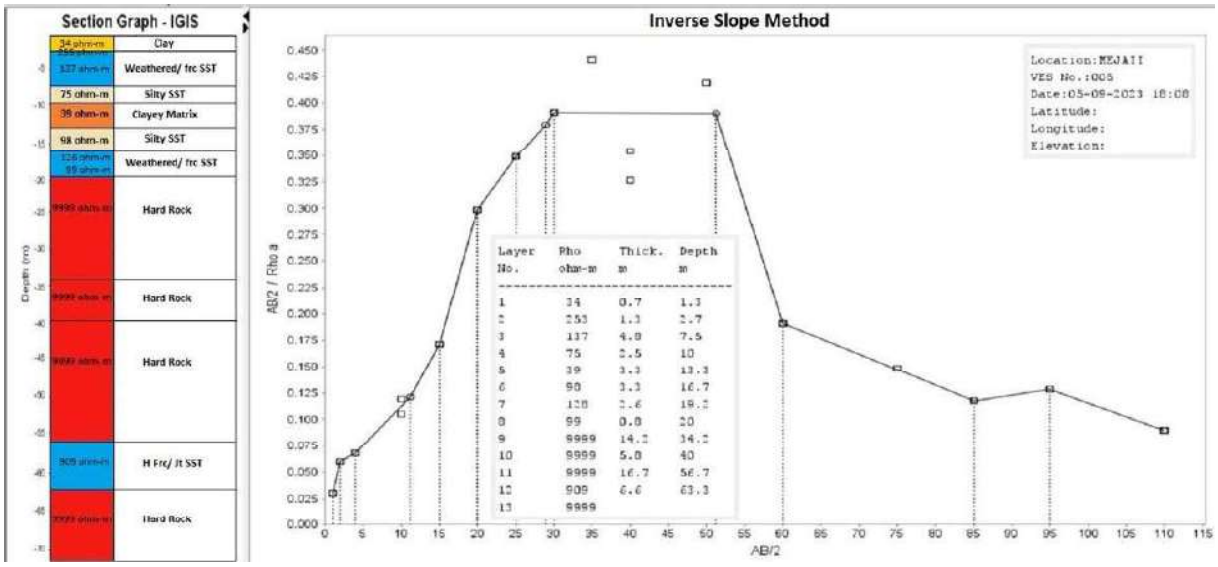


Figure 6.4: VES-02, Survey conducted inside the township of NTPC, MEJA

VES-01:

Near ash dyke VES survey was carried out upto the depth of 95 meter (~310 ft). The results of VES-01, indicate that the zone between 6.5-8.5 m show a low resistivity zone which is interpreted as a fractured/jointed sandstone zone, this may be a water-saturated basically upper most aquifer which is recharged from the nearby ash pond or reservoir. Hard and compact Sandstone is the major lithological units observed in resistivity log varied from 8.5 to 53.0 m, 56.0 to 67.5m which is totally impervious and unsaturated. However various

small zone of saturation was observed in VES data between 53.0 to 56.0m, 67.5 to 70.0m and 77.0 to 84.0 m where the fractured/jointed sandstone layers are showing relatively low resistivity values. However, between 89.3 m to 95.0 m, highly fractured Sandstone shows the signature of water bearing zone. In the drilling cuttings it was observed that secondary porosity was developed in vugs/veins resulting increased porosity and permeability, hence these sandstones are producing low to medium discharge.

VES -02

The results of VES-02, indicate that the zone between 3-7 m show a low resistivity zone which is interpreted as a weathered-fractured/jointed sandstone zone, this may be a water-saturated basically upper most aquifer which is recharged from the nearby ash pond or reservoir. The log is further succeeded by silt and clay deposited low resistivity zone from 7 to 15m, however 15-20m zone indicating fractured/weathered sandstone and might be the good option to develop recharge borewell for rainwater harvesting purpose. Hard and compact Sandstone is the major lithological units observed in resistivity section varied from 20-56 m. However, another zone of saturation was observed in VES data between 56 to 63m where the fractured/jointed sandstone layers are showing relatively resistivity values close to water bearing zone and also act as a suitable zone for recharge well.

6.4 Drilling of Borewell

As per the scope of the work, 1 nos. of Borehole/Piezometer was drilled near the Ash dyke of the NTPC, Meja. Proposed depth of the piezometer was decided ~150 ft, but due to encountering the water table at deeper depth the total drilling depth was 280 ft. The geographical location of Borewell/Piezometers was provided by the NIH Authority after consulting with NTPC officials. A DTH drilling rig was deployed to drilled the borehole of desired depth.

S. No.	Location	Code	Latitude	Longitude	Drilled Depth (ft)	Casing depth. (ft)
1	Ash Dyke Area	PZ-1	25.120573	81.932327	280	60 ft

Figure 6.5: Drilling operation in progress for construction of the Piezometer around new Ash Dyke, NTPC Meja,

During the course of drilling cutting were collected at every 20ft interval for preparation of detailed lithology of the borehole and the collected samples handed over to the NIH Laboratory for further analysis.

Figure 6.6: Soil/Sediment from drilling samples collected from the newly installed Piezometers at NTPC, Meja

The detail of the bore well-constructed is:

Main location: NTPC temple

Hole Depth- 280 ft

Hole size – 7 inch

Casing size- 5 inch

Casing Depth- Uncased (weathered /fracture zone 200-240, 260-280, total casing 60ft)

Pumping capacity- 2 H. P. Submersible pump

LPM- 40-50

6.5 Pump Test

Hydrogeologists determine the hydraulic characteristics of water-bearing formations, by conducting pumping tests. The basic principle of a pumping test is that if we pump water from a well and measure the pumping rate and the drawdown in the well then, we can substitute these measurements into an appropriate formula and can calculate the hydraulic characteristics of the aquifer. It is also called as aquifer tests for aquifer parameter evaluation. Aquifer pump tests are made to determine the transmissibility and, when using the nonequilibrium procedure, the coefficient of storage of an aquifer. The principle of a pumping test involves applying a stress to an aquifer by extracting groundwater from a pumping well and measuring the aquifer response to that stress by monitoring drawdown as a function of time. These measurements are then incorporated into an appropriate well-flow equation to calculate the hydraulic parameters of the aquifer. The objectives of the pumping test is to determine well yield, well efficiency and aquifer parameters. The number of observation wells required to furnish adequate information depends on the geologic and hydrologic conditions present and the aquifer test method to be used.

Pumping tests provide very useful information that is needed to properly select pumping equipment, assess aquifer conditions, and evaluate well performance. An aquifer test is designed to exert a known stress on an aquifer so that the aquifer's response may be recorded. An aquifer's response is captured by drawdown and recovery data collected at the pumping well and all observation wells during the test.

The methods employed during the test are Constant rate and Recovery Phase, during the discharge stage, the well was pumped at a constant rate, and the water level in the pumped well was measured at intervals. After pumping for 4 hours, the well was allowed to recharge, and the water level was measured again at the same intervals as that of the discharge stage. The following equipment were used in carrying out the pumping test.

1. Submersible pump and cable
2. Flow meter (to measure volume of water discharged)
3. Depth/water level sounder (for determining the depth and water level)
4. Stopwatch (for taking time intervals)
5. Digital water level recorder (DWLR)

6.6 Results of Pumping Test:

The methods adopted for this study are Jacob straight line method and Theis's Recovery method. The data was analyzed using the Excel based spread sheet developed for the pump test.

In Thesis's Time-drawdown curve matching method the time versus drawdown were plotted on a double logarithmic paper taking time (t) along horizontal axis and drawdown (s) along vertical axis. Transmissivity (T) is computed by Theis's equation, which can be written as:

$$\text{Transmissivity (T)} = 2.303*Q/4\,\pi\,\Delta s$$

Where Q is discharge in m^3/day

Δs change in drawdown over a log cycle,

Thus,

In case of Exploratory Well, Jacob's straight-line method

Discharge (Q) = 57.6 m^3/day

ΔS = 26 m

$T = 2.303*Q/4*\pi\,\Delta s$

T1 = 2.303 x 57.6 / 4*3.14*26

T1= 0.40 m^2/day

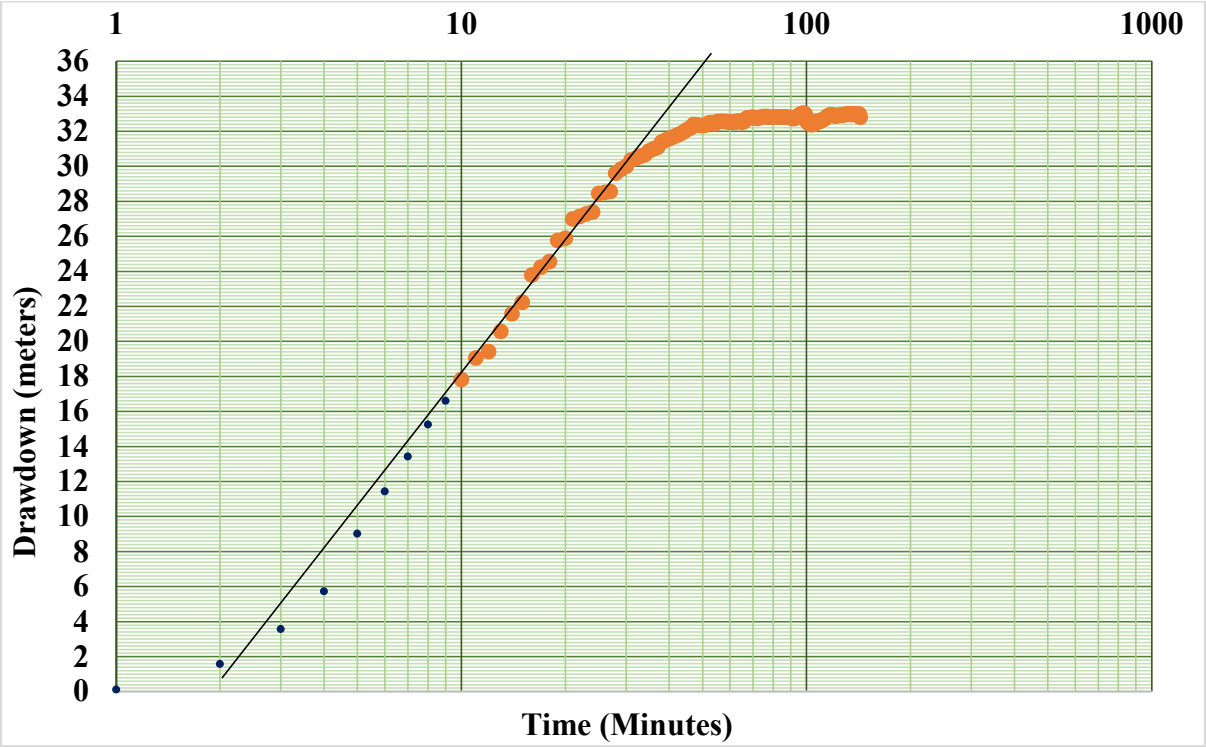


Figure 6.7: Jacob;s straight line recovery method

In case of Exploratory Well, Theis's recovery method, residual drawdown **(s')** is plotted versus t/t' on a semi-logaritmic paper **(t/t'** on the logarithmic scale**).**

Discharge (Q) = 57.6 m^3/day

ΔS = 28 m

T2 = 2.303*Q/4* π Δs

T2 = 2.303 x 57.6 / 4*3.14*28

= 0.37 m^2/day

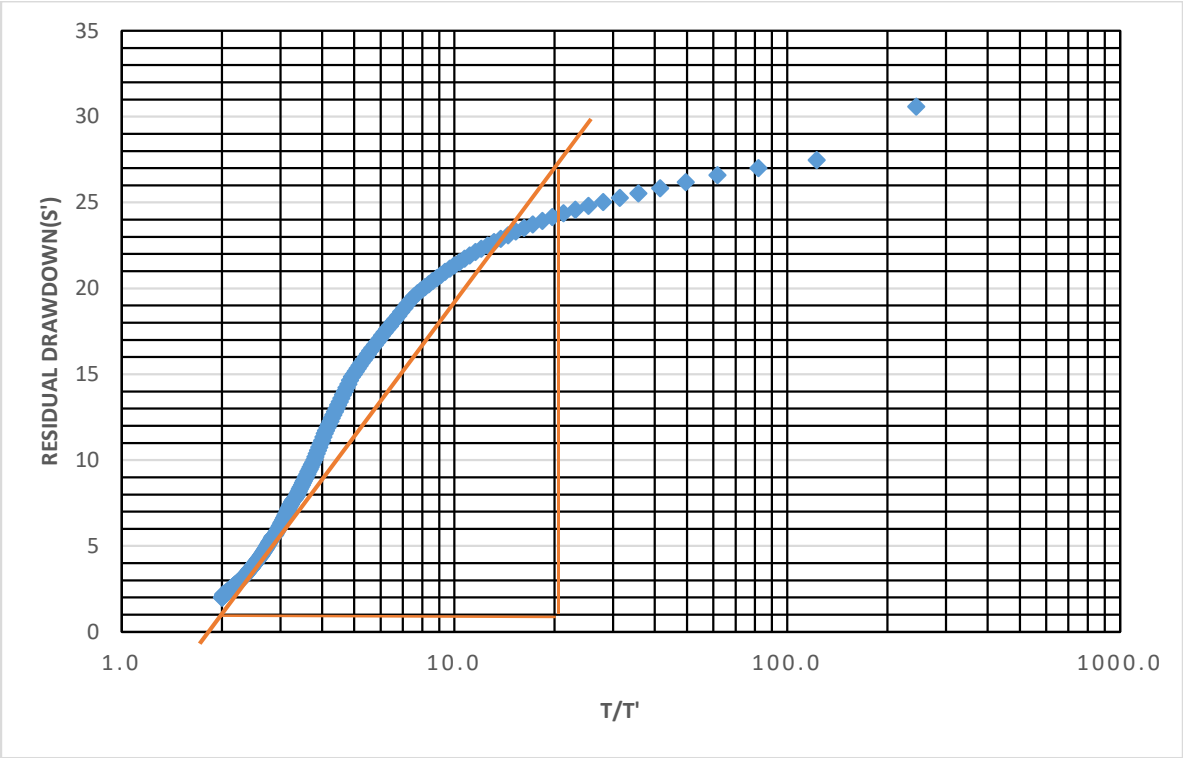


Figure 6.8: Theis recovery method

The Transmissivity of the aquifer has been determined using two methods. The results obtained are given in the table:

Table 6.3: Transmissivity values using Theis recovery and Jacob's strainght line methods

S. No.	Method	Transmissivity (m^2/d)
1	Jacob straight line method	0.40
2	Thesis Recovery method	0.37

6.7 Summary

(i) The bore hole drilling data reveals that the lithology of the region is basically, Sandstone of various grade and composition. The water bearing zone in the area is comprises of fractured sandstone basically between 200-240, 260-280 ft bgl. In the drilling cuttings it was observed that secondary porosity was developed in vugs/veins resulting increased porosity and permeability, hence these sandstones are producing low to medium discharge.

(ii) The resistivity (VES-01) data demarked the zones between 53.0 to 56.0m, 67.5 to 70.0m and 77.0 to 84.0m and 89 to 95m, are jointed/ fractured Sandstone showing

the signature of water bearing zone in VES-01. Moreover, at VES-02 between 15 to 20m and 56 to 63m depth where the fractured/jointed sandstone layers are showing relatively low resistivity values close to water bearing zone and might be the good option to develop recharge borewell for rainwater harvesting purpose.

(iii) In the pump test, Thesis's Time-drawdown curve matching method show Transmissivity value of the piezometer around 0.40 m^2/day, whereas, Theis's recovery method the Transmissivity of the aquifer is coming approx. to 0.37 m^2/day. Indicating very low value of transmissivity and that can result to low yield.

7. Water Quality Assessment

7.1 General

The effluent of MUNPL, MEJA plant is being discharged after proper treatment. The effluents may consist of a number of pollutants, like oil and grease, carbonate, bicarbonate, nitrite, phosphate, TSS, TDS, volatile solids, organic matter and other toxic elements. The disposal of wastewater without proper management leads to significant water quality problems when mixed with fresh water or seepage into groundwater. This downward seepage may contaminate the groundwater resource and, therefore, assessment of ambient groundwater quality is very necessary.

To assess the groundwater water quality in and around the MUNPL, MEJA plant area, the water samples for quality monitoring were collected as 32 samples in December, 2021; 37 samples in May, 2022 and 40 samples in August, 2022 for the 3 seasons post-monsoon, pre-monsoon and monsoon, respectively from thirteen locations from MUNPL, MEJA plant area as well as a buffer zone of 25 km radius (Table 7.1). Figures 7.1 (a) and (b) show the locations of water sampling sites, which include ponds, wells, hand pumps, zinc pond, etc. These locations are well distributed in the study area**.** The water quality parameters include: pH, water temperature, electrical conductivity, total dissolved solids (TDS), alkalinity, total hardness, bicarbonate, fluoride, chloride, sulphate, nitrate, calcium, magnesium, sodium, potassium, and trace metals viz. iron (Fe), zinc (Zn), copper (Cu), arsenic (As), lead (Pb), cadmium (Cd), chromium (Cr) and nickel (Ni).

Table 7.1. Details of various sampling sites for water quality assessment

Sl. No.	Post monsoon (Dec 21)		Pre-Monsoon (May 22)		Monsoon (Aug 22)	
	Sample id	Village	Sample id	Village	Sample id	Village
1	11	Ash Dyke	11	Ash Dyke	11	Ash Dyke
2	12	Patai	12	Patai	12	Patai
3	13	Mai Kala	13	Mai kala	13	Mai kala
4	14	SahPur kala1	14	Sahpur Kala1	14	Sahpur Kala1
5	15	SahPur kala2	15	Sahpur Kala2	15	Sahpur Kala2
6	16	SahPur kala3	16	Sahpur Kala3	16	Sahpur Kala3
7	17	Jhariyari1	17	Jhariyari1	17	Kohrar

8	18	Jhariyari2	18	Jhariyari2	18	Lal Tara
9	19	Kohrar	19	Kohrar	19	Saliya Khurd
10	20	Lal Tara	20	Lal Tara	20	Salaiya Kala1
11	21	Salaiya Khurd	21	Saliya Khurd	21	Salaiya Kala2
12	22	Salaiya Kala1	22	Salaiya Kala	22	Piparao
13	23	Salaiya Kala2	23	Piparao	23	Dighalo1
14	24	Piparao	24	Dighalo1	24	Dighalo2
15	25	Dighalo1	25	Khuta 1	25	Khuta 1
16	26	Dighalo2	26	Khuta 2	26	Khuta 2
17	27	Khuta1	27	Kathauli	27	Kathauli
18	28	Khuta2	28	Dabar	28	Dabar
19	29	Kathauli	29	Subhash	29	Subhash
20	30	Dabar1	30	Semarieha	30	Shamlipur
21	31	Dabar2	31	Koraon	31	Semarieha
22	32	Siyamlipur	32	Dasauti	32	Koraon
23	33	Semarieha	33	Itwakala	33	Dasauti
24	34	Koraon	34	Baghol	34	Itwakala
25	35	Dasauti	35	Saliya Khurd2	35	Baghol
26	36	Itwakala	36	Chand Khamariya	36	Saliya Khurd2
27	37	Baghol1	37	Pal Patti	37	Chand Khamariya
28	38	Baghol2	38	Jhariyari3	38	Pal Patti
29	39	Chand khamariya	39	Ash Dyke2	39	Jhariyari
30	40	Pal patti	40	Dabar Paudhsala	40	Ash Dyke2
31	41	Jhariyari	41	Subhash2	41	Dabar Paudhsala
32	42	Ash Dyke2	42	Ash Dyke3	42	Subhash2
33			43	Ash Dyke4	43	Ash Dyke3
34			44	Dighalo2	44	Jhadiyahi
35			45	Shambholri Nagar	45	Dighalo
36			46	Khamoriya	46	Shambri
37			47	Tons River	47	Khamoriya
38					48	Tons River
39					49	Lal Tara2
40					50	Pal Patti2

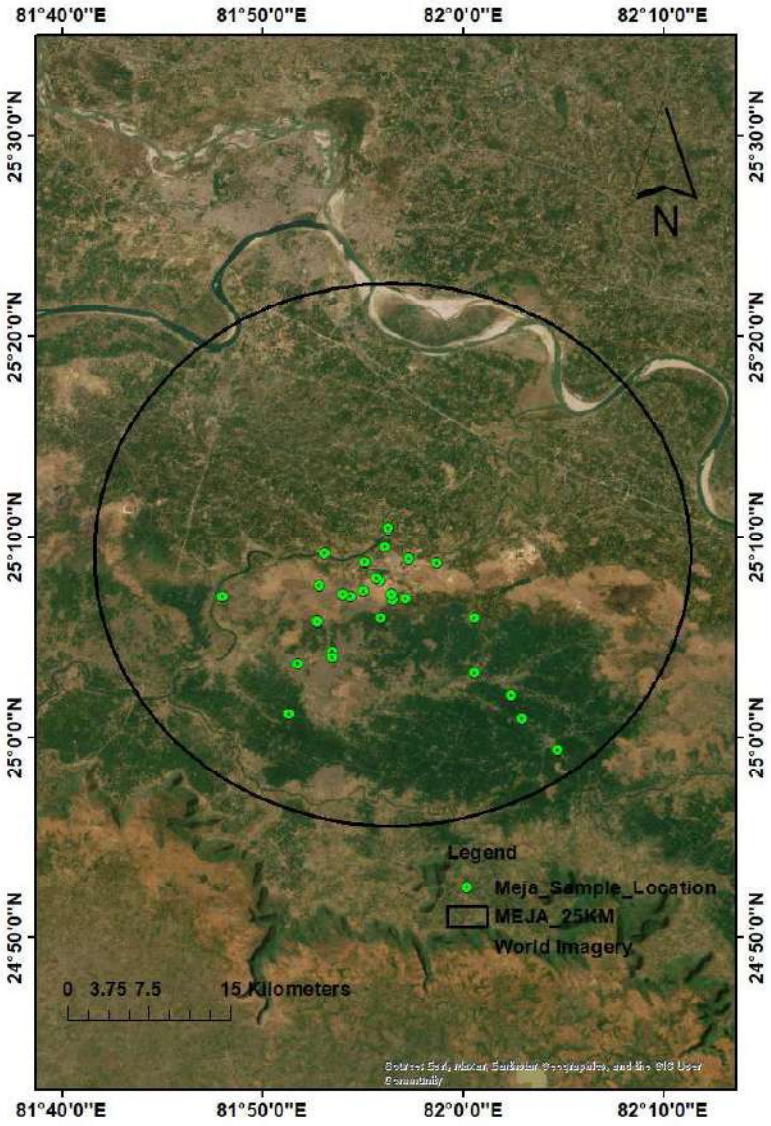


Figure 7.1(b). Google view showing water sampling sites for water quality assessment in the study area.

7.2 Chemicals and Reagents

Analytical grade reagents were used in the digestion and extraction processes. Milli-Q water was used throughout the experiment and other dilution purposes. All stock solutions were kept in a state of darkness in a lab refrigerator at 4°C.

7.3 Sample Collection and Preservation

Groundwater samples were collected from hand pumps using outside taps after thoroughly flushing the water for at least 15 min or until temperature measurements indicated

that all onsite storage was purged and water originated from the well bore or aquifer. All sampling containers were rinsed three times with sample water before collecting the final sample. The samples were collected in acid washed LDPE (Low-Density Polyethylene) tarson bottles. The samples for metal analysis are preserved by the addition of nitric acid by adding 6-8 drops of conc. HNO_3 in 60 ml water sample to acidify the sample to pH < 2 in the field itself. Samples for analysis of major anions (bicarbonate, sulphate, fluoride, chloride, and nitrate) and cations (sodium, potassium, calcium and magnesium) were collected as unpreserved.

7.4 Laboratory Analysis

Water samples were analysed in the laboratory at the National Institute of Hydrology **(**NIH**)**, Roorkee to determine various water quality constituents**.** The samples were filtered through 0.45µm and used for the analysis of major cations (Na^+, K^+, Ca^{2+} and Mg^{2+}) and anions (F^-, Cl^-, SO_4^{2-}, NO_3^-, etc.) using the ion chromatography (IC) technique. For trace metals analysis (Fe, Zn, Cu, Cd, Cr, Ni, Pb, As, etc.), inductively coupled plasma-optical emission spectrometer (ICP-OES) was used. Cations and anions analysis were performed in three replicates for each sample. An overall precision, expressed as percent relative standard deviation (RSD), was obtained below 10% for the entire samples. The summary of water quality results of collected water samples is presented in Table 7.2 along with the prescribed limits by BIS, 2012.

Table 7.2: Statistical summary of groundwater quality parameters of samples collected from the study area

Post monsoon 2021

Parameters	Min. Value		Av. Value		Max. Value		BIS:10500 (Acceptable Limit)	BIS:10500 (Permissible Limit)	%age GW/SW Samples within Acceptable Limit	%age GW/SW Samples within Permissible Limit
	Ground Water (29 nos.)	Surface water (3 nos.)	Ground Water (29 nos.)	Surface water (3 nos.)	Ground Water (29 nos.)	Surface water (3 nos.)				
pH	6.50	7.40	7.50	7.67	7.90	7.90	6.5-8.5	6.5-8.5	100/100	100/100
EC (µS/cm)	110	140	1295	527	5800	1090	-	-	-	-
HCO_3^- (mg/L)	54.9	54.9	458.4	314.4	1293.9	658.8	-	-	-	-
TDS (mg/L)	70	90	829	333	3712	698	500	2000	31/100	93/100
F^- (mg/L)	0.21	0.02	0.89	0.43	2.36	1.18	1	1.5	66/100	83/100

Cl^- (mg/L)	10	18	120	46	660	91	250	1000	93/100	100/100
NO_3^- (mg/L)	0.10	nd	0.61	0.03	3.10	0.10	45	45	100/100	100/100
Ca^{++}(mg/l)	3.18	11.87	26.50	43.88	127.13	61.71	75	200	93/100	100/100
Mg^{++}(mg/l)	2.33	4.57	8.42	7.54	11.30	9.09	30	100	100/100	100/100
Na^+(mg/l)	2.56	6.68	143.23	88.25	816.60	176.2	-	-		
K^+(mg/l)	0.35	1.31	31.93	4.35	334	9.9	-	-		
Fe (mg/L)	0.01	0.06	1.50	1.09	14.85	2.81	0.3	0.3	45/33	45/33
Zn (ppb)	14.56	18.81	162.10	41.99	556.08	54.40	5000	15000	100/100	100/100
Cu (ppb)	0.13	0.96	2.79	3.13	12.52	5.01	50	1500	97/100	100/100
Total Arsenic (ppb)	0.04	2.44	5.74	5.51	10.89	8.26	10.00	50.00	93/100	100/100
Pb (ppb)	0.12	2.02	3.03	4.00	11.31	7.07	10	10	97/100	97/100
Cd (ppb)	0.05	0.16	0.87	0.42	5.63	0.63	3	3	93/100	93/100
Cr (ppb)	0.06	0.04	1.99	1.53	9.89	3.93	50	50	100/100	100/100
Ni (ppb)	0.12	0.03	2.80	1.31	10.98	0.87	20	20	100/100	100/100

ND: Not Detected.

Pre monsoon 2022

Parameters	Min. Value		Av. Value		Max. Value		BIS:10500 (Acceptable Limit)	BIS:10500 (Permissible Limit)	%age GW/SW Samples within Acceptable Limit	%age GW/SW Samples within Permissible Limit
	Ground Water (32 nos.)	Surface water (5 nos.)	Ground Water (32 nos.)	Surface water (5 nos.)	Ground Water (32 nos.)	Surface water (5 nos.)				
pH	7.05	6.92	7.55	7.34	8.02	7.62	6.5-8.5	6.5-8.5	100/100	100/100
EC (µS/cm)	210	260	1116	930	5400	1600	-	-	-	-
HCO_3^- (mg/L)	90.28	48.80	410.84	155.4	866.20	262.3	-	-	-	-
TDS (mg/L)	257	288	864	773	3361	1432	500	2000	22/40	94/100
F^- (mg/L)	0.03	1.14	0.73	6.63	4.72	16.31	1	1.5	94/60	94/60
Cl^- (mg/L)	5.29	33.93	120.98	137.38	923.70	336.8	250	1000	91/80	100/100
NO_3^- (mg/L)	0.18	0.31	61.89	8.59	1068.50	33.97	45	45	78/100	78/100
SO_4^{--}(mg/l)	0.11	14.68	85.51	269.51	572.66	627.2	200	400	91/60	94/60
Ca^{++}(mg/l)	27.16	13.89	65.01	70.61	142.80	130.7	75	200	66/40	100/100
Mg^{++}(mg/l)	4.63	4.30	7.75	7.34	10.24	8.80	30	100	100/100	100/100
Na^+(mg/l)	15.51	14.62	121.24	120.37	808.10	227.5	-	-		
K^+(mg/l)	0.43	2.57	12.94	23.03	136	39.6	-	-		
Fe (mg/L)	0.01	0.01	0.87	0.91	4.56	2.18	0.3	0.3	60/20	60/20
Zn (ppb)	10.98	55.91	514.05	199.37	4461.23	335.4	5000	15000	100/100	100/100
Cu (ppb)	0.12	3.72	7.10	7.16	18.35	17.29	50	1500	97/100	100/100
Total Arsenic	0.17	2.81	6.96	9.47	24.45	19.56	10.00	50.00	78/60	100/100

(ppb)										
Pb (ppb)	0.92	12.7	10.51	12.7	42.40	12.7	10	10	94/80	94/80
Cd (ppb)	0.26	0.41	40.01	1.18	2.22	2.39	3	3	94100	94/100
Cr (ppb)	0.11	0.95	1.79	2.25	7.72	3.68	50	50	100/100	100/100
Ni (ppb)	0.40	1.10	4.38	7.88	31.71	19.62	20	20	100/100	100/100

ND: Not Detected.

Monsoon, 2022

Parameters	Min. Value		Av. Value		Max. Value		BIS:10500 (Acceptable Limit)	BIS:10500 (Permissible Limit)	%age GW/SW Samples within Acceptable Limit	%age GW/SW Samples within Permissible Limit
	Ground Water (35 nos.)	Surface water (5 nos.)	Ground Water (35 nos.)	Surface water (5 nos.)	Ground Water (35 nos.)	Surface water (5 nos.)				
pH	6.65	6.95	7.23	7.76	8.10	8.20	6.5-8.5	6.5-8.5	100/100	100/100
EC (µS/cm)	80	160	978	870	1500	1600	-	-	-	-
HCO_3^- (mg/L)	39.04	96.38	387.33	127.5	978.44	187.9	-	-	-	-
TDS (mg/L)	169	177	799	715	2738	1224	500	2000	26/60	94/100
F^- (mg/L)	ND	0.01	0.25	3.46	1.87	12.98	1	1.5	94/80	94/80
Cl^- (mg/L)	3.18	14.73	92.83	107.18	518.52	225.8	250	1000	91/100	100/100
NO_3^- (mg/L)	0.01	1.40	41.13	1.99	275.38	2.97	45	45	71/100	71/100
SO_4^{--}(mg/l)	4.42	4.82	74.24	299.7	381.57	594.2	200	400	98/60	98/60
Ca^{++}(mg/l)	26.40	13.89	56.88	77.45	197.21	122.8	75	200	83/100	100/100
Mg^{++}(mg/l)	1.42	4.32	12.02	11.61	19.16	16.8	30	100	100/100	100/100
Na^+(mg/l)	0.42	9.54	134.27	46.21	817.70	194.8	-	-		
K^+(mg/l)	0.08	1.76	17.91	13.97	145	29.5	-	-		
Fe (mg/L)	0.02	0.38	1.06	0.31	6.69	0.53	0.3	0.3	60/40	60/40
Zn (ppb)	6.56	28.12	280.98	43.03	2261.12	50.79	5000	15000	100/100	100/100
Cu (ppb)	1.23	1.42	3.38	4.28	9.22	7.14	50	1500	100/100	100/100
Total Arsenic (ppb)	6.01	9.32	14.37	13.72	72.10	18.59	10.00	50.00	63/40	94/100
Pb (ppb)	5.43	ND	25.15	ND	44.87	ND	10	10	97/100	97/100
Cd (ppb)	2.34	ND	10.07	ND	17.80	ND	3	3	97100	97/100
Cr (ppb)	5.02	ND	5.53	ND	6.03	ND	50	50	100/100	100/100
Ni (ppb)	2.88	22.55	10.73	22.55	44.33	22.55	20	20	97/80	97/80

ND: Not Detected.

7.5 Results and Discussion

The comparative analysis of results is done for all the locations considering BIS: 10,500 (BIS, 2012) standards acceptable and permissible limits for various water quality parameters. Based on the data presented above, results are discussed parameter-wise as follows:

7.5.1 pH

In water, pH indicates the acidic and alkaline conditions of water because of various geochemical reactions taking place. If pH is below 7, it indicates acidic nature of water. pH value at 7 indicates neutral condition, while pH above 7 indicates alkaline conditions.

Based on the measured values, pH varies between 6.5 to 7.9 (avg. 7.7) and falls under the acceptable limit at all the locations in post monsoon season. In pre-monsoon 2022, pH varies between 7.5 to 8.02 (avg. 7.55) and falls under the acceptable limit at all the locations. In monsoon 2022, pH varies between 7.5 to 8.02 (avg. 7.55) and falls under the acceptable limit at all the locations.

7.5.2 Electrical Conductivity (EC)

The EC of groundwater is a rapid and good measure of dissolved solids (TDS) and is directly related to the concentration of ions present in water. In post monsoon season 2021, the data indicates that EC varies considerably from 110 to 5800 µS/cm with an average of 1295 µS/cm in the groundwater samples. EC, with an equivalent limit of total dissolved solids (TDS), is found within the equivalent acceptable limit (31% samples) and all surface water samples fall within the category of equivalent permissible limit at all the sampling points.

In pre-monsson season 2022, the data indicates that EC varies considerably from 210 to 5400 µS/cm with an average of 1116 µS/cm in the groundwater samples. EC, with an equivalent limit of total dissolved solids (TDS), is found within the equivalent acceptable limit (22% samples), majority of the groundwater samples have high TDS values to the

dissolution of salts while most of the surface water samples fall in the acceptable limit and all samples were within the permissible limits.

In monsoon 2022, the data indicates that EC varies considerably from 210 to 5400 µS/cm with an average of 1116 µS/cm in the groundwater samples. EC, with an equivalent limit of total dissolved solids (TDS), is found within the equivalent acceptable limit (22% samples), majority of the groundwater samples have high TDS values to the dissolution of salts while most of the surface water samples fall in the acceptable limit and all samples were within the permissible limits.

7.5.3 Major Anions

In post monsoon 2021, the concentration of HCO_3^-, F^-, Cl^-, and NO_3^- in groundwater range from 54.9 to 1293.9 mg/l, 0.21 to 2.36 mg/l, 10 to 260 mg/l, and 0.10 to 3.10 mg/l, with average 458, 0.89, 120 and 0.61 mg/l, respectively. Fluoride and Chloride are found within the acceptable limit at 66 and 93% of locations while all other samples including surface water samples are found within permissible limit at all the locations. For bicarbonate parameter, no limit is set by BIS (2012). Thus no concerns exist with regard to major anions on the groundwater quality of the study area. Order of dominance of anions $HCO_3^- > Cl^- > SO_4^{2-} > NO_3^- > F^-$ for groundwater and $HCO_3^- > Cl^- > SO_4^{2-} > F^- > NO_3^-$ for surface water samples (fig. 2).

In pre-monsoon season 2022, the concentration of HCO_3^-, F^-, Cl^-, SO_4^{2-} and NO_3^- range from 90.28 to 866.20 mg/l, 0.03 to 16.31 mg/l, 5.29 to 923.70 mg/l, 0.11 to 572.66 mg/l, and 0.78 to 1068.50 mg/l, with average 410.84, 0.73, 120.98, 85.51 and 61.89 mg/l, respectively while in surface water samples values for these anions range from 48.80 to 262.3 mg/l, 1.14 to 16.31 mg/l, 33.93 to 336.8 mg/l, 14.68 to 627.2 mg/l, and 0.31 to 33.97 mg/l, with average 155.4, 6.63, 137.38, 269.51 and 8.61 mg/l, respectively. Chloride and sulphate are found within the acceptable limit at 91% locations in groundwater samples and 80% & 60%, respectively for surface water samples. Nitrate in 78% groundwater samples were within acceptable limit and in surface water it was safe at all the locations, while for fluoride 94% samples of groundwater and 60% samples of surface water are within the acceptable and permissible limit. For bicarbonate parameter, no limit is set by BIS (2012). Thus no concerns exist with regard to major anions on the groundwater quality of the study area. Order of

dominance of anions HCO_3^- > Cl^- > SO_4^{2-} > NO_3^- > F^- for groundwater and SO_4^{2-} > HCO_3^- > Cl^- > NO_3^- > F^- for surface water samples (fig. 2).

In monsoon 2022, the concentration of HCO_3^-, F^-, Cl^-, SO_4^{2-} and NO_3^- range from 90.28 to 866.20 mg/l, 0.03 to 16.31 mg/l, 5.29 to 923.70 mg/l, 0.11 to 572.66 mg/l, and 0.78 to 1068.50 mg/l, with average 410.84, 0.73, 120.98, 85.51 and 61.89 mg/l, respectively while in surface water samples values for these anions range from 48.80 to 262.3 mg/l, 1.14 to 16.31 mg/l, 33.93 to 336.8 mg/l, 14.68 to 627.2 mg/l, and 0.31 to 33.97 mg/l, with average 155.4, 6.63, 137.38, 269.51 and 8.61 mg/l, respectively. Chloride and sulphate are found within the acceptable limit at 91% locations in groundwater samples and 80% & 60%, respectively for surface water samples. Nitrate in 78% groundwater samples were within acceptable limit and in surface water it was safe at all the locations, while for fluoride 94% samples of groundwater and 60% samples of surface water are within the acceptable and permissible limit. For bicarbonate parameter, no limit is set by BIS (2012). Thus no concerns exist with regard to major anions on the groundwater quality of the study area. Order of dominance of anions HCO_3^- > Cl^- > SO_4^{2-} > NO_3^- > F^- for groundwater and SO_4^{2-} > HCO_3^- > Cl^- > NO_3^- > F^- for surface water samples (Fig. 2).

7.5.4 Major Cations

In post-monsoon 2021, the concentration of Ca^{2+}, Mg^{2+}, Na^+ and K^+ in groundwater samples range from 3.18 to 127.13 mg/l, 2.33 to 11.30 mg/l, 2.56 to 840.60 mg/l and 0.35 to 334 mg/l, with average 36.50, 8.42, 143.23 and 31.93 mg/l, respectively while in surface water samples values for these cations range from 11.87 to 61.71 mg/l, 4.57 to 9.09 mg/l, 6.68 to 176.2 mg/l and 1.31 to 9.9 mg/l, with average 43.88, 7.54, 88.55 and 4.33 mg/l, respectively. Calcium is found within the acceptable limit in 93% groundwater samples and 100% surface water sample while magnesium is found within acceptable limit at all the locations and all samples are found within permissible limit at all locations. Sodium and potassium are found in low concentrations. For both these parameters, no limits are set by BIS (2012). Thus there are no concerns of major cations on the groundwater quality. Order of dominance of cations are found as Na^+ > Ca^{2+} >K^+> Mg^{2+} in all the water samples (Fig. 2).

In pre-monsoon 2022, the concentration of Ca^{2+}, Mg^{2+}, Na^+ and K^+ in groundwater samples range from 27.16 to 142.80 mg/l, 4.63 to 10.24 mg/l, 15.51 to 808.10 mg/l and 0.43

to 136 mg/l, with average 65.01, 7.75, 121.24 and 12.94 mg/l, respectively while in surface water samples values for these cations range from 13.89 to 130.7 mg/l, 4.30 to 8.80 mg/l, 14.62 to 227.5 mg/l and 2.57 to 29.6 mg/l, with average 70.61, 7.34, 120.37 and 23.03 mg/l, respectively. Calcium is found within the acceptable limit in 66% groundwater samples and 40% surface water sample while magnesium is found within acceptable limit at all the locations and all samples are found within permissible limit at all locations. Sodium and potassium are found in low concentrations. For both these parameters, no limits are set by BIS (2012). Thus there are no concerns of major cations on the groundwater quality. Order of dominance of cations are found as $Na^+ > Ca^{2+} > K^+ > Mg^{2+}$ in all the water samples (Fig. 2).

In monsoon 2022, the concentration of Ca^{2+}, Mg^{2+}, Na^+ and K^+ in groundwater samples range from 27.16 to 142.80 mg/l, 4.63 to 10.24 mg/l, 15.51 to 808.10 mg/l and 0.43 to 136 mg/l, with average 65.01, 7.75, 121.24 and 12.94 mg/l, respectively while in surface water samples values for these cations range from 13.89 to 130.7 mg/l, 4.30 to 8.80 mg/l, 14.62 to 227.5 mg/l and 2.57 to 29.6 mg/l, with average 70.61, 7.34, 120.37 and 23.03 mg/l, respectively. Calcium is found within the acceptable limit in 66% groundwater samples and 40% surface water sample while magnesium is found within acceptable limit at all the locations and all samples are found within permissible limit at all locations. Sodium and potassium are found in low concentrations. For both these parameters, no limits are set by BIS (2012). Thus there are no concerns of major cations on the groundwater quality. Order of dominance of cations are found as $Na^+ > Ca^{2+} > K^+ > Mg^{2+}$ in all the water samples (Fig. 2).

7.5.5 Total Arsenic

In post monsson 2021, Arsenic ranges between 0.04 to 10.89 ppb with an average of 5.74 ppb. Ninety three percent (93%) samples are found within the acceptable limit (10 ppb) but all samples are found within the permissible limit (50 ppb) at all the locations. The locations where arsenic concentration is also slightly exceeded its acceptable limit are Jhariyari, and Piparao. This again indicates no concerns of groundwater as well as surface water quality.

In pre-monsoon 2022, Arsenic ranges between 0.17 to 24.45 ppb with an average of 6.96 ppb in groundwater samples and between 2.81 to 19.56 ppb with an average of 9.47 ppb in surface water samples. 78% of groundwater and 60% samples are found within the

acceptable limit (10 ppb) but all samples are found within the permissible limit (50 ppb) at all the locations. This again indicates no concerns of groundwater as well as surface water quality.

In monsoon 2022, Arsenic ranges between 0.17 to 24.45 ppb with an average of 6.96 ppb in groundwater samples and between 2.81 to 19.56 ppb with an average of 9.47 ppb in surface water samples. 78% of groundwater and 60% samples are found within the acceptable limit (10 ppb) but all samples are found within the permissible limit (50 ppb) at all the locations. This again indicates no concerns of groundwater as well as surface water quality.

7.5.5 Trace Metals

In post monsoon 2021, Fe, Zn, and Cu concentration range between 0.01 to 14.85 mg/l, 14.56 to 556.08ppb and 0.13 to 12.52 ppb, with average 1.50 mg/l, 162.10 ppb, and 2.79 ppb, respectively. For iron, 45% of the samples are found within the acceptable and permissible limits. There is no relaxation for the permissible limit. Zinc is found within the acceptable limits for all locations. For copper, 97% samples are found within acceptable limits and all samples are found within permissible limits.

The Pb, Cd, Cr and Ni concentration have no relaxation above their acceptable limits as per BIS (2012) standards. The concentration of Pb, Cd, Cr and Ni range between 0.12 to 11.31, 0.05 to 5.63, 0.06 to 9.89 and 0.12 to 10.98 ppb, with average of 3.03, 0.87, 1.99, and 2.80, respectively. The maximum concentration values indicate that the concentrations of all these trace metals are within the acceptable limits of BIS (2012) at all the sampling locations at all times.

In pre-monsoon 2022, Fe, Zn, and Cu concentration in groundwater samples range between 0.01 to 4.56 mg/l, 10.98 to 4461.23 ppb and 0.12 to 18.35 ppb, with average 0.87 mg/l, 514.05 ppb, and 7.10 ppb, respectively while in surface water samples these values range between 0.01 to 2.18 mg/l, 55.91 to 335.4 ppb and 3.72 to 17.29 ppb, with average 0.91 mg/l, 199.37 ppb, and 7.16 ppb, respectively. For iron, 60% of the groundwater samples and 20% of surface water samples are found within the acceptable and permissible limits, respectively. There is no relaxation for the permissible limit. Zinc is found within the

acceptable limits for all locations. For copper, 97% samples are found within acceptable limits and all samples are found within permissible limits.

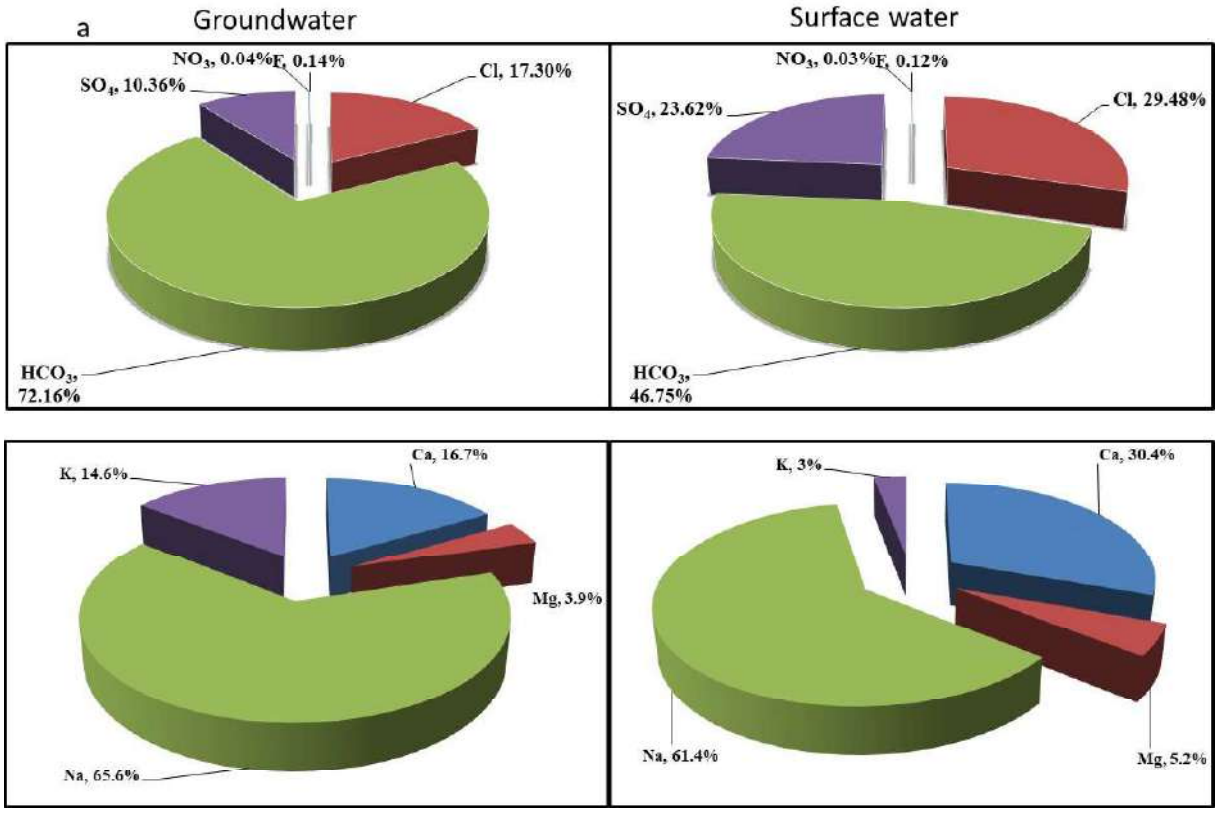
The Pb, Cd, Cr and Ni concentration have no relaxation above their acceptable limits as per BIS (2012) standards. The concentration of Pb, Cd, Cr and Ni in groundwater samples range between 0.92 to 42.40, 0.26 to 2.22, 0.11 to 7.72 and 0.40 to 31.71 ppb, with average of 10.51, 40.01, 1.79 and 4.38 ppb, respectively while in surface water samples these values range between 12.7, 0.41 to 2.39, 0.95 to 3.68 and 1.10 to 19.62 ppb, with average of 12.7, 1.18, 2.25 and 7.88 ppb, respectively. The maximum concentration values indicate that the concentrations of all these trace metals are within the acceptable limits of BIS (2012) at all the sampling locations at all times.

In monsoon 2022, Fe, Zn, and Cu concentration in groundwater samples range between 0.01 to 4.56 mg/l, 10.98 to 4461.23 ppb and 0.12 to 18.35 ppb, with average 0.87 mg/l, 514.05 ppb, and 7.10 ppb, respectively while in surface water samples these values range between 0.01 to 2.18 mg/l, 55.91 to 335.4 ppb and 3.72 to 17.29 ppb, with average 0.91 mg/l, 199.37 ppb, and 7.16 ppb, respectively. For iron, 60% of the groundwater samples and 20% of surface water samples are found within the acceptable and permissible limits, respectively. There is no relaxation for the permissible limit. Zinc is found within the acceptable limits for all locations. For copper, 97% samples are found within acceptable limits and all samples are found within permissible limits.

The Pb, Cd, Cr and Ni concentration have no relaxation above their acceptable limits as per BIS (2012) standards. The concentration of Pb, Cd, Cr and Ni in groundwater samples range between 0.92 to 42.40, 0.26 to 2.22, 0.11 to 7.72 and 0.40 to 31.71 ppb, with average of 10.51, 40.01, 1.79 and 4.38 ppb, respectively while in surface water samples these values range between 12.7, 0.41 to 2.39, 0.95 to 3.68 and 1.10 to 19.62 ppb, with average of 12.7, 1.18, 2.25 and 7.88 ppb, respectively. The maximum concentration values indicate that the concentrations of all these trace metals are within the acceptable limits of BIS (2012) at all the sampling locations at all times.

The composition and various anions and cations and type of water was also investigated using various diagrams viz. Piper diagram, Wilcox diagram, Durov's diagram, and Schoeller's diagram as follows**:**

Piper diagram of the groundwater samples collected from various locations of the buffer zone are presented in the Figure 7.3. Most of the water samples show Na^+ - Mg^{2+} and HCO_3^- type of water. Such waters have dominance of weak acidic anions. Such waters have temporary hardness. The water samples from some of the locations belong to the Cl^- - SO_4^- and Na^+ **/ mixed** type of water. Such waters have dominance of strong acidic anions.



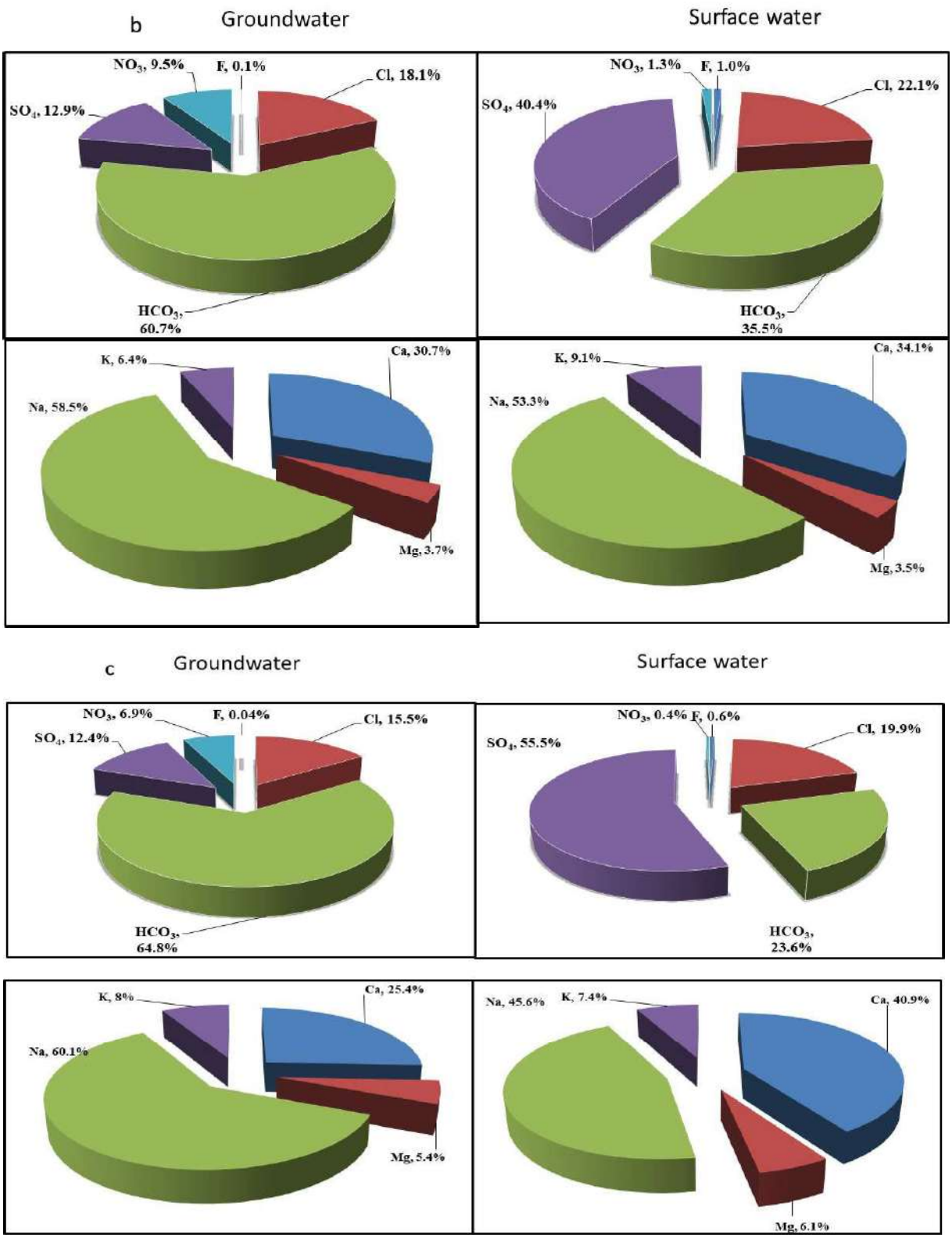


Figure 7.2. Dominance of anion and cation in water samples collected from MUNPL, MEJA

(a**)** Pre**-**monsoon, **(**b**)** monsoon **(**c**)** post monsoon**.**

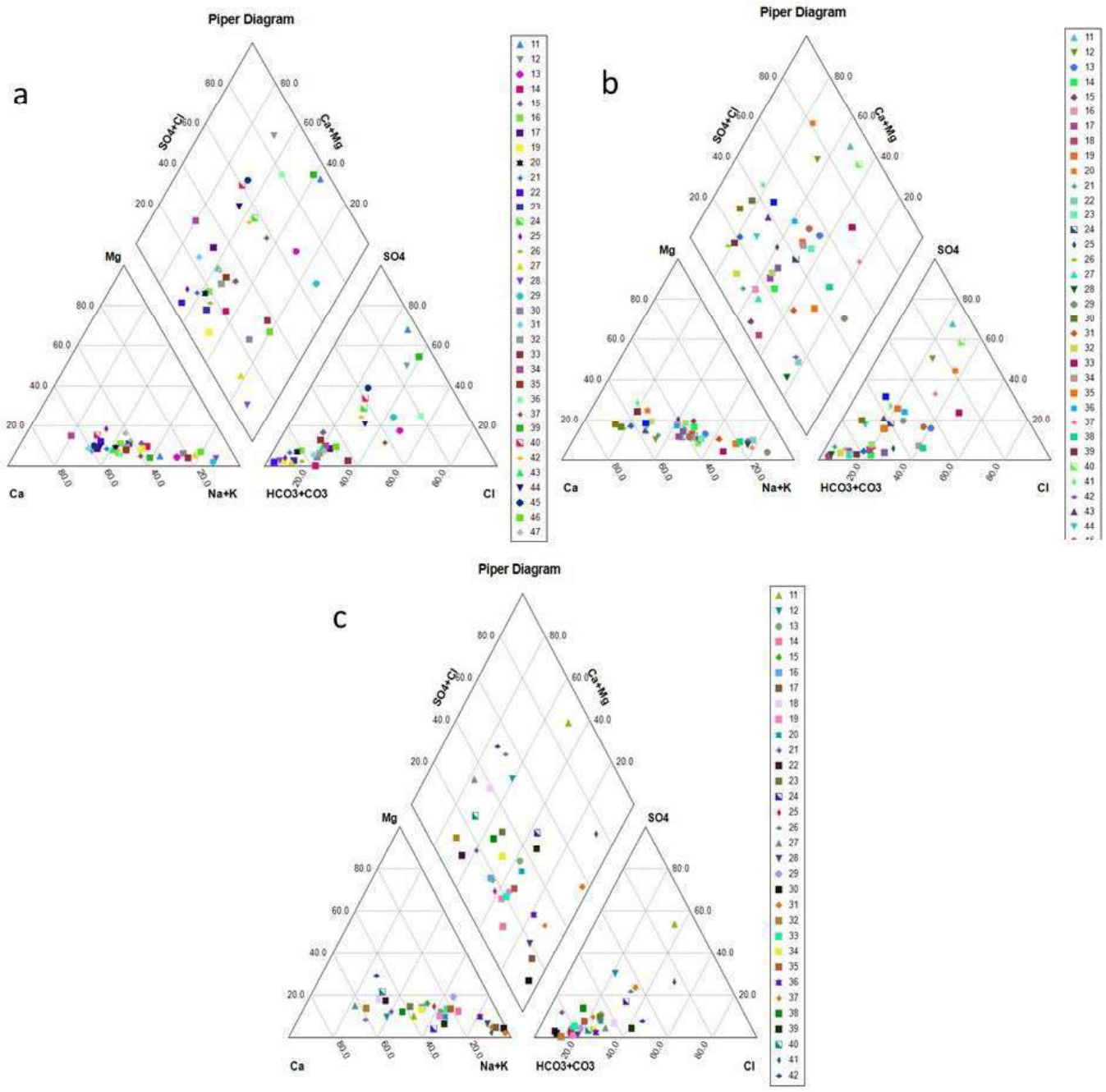


Figure 7.3. Piper diagram showing variation of anion and cation in water samples collected from MUNPL, MEJA **(**a**)** Pre**-**monsoon, **(**b**)** monsoon **(**c**)** post monsoon**.**

Wilcox diagram (Wilcox, 1955) is a useful representation of sodium alkalinity and salinity hazards. Based on this plot (Figure 7.4), most of the samples fall under the good to permissible categories

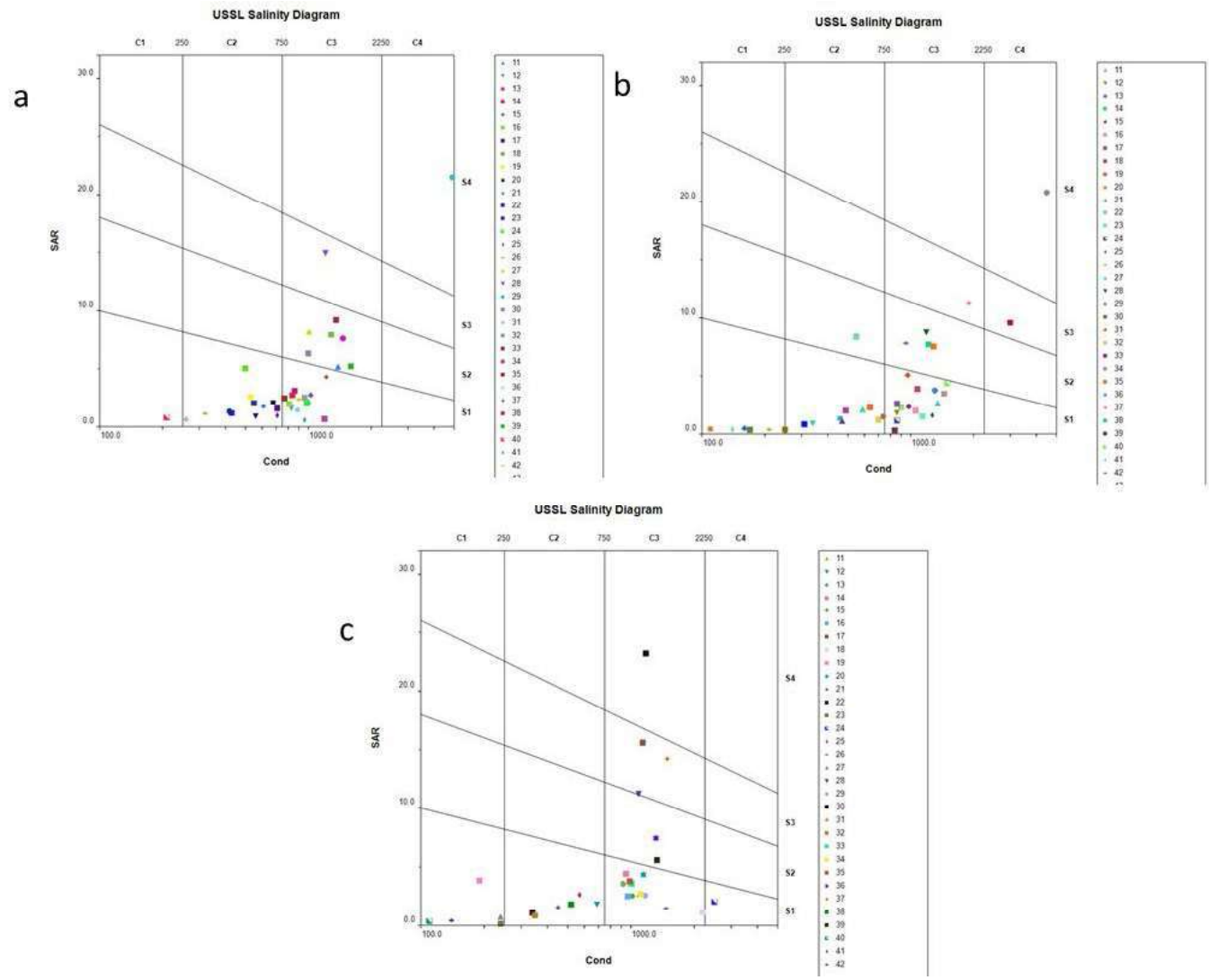


Figure 7.4. Wilcox diagram showing sodium and salinity hazard in water samples collected from MUNPL, MEJA **(**a**)** Pre**-**monsoon, **(**b**)** monsoon **(**c**)** post monsoon**.**

Durov's diagram is used to identify processes and reaction paths such as mixing, cation exchange, and dissolution affecting groundwater composition. Groundwater samples plotted on the Durov's diagram (Figure 7.5) show that the water samples for most of the samples show Na^+ – Cl^- - HCO_3^- type of water except for few locations.

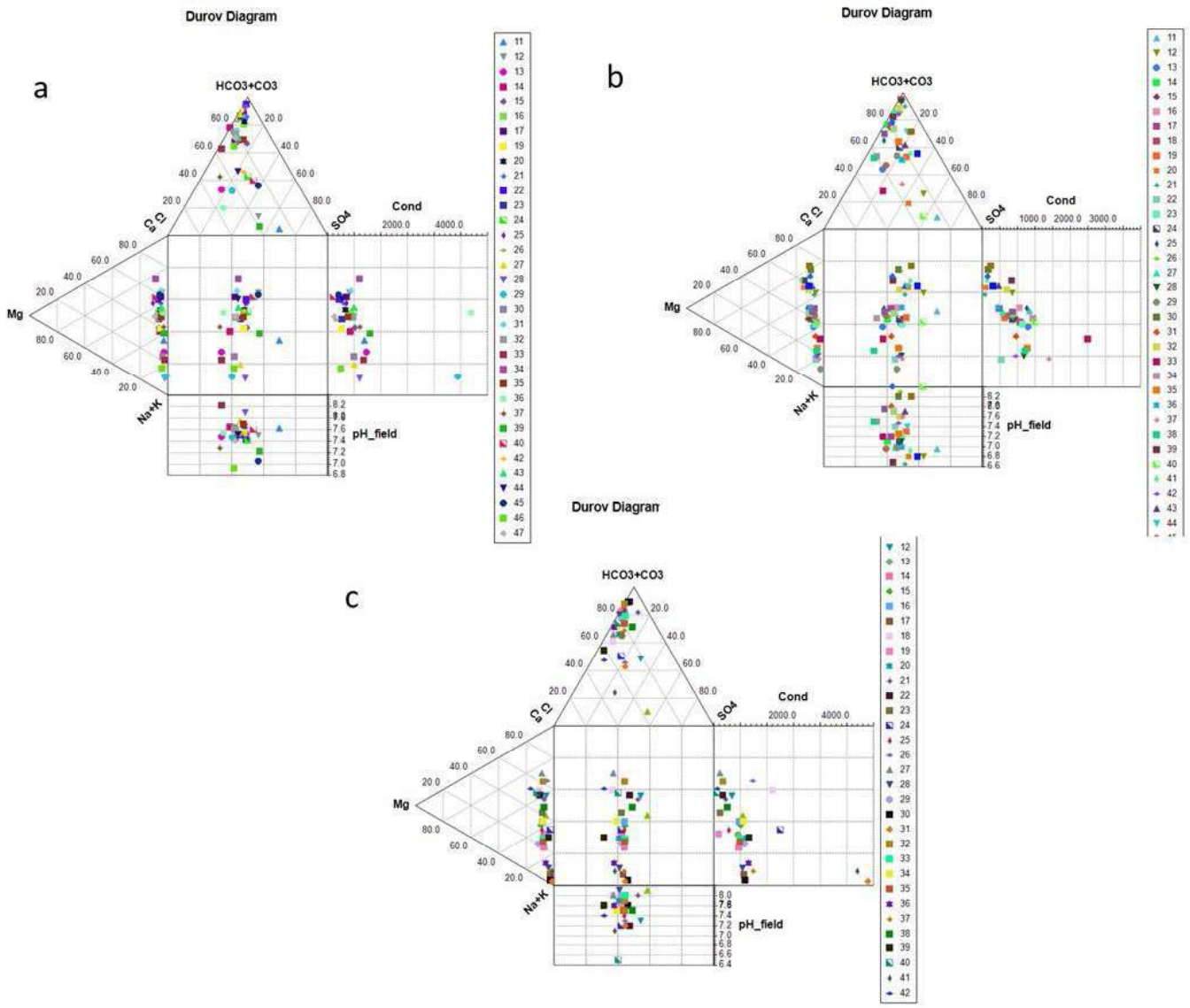


Figure 7.5. Durov's diagram dissolution effects and reaction paths in water samples collected from MUNPL, MEJA **(**a**)** Pre**-**monsoon, **(**b**)** monsoon **(**c**)** post monsoon**.**

Groundwater chemical analysis is also performed on the Schoeller's diagram (Figure 7.6), which reveals that the groundwater samples of the study area had more or less the same trend of major ions; most dominated by the Na^+ and HCO_3^- ions.

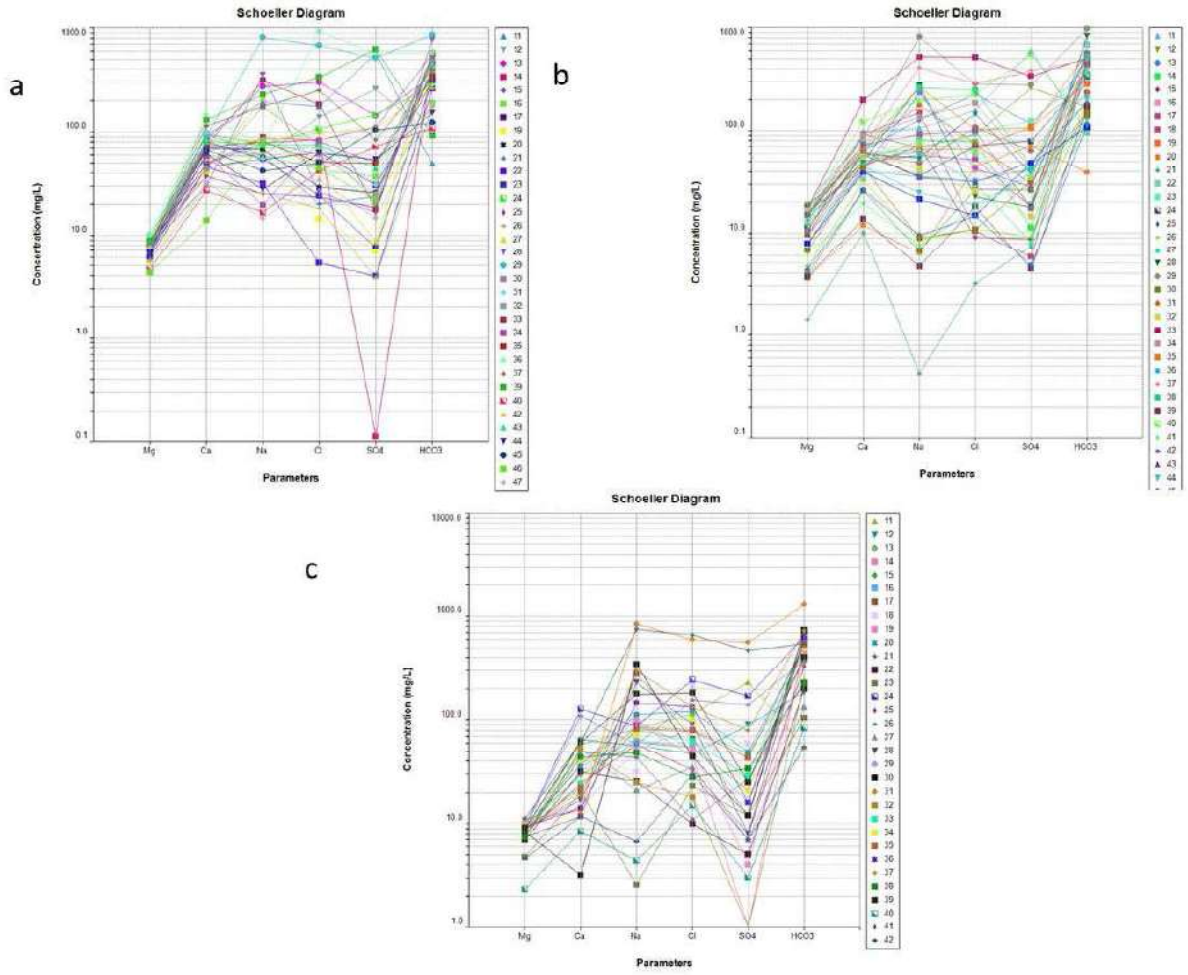


Figure 7.6. Schoeller's diagram showing facies of water samples collected from MUNPL, MEJA **(**a**)** Pre**-**monsoon, **(**b**)** monsoon **(**c**)** post monsoon**.**

7.8 Summary

(i) Ambient groundwater and surface water from various locations of the buffer zone have been analysed based on the samples collected from the field. The sampling locations were widespread in and around the study area. In general, mostly the water quality parameters were found within the permissible limits and some exceeding the limits.

(ii) pH and EC/TDS are found mostly within the permissible limits except TDS of few samples was found exceeding the permissible limit. Bicarbonates are found in low concentration, therefore, total hardness is also within the permissible limit..

(iii)Calcium is found exceeding the permissible limit in some groundwater samples, being geogenic in nature, and one surface water sample. Potassium is found in low concentration while concentration of sodium at few locations is found in higher concentration.

(iv)In post monsoon 2021, Fluoride and Chloride are found within the acceptable limit at 66 and 93% of locations while all other samples including surface water samples are found within permissible limit at all the locations.

(v) In pre-monsoon 2022, Chloride and sulphate are found within the acceptable limit at 91% locations in groundwater samples and 80% & 60%, respectively for surface water samples. Nitrate in 78% groundwater samples were within acceptable limit and in surface water it was safe at all the locations, while for fluoride 94% samples of groundwater and 60% samples of surface water are within the acceptable and permissible limit.

(vi) In monsoon 2022, Chloride and sulphate are found within the acceptable limit at 91% locations in groundwater samples and 80% & 60%, respectively for surface water samples. Nitrate in 78% groundwater samples were within acceptable limit and in surface water it was safe at all the locations, while for fluoride 94% samples of groundwater and 60% samples of surface water are within the acceptable and permissible limit.

(vii) Concentration of fluoride in 33% groundwater samples; sulphate and nitrate in 22 % groundwater samples are found beyond the permissible limit.

(viii) For arsenic, all samples are found within the permissible limit (50 ppb) for all the sampling locations.

(ix) In post monsoon 2021, iron in 45% of the samples are found within the acceptable and permissible limits. There is no relaxation for the permissible limit. Zinc is found

within the acceptable limits for all locations**.** For copper, 97**%** samples are found within acceptable limits and all samples are found within permissible limits**.**

(x) In pre monsoon 2022, iron in 60% of the groundwater samples and 20% of surface water samples are found within the acceptable and permissible limits, respectively. There is no relaxation for the permissible limit. Zinc is found within the acceptable limits for all locations. For copper, 97% samples are found within acceptable limits and all samples are found within permissible limits.

(xi) In monsoon 2022, iron in 60% of the groundwater samples and 20% of surface water samples are found within the acceptable and permissible limits, respectively. There is no relaxation for the permissible limit. Zinc is found within the acceptable limits for all locations. For copper, 97% samples are found within acceptable limits and all samples are found within permissible limits.

(xii) No impact of MUNPL, MEJA effluents is found on the surface and ground water regime because no effluents are discharged out by the MUNPL, MEJA and the effluents from the ash dyke also do not indicate any harmful parameter.

Table 7.3: Comparison of groundwater quality parameters of samples collected from the study area

PLOTS	PRE-MONSOON	POST-MONSOON	MONSOON
Pie chart	The majority of samples are Na-HCO_3 type then Ca-Cl or $CaSO_4$type	The majority of samples are Na-HCO_3 type then Ca/K-Cl type.	-
Wilcox	0.67% of samples are unsuitable and 2% are permissible to doubtful while a significant majority of 97.33% fall in the excellent to good category.	0.67% of samples are unsuitable 1% are doubtful to unsuitable 2.3% are permissible to doubtful 16.7 fall in good to permissible while a significant majority of 79.3% fall in the Excellent to good category.	

Piper Water Type	47% Ca-HCO_3 14.7% Na-Cl-SO4 type and Ca-Na-HCO_3 type each,8.82% $NaHCO_3$ 11.8% mixed Ca Mg Cl type 2.9% CaCl	41.22 % Ca-HCO_3 14.7% Na-Cl-SO4 type 17.64% mixed CaMg-Cl type and CaNa-HCO_3 type each 5.9% Na-HCO_3 type 2.9% CaCl	17.64% $NaHCO_3$ 5.9% $NaClSO_4$ 11.8% mixed CaMgCl 23.5% $CaHCO_3$ 41.16 % $CaNaHCO_3$
Durov Dominance	67.5% of samples belong to field 5, indicating exchanged water where HCO_3^- and Na^+ are dominant,20.8% fall in field 8, indicating the dominance of Na+ and Cl-,5.9% of samples belong to field 2, 2.9% of samples in field 6, indicating either a dominance of Sulphate or an indiscriminate anion, and Na^+ dominant cation,2.9% of samples in field 7 indicates Cl and Na dominance, which may be due to reverse ion exchange of NaCl waters.	67.3% of the data points fall in field 5, indicating exchanged water where HCO_3^- and Na^+ are dominant 20.8% fall in field 8, indicating the dominance of Na+ and Cl-rest 2.9% of samples fall in field 2 dominated by Ca and HCO_3 ions.	67.7% of samples belong to field 5, indicating exchanged water where HCO_3^- and Na^+ are dominant,29.4% of samples belong to field 8 indicating the dominance of Na+ and Cl-,2.9% of samples fall in field 2 dominated by Ca and HCO_3 ions.
USSL	,11.8%C_3S_2 17.6% C_1S_1 29.4%C_1S_2 29.6% C_3S_1 2.9% C_4S_4 2.9% C_3S_4 2.9% C_3S_3 2.9% C_2S_2	2.9% C_4S_4 2.9% C_3S_3 2.9% C_1S_1 20.6% C_3S_2 35.3 % C_2S_1 35.4% C_3S_1	2.9% C_3S_1 2.9% C_4S_1 8.8% C_3S_3 8.8% C_3S_2 14.7% C_1S_1 17.6% C_2S_1 44.3% C_3S_1
Schoeller	Higher levels of Na, HCO_3, and Cl lower levels of Mg, Ca and SO_4 .weak acids (CO_3^{2-} and HCO_3^-), dominant over strong acids (Cl^- and SO_4^{2-})	Higher levels of Na, HCO_3, Cl, and SO4 lower levels of Mg, Ca weak acids (CO_3^{2-} and HCO_3^-), almost equal to strong acids (Cl^- and SO_4^{2-})	Higher levels of Na, HCO_3, Cl, and SO_4 lower levels of Mg, Ca weak acids (CO_3^{2-} and HCO_3^-), almost equal to strong acids (Cl^- and SO_4^{2-})
HPI	Dighalo(238.41) has the highest HPI while the rest have low HPI	Dighalo(99.57) and Baghol(118.68) have higher HPI, Salaya Khurd and Salaiya Kala have medium HPI while the rest have low HPI	Salaiya kala(33.15) and Dasauti(21.37) have medium HPI and Baghol(57.8) has a slightly higher HPI while Dighalo (369.78) has the highest HPI. Rest have low HPI

The values of various groundwater quality parameters are of geogenic nature and no impact of MUNPL, MEJA effluents has been observed on the surface and ground water quality of the study area.

8 Source sustainability

8.1 General

Sustainable water systems should provide adequate water quantity and appropriate water quality for a given need, without compromising the future ability to provide this capacity and quality. Water systems in the realm of sustainable development may not literally include the use of water, but include systems where the use of water has traditionally been required. There are 3 important components required: economic feasibility, social responsibility and environmental integrity

8.2 Water usage in plant

In the plant area and residential area, water is generally used for:

(1) drinking,

(2) in industrial operations (energy production, manufacturing of goods, etc.),

(3) domestic applications, and

(4) agriculture (irrigationg the plantations)

The total allocated water to the power plant is 32,29,480 m^3/month and maximum usage of the water is 28,47,173 m3 during the period 2021-24 which is well within the limits.

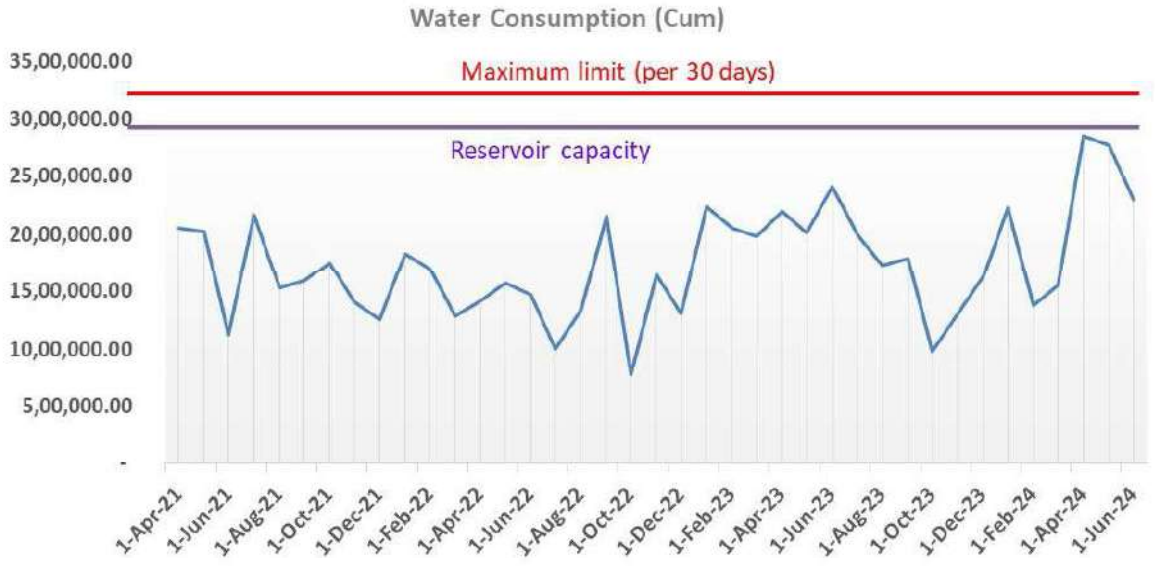


Figure 8.1. Water usage in the power plant.

9 APPRAISAL AND REMEDIAL MEASURES

9.1 Influence of MUNPL, MEJA, Meja power plant Effluents on the Water Quality of the Area and its Surroundings

In the present investigations, groundwater and surface water samples were collected from MUNPL, MEJA, Meja power plant area and surrounding areas including plant effluents. After the determination of selected heavy metal content in groundwater and surface water samples, the collected data was used for the calculation of heavy metal pollution index (HPI) by using the permissible limits of heavy metal for drinking water and the permissible limits for occurrence in natural water resources. By using the statistical formulae and methodology, heavy metal pollution index for groundwater and surface water resources for the selected sampling sites were determined. The calculated heavy metal pollution index for the representative samples of ground and surface water are summarized in Table 10.1.

The heavy metal pollution index (HPI) of the underground and surface water samples was calculated using the following equation:

$$HPI = \frac{\sum_{n=1}^{n} WiQi}{\sum_{n=1}^{n} Wi} \quad \ldots \quad (10.1)$$

Where, Wi = Unit Weightage of the i^{th} parameter, Qi = Sub index of the ith parameter, n = is the total number of parameters considered. Weighted arithmetic index method has been used for calculation of HPI. The unit weight (Wi) has been found out using the formula:

$$Wi = \frac{K}{Si} \quad \ldots \quad (10.2)$$

Where, K = proportionality constant, Si = standard permissible value of the ith parameter.

The sub-index (Qi) of the parameter is calculated by the equation:

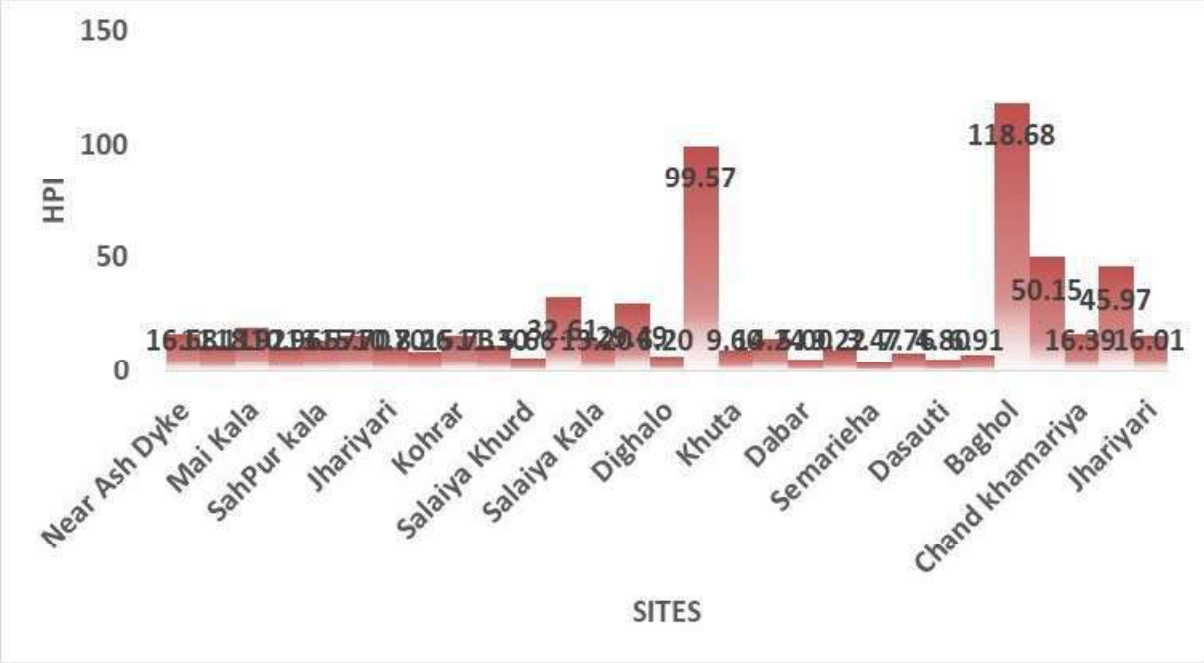
$$Qi = \sum_{n=1}^{n} \frac{|Mi - Ii|}{Si - Ii} \quad \ldots \quad (10.3)$$

Where, Mi = is the monitored value of heavy metal of the ith parameter, Ii = is the ideal value of the ith parameter which is taken from the Indian drinking water specification (BIS, 2012), Si = is the standard value of the i^{th} parameter (ppb). After completion of the result, the concentration of each pollutant was converted into the HPI. The higher HPI value causes the greater damage to the health. Generally, the critical heavy metal pollution index value is 100.

Table 9.1. Calculated HPI for various water sampling sites.

Sl. No.	Post monsoon (Dec 21)		Pre-Monsoon (May 22)		Monsoon (Aug 22)	
	Village	HPI	Village	HPI	Village	HPI
1	Ash Dyke	16.68	Ash Dyke	43.47	Ash Dyke	20.90
2	Patai	11.11	Patai	19.95	Patai	0.74
3	Mai Kala	18.92	Mai kala	19.17	Mai kala	0.98
4	SahPur kala1	10.96	Sahpur Kala1	11.93	Sahpur Kala1	1.06
5	SahPur kala2	13.57	Sahpur Kala2	13.12	Sahpur Kala2	0.74
6	SahPur kala3	15.70	Sahpur Kala3	13.39	Sahpur Kala3	0.72
7	Jhariyari1	10.70	Jhariyari1	14.95	Kohrar	0.04
8	Jhariyari2	8.26	Jhariyari2	10.85	Lal Tara	0.27
9	Kohrar	15.73	Kohrar	13.38	Saliya Khurd	0.93
10	Lal Tara	11.30	Lal Tara	13.76	Salaiya Kala1	0.73
11	Salaiya Khurd	5.66	Saliya Khurd	12.45	Salaiya Kala2	33.13
12	Salaiya Kala1	32.61	Salaiya Kala	17.43	Piparao	0.97
13	Salaiya Kala2	13.20	Piparao	19.24	Dighalo1	1.12
14	Piparao	29.49	Dighalo1	238.41	Dighalo2	1.27
15	Dighalo1	6.20	Khuta 1	29.27	Khuta 1	0.88
16	Dighalo2	99.57	Khuta 2	14.84	Khuta 2	4.08
17	Khuta1	9.60	Kathauli	12.74	Kathauli	1.44
18	Khuta2	12.22	Dabar	14.30	Dabar	0.74

19	Kathauli	14.24	Subhash	15.25	Subhash	3.38
20	Dabar1	5.00	Semarieha	5.79	Shamlipur	1.19
21	Dabar2	9.22	Koraon	11.77	Semarieha	0.61
22	Siyamlipur	15.90	Dasauti	14.62	Koraon	1.35
23	Semarieha	3.47	Itwakala	11.47	Dasauti	21.37
24	Koraon	7.76	Baghol	28.51	Itwakala	1.54
25	Dasauti	4.80	Saliya Khurd2	28.79	Baghol	57.80
26	Itwakala	6.91	Chand Khamariya	31.35	Saliya Khurd2	2.04
27	Baghol1	118.68	Pal Patti	22.05	Chand Khamariya	7.10
28	Baghol2	50.15	Jhariyari3	11.72	Pal Patti	1.12
29	Chand khamariya	16.39	Ash Dyke2	26.19	Jhariyari	6.07
30	Pal patti	45.97	Dabar Paudhsala	45.84	Ash Dyke2	2.47
31	Jhariyari	16.01	Subhash2	14.73	Dabar Paudhsala	0.22
32	Ash Dyke2	9.37	Ash Dyke3	15.96	Subhash2	0.94
33			Ash Dyke4	16.00	Ash Dyke3	2.93
34			Dighalo2	836.78	Jhadiyahi	1.68
35			Shambholri Nagar	24.06	Dighalo	369.83
36			Khamoriya	32.66	Shambri	1.99
37			Tons River	50.84	Khamoriya	1.57
38					Tons River	2.51
39					Lal Tara2	0.23
40					Pal Patti2	1.77


150
100
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Near Ash Dyke
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Kohrar
Salaiya Khurd
Salaiya Kala
Dighalo
Khuta
Dabar
Semarieha
Dasauti
Baghol
Chand khamariya
Jhariyari
SITES


900
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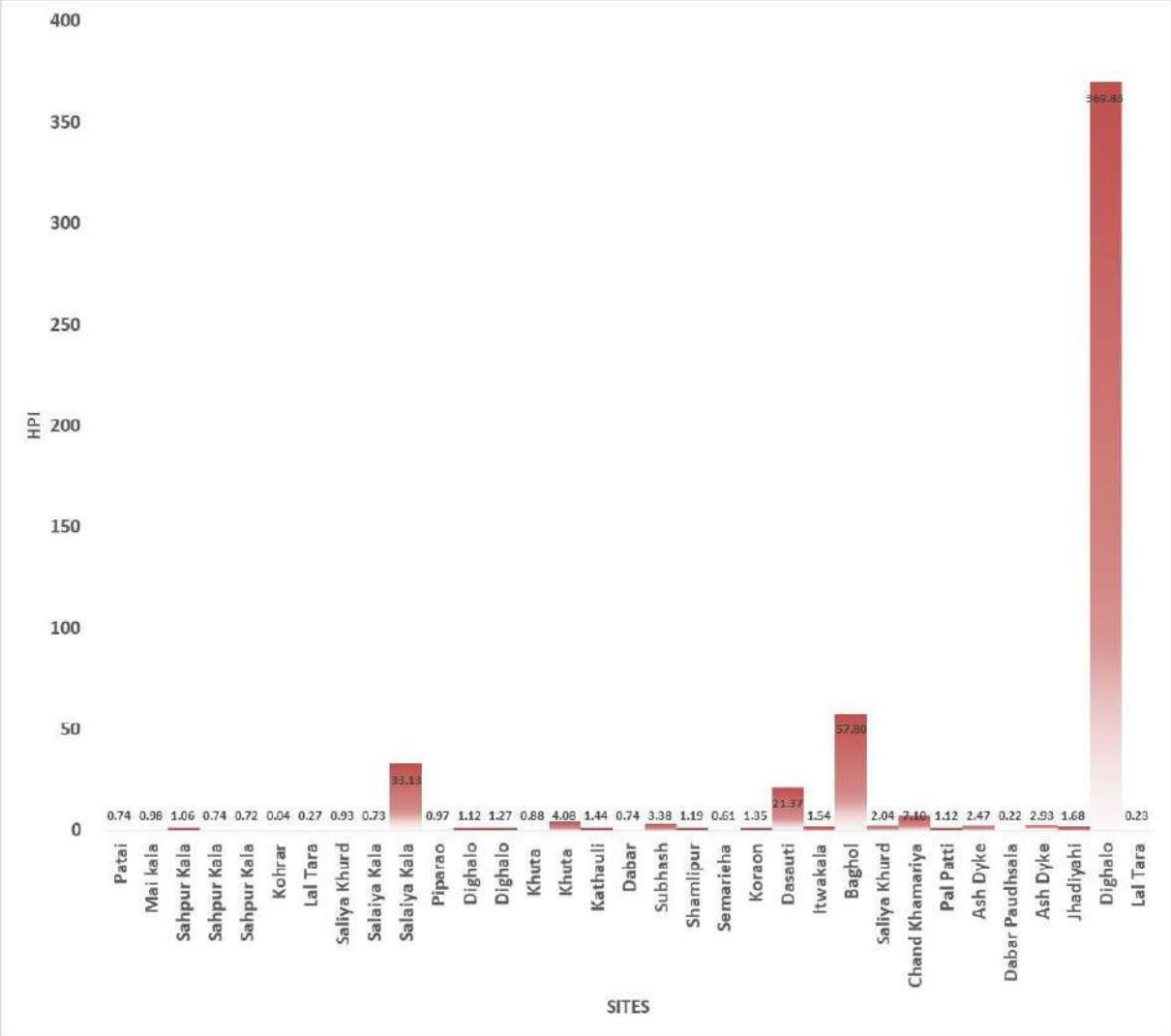

Figure 9.1. Heavy metal pollution index for various water sampling sites (post monsoon, Pre-monsoon and monsoon)

It is seen from Figure 10.1 that the HPI of groundwater for most of the sampling locations is low as compared with the critical pollution limit of 100. Among the groundwater samples, the HPI of hand pumps located at Baghol and Dighalo is more than 100 and require further monitoring while the least (0.72) HPI was found for Shahpur Kala 2.

It is obvious that higher the heavy metal pollution index value, greater the threat. Values of almost all samples are well within the critical limit of 100 values. This high values of HPI at these sites may be due to the high iron and lead contents in groundwater

(beyond permissible limit). HPI is fully based on the results of the collected groundwater samples.

9.2 Influence of Effluents of MUNPL, MEJA project on the Characteristics of Sub-Surface Formations

The influence of MUNPL, MEJA effluents was analysed in multiple ways through soil sampling and water sampling from MUNPL, MEJA project area and a buffer zone of 25 km. Water samples were collected from the project area namely Hand Pump, pond etc. The pond does not indicate any signs of contamination due to MUNPL, MEJA. Some general physico-chemical parameters of the hand pump water are found beyond the BIS permissible limit. However, the heavy metal pollution index (HPI) of groundwater does not indicate any sign of contamination due to MUNPL, MEJA project. The water sample from the pond falls beyond the BIS permissible limits. Some samples has concerns related to water quality and needs proper management with respect to its quality. The surface soils are mainly sandy or silt loam type, which provide enough protection from surface contamination to leach down into the subsurface.

9.3 Recommendations regarding solutions for prevention and control of pollution - Suggested environmentally sound and sustainable management plan for handling of plant effluents

In general, the generation of large volume of water from the project area containing heavy metals may be an unavoidable situation because the industry needs large quantities of water to pump out for the project operations and thereby disposed-off all this water in a planned and safe manner. The MUNPL, MEJA is already having its properly managed system from pumping of water from the plant area up to the ash dyke. Moreover, MUNPL,

MEJA has maintained the zero waste water disposal policy. MUNPL, MEJA is also having the sewage treatment plant for proper treatment of their domestic effluents.

The MUNPL, MEJA should continue to comply with the water conservation techniques like zero wastewater discharge, reuse of demineralised backwash water after proper treatment and implement rain water harvesting.

Remedial measures for the control of pollution, in future as well, are given below. Effluents should be managed properly by:

1. Complete lining of drains carrying effluents for disposal to prevent leaching of heavy metals and groundwater contamination.
2. Creating plantations and irrigate them.
3. Continuous monitoring of the groundwater conditions using piezometers.
4. Maximising recycling of the treated effluents in the plant.
5. Public awareness raising programmes are also important for the preventive measures.

9.4 Development of monitoring network

Network planning is the backbone of any monitoring system. In hydrology, monitoring of data is mostly site specific and proper representation of this data on spatial scale requires proper network planning. Therefore, going for any kind of instrumentation in any area or basin, planning for the establishment of network stations for instrumentation is of prime importance. From the study it has been found that Water level measurements from observation wells are the principal source of information about the hydrologic stresses acting on aquifers and how these stresses affect ground water recharge, storage, and discharge. Monioring of wells at Salaikalan and Maikalan are important and maximum water level fluctuations are observed.

In addition to monitoring surface water for Tons river and Ganga river, groundwater monitoring network is necessary for measurements of groundwater level and groundwater quality. The data monitored under this task are used to estimate the availability of groundwater storage, its variation with time both in quantity and quality. These networks can

also be used for water sample collection for the isotopic analysis for identification of potential sources of recharge.

Groundwater with high salinity values are found in Subhash and Sauti; high fluoride concentrations are observed at Khuta and Lal Tara, Trace metals are found higher in Dighalo. These points should be monitored for water quality regularly 2 times a year, pre-monson and post monsoon seasons.

10. Summary, Findings and Recommendations

10.1 Summary

(a) The Meja Urja Nigam Pvt. Ltd. (MUNPL, MEJA) a joint venture incorporated in 2008 between NTPC and UPRVUNL in District Prayagraj of Uttar Pradesh. The present capacity of TPP is 1320 MW (2×660 MW) and the same is under commercial operation. The plant is also connected to river Ganga at Bijora village, through a network of about 30 km pipeline, to transport water for industrial purposes. Meja Thermal Power Station is the first supercritical power plant (SCPP) of Uttar Pradesh. It uses 20 per cent less coal compared to them. It generates less carbon emissions. A supercritical coal plant is a coal-fired power plant with more modern designs. It differs from traditional coal power plants as the water running through it works as a supercritical fluid. This reduces the amount of heat transfer to the water which in normal cases is needed in a conventional coal plant. Therefore, less coal is used to heat the same amount of water.

(b) The core zone area is comprised of the 'Meja Project Area' measuring about 6400 ha (64 sq. km) that lies between the latitudes 25° 06' 45" to 25° 11' 33"N and longitudes 81° 52' 30" to 82° 00' 00"E, and the 'Buffer Zone' of 25 km from the Meja Project Area measuring about 19,5900 ha (1959 sq. km) that lies between the latitudes 24o 50' to 25o 25' N and longitudes 81o 40' to 82o 15' E. The extended buffer zone area all around the Meja Project Area has been taken for analysis to investigate the physiography of the surrounding area particularly to see the connectivity of the surface drainage pattern, settlements, water bodies, groundwater, etc. All these areas lie in the Survey of India Toposheet No. 63G16.

(c) The study area is characterized by Active Flood Plains, Older Alluvial Plain and Rocky Surface (Denudational hills). The active flood plain is quite localized and confined only to the river system, whereas the older alluvial plain is characterized by depositional and erosional terraces found in patches along the active plain. The denudational hills found prominent in trans Yamuna area formed mainly of quartzite10 and the core area of the Meja power plant is situated on the denudational hills. The MUNPL, MEJA project area is occupying part of Ganga basin and another part of Tons Sub- basin. The seasonal rivers as well as tributaries are ephemeral and flow only in response to heavy precipitation.

(d) The district represents a complex geology with the formation belonging to Quaternary (Alluvium - Sand, silt, clay and Kankar, Laterite.) period covering major part in the northern side of the district overlying the Vindhyan formations (Sand stone and shale - Kaimur sandstone and Bijaigarh Shale) in the southern plateau. The oldest formations exposed are Bijaigarh Shale in the edge of the district around Hanumangunj in Koraon block. Further to the north the sandstone and quartzites, representing the uppermost part of the Kaimur series, are seen as isolated part of the district covering the blocks of Meja,,Manda, Koraon and Shankargarh, The Vindhyans forms the floor of the younger sediments in the Cis-Yamuna area. The Laterite normally overlies Vindhyans at certain places. It is reddish brown to chocolate in color, highly ferruginous, and perforated mass. Alluvium found in the whole of Trans-Ganga, Doab and Part of Trans - Yauna tract of Quaternary age. The alluvium detritus of Vindhyan is found at some places in the southern part of the Doab. In Trans - Yamuna tract, The Vindhyan detritus merges with the Yamuna sand and silt. The thickness of the alluvial sediments gradually increases in the north and maximum thickness is encountered within the flood plain area of river

Ganga and Yamuna. Greater thickness is encountered within the Trans - Ganga area where it exceeds 300 meters followed by doab region where it is less than 250 meters and ultimately less than 50 meters in the Trans-Yamuna region. The alluvial sediments essentially composed sands of various grades, clay and silts within the unconsolidated granular mass assemblage of nodular concretions of Calcium Carbonate have been recorded at different depths (CGWB, 2019).

(e) Groundwater occurs in alluvium and in the weathered and joint sandstones in areas which are underlain by the hard rocks. Two broad hydrogeological units, namely, unconsolidated (Alluvium) and consolidated (hard rock) are the major components. The Alluvial formations occur in the Trans-Ganga and Doab region. Occurrence of consolidated formations is restricted primarily to Trans Yamuna tract. In the study area, the thickness of alluvium is more than 300 m with the discharge rates of 2000-3000 lpm.

(f) In the study area wells and tube wells are the main ground water abstraction structures. Ground water is being developed in the area by medium to deep tube wells, dug wells, dug-cum bored wells. Based on 3 exploratory wells data in the area CGWB observed yield at Pipraon village was about 770 lpm (good to excellent on groundwater prospective) whereas yield of 107 lpm encountered at Saliya Khurd village belongs to very poor prospective area.

(g) Analysis of long series daily rainfall data of 36 years (1985-2021) of the study area showed that annual rainfall varied from year to year ranging between 379. mm to 1300 mm with an average of 858 mm. About 921 mm (89.07 % of the annual rainfall) is received during the monsoon months, June through September. Probability analysis of the annual rainfall data carried out at various dependability levels showed that the

quantity of rainfall at 20%, 50%, and 90% probability of exceedance is 370, 250, and 130 mm, respectively.

(h) The bore hole drilling data reveals that the lithology of the region is basically, Sandstone of various grade and composition. The water bearing zone in the area is comprises of fractured sandstone basically between 200-240, 260-280 ft bgl.

(i) Ambient groundwater and surface water from various locations of the buffer zone have been analysed based on the samples collected from the field. The sampling locations were widespread in and around the study area. In general, mostly the water quality parameters were found within the permissible limits and some exceeding the limits.

(j) In monsoon 2022, iron in 60% of the groundwater samples and 20% of surface water samples are found within the acceptable and permissible limits, respectively. There is no relaxation for the permissible limit. Zinc is found within the acceptable limits for all locations. For copper, 97% samples are found within acceptable limits and all samples are found within permissible limits.

(k) No impact of MUNPL, MEJA effluents is found on the surface and ground water regime because no effluents are discharged out by the MUNPL, MEJA and the effluents from the ash dyke also do not indicate any harmful parameter.

10.2 Findings

(i) The area shows large variations in the topography, with a slope range of 0 to 30.30 degrees

(ii) The trend analysis carried out on the annual rainfall time series covering 36 years' period from 1985 to 2021 indicated the significant rising trend in the annual rainfall of the area.

(iii) The infiltration rate varies from 0.3 (Ladiyari) to 7 mm/hour (Basahih) in various parts of the study area indicating low infiltration rates.

(iv) In the drilling cuttings it was observed that secondary porosity was developed in vugs/veins resulting increased porosity and permeability, hence these sandstones are producing low to medium discharge.

(v) The resistivity (VES-01) data demarked the zones between 53.0 to 56.0m, 67.5 to 70.0m and 77.0 to 84.0m and 89 to 95m, are jointed/ fractured Sandstone showing the signature of water bearing zone in VES-01. Moreover, at VES-02 between 15 to 20m and 56 to 63m depth where the fractured/jointed sandstone layers are showing relatively low resistivity values close to water bearing zone and might be the good option to develop recharge borewell for rainwater harvesting purpose.

(vi) In the pump test, Thesis's Time-drawdown curve matching method show Transmissivity value of the piezometer around 0.40 m2/day, whereas, Theis's recovery method the Transmissivity of the aquifer is coming approx. to 0.37 m2/day. Indicating very low value of transmissivity and that can result to low yield.

(vii) Depth to water level ranges from 2.4 to 8.6 mbgl, during the survey period in September 2023. In Monsoon 2424, it was observed that water levels are higher which are going down by about 5-10 m down in the pre-monsoon period.

(viii) pH and EC/TDS are found mostly within the permissible limits except TDS of few samples was found exceeding the permissible limit. Bicarbonates are found in low concentration, therefore, total hardness is also within the permissible limit.

(ix) In post monsoon 2021, Fluoride and Chloride are found within the acceptable limit at 66 and 93% of locations while all other samples including surface water samples are found within permissible limit at all the locations. Concentration of fluoride in 33% groundwater samples; sulphate and nitrate in 22 % groundwater samples are found beyond the permissible limit.

(x) For arsenic, all samples are found within the permissible limit (50 ppb) for all the sampling locations.

(xi) The influence of MUNPL, MEJA effluents was analysed in multiple ways through water sampling from MUNPL, MEJA project area and a buffer zone of 25 km. Water samples were collected from the project area namely Hand Pump, pond etc. The pond does not indicate any signs of contamination due to MUNPL, MEJA. Some general physico-chemical parameters of the hand pump water are found beyond the BIS permissible limit. However, the heavy metal pollution index (HPI) of groundwater does not indicate any sign of contamination due to MUNPL, MEJA project. The water sample from the pond falls beyond the BIS permissible limits. Some samples have concerns related to water quality and needs proper management with respect to its quality. The surface soils are mainly sandy or silt loam type, which provide enough protection from surface contamination to leach down into the subsurface.

(xii) The influence of MUNPL, MEJA on the surround areas was analysed in multiple ways through water sampling from MUNPL, MEJA project area and a buffer zone of 25 km.

The values of various groundwater quality parameters are of geogenic nature and no impact of MUNPL, MEJA effluents has been observed on the surface and ground water quality of the study area. However, it is advised to review the groundwater quality status after every three years.

10.3 Recommendations

(i) Though the MUNPL, MEJA has already implemented many rainwater conservation measures, they may further continue to implement more conservation measures in future as well. It is also recommended to make maximum possible reuse of treated wastewater in the project area.

(ii) Remedial measures to protect the surface and ground water resource from contamination, in future, are as follows:

a) Complete lining of drain carrying effluents for disposal to prevent leaching of heavy metals and groundwater contamination.

b) Creating plantations and irrigate them.

c) Continuous monitoring of the groundwater conditions using piezometers.

d) Maximum recycle and reuse of the treated effluents in the plant.

e) Public awareness raising programmes are also important for the preventive measures.

Annexure-I

Water Quality Results of Samples Collected from the MUNPL, MEJA project area and Surroundings during the Study Period

(a) Physico-Chemical and Major Ion Parameters (December, 2021)

Serial no.	Location	Source	pH	EC (µS/cm)	CO_3^{-2} (mg/L)	HCO_3^- (mg/L)	F^- (mg/L)	Cl^- (mg/L)	SO_4^{--} (mg/L)	NO_3^- (mg/L)	NO_2^- (mg/L)	Ca^{++} (mg/L)	Mg^{++} (mg/L)	Na^+ (mg/L)	K^+ (mg/L)
1	Ash Dyke	Ash Dyke	7.9	1100	0.0	54.9	0.94	115	54.9	230	n.a.	58.07	9.09	**82.77**	**9.89**
2	Patai	Patai	7.3	690	0.0	184.22	0.26	47	184.22	90	n.a.	64.39	7.39	**56.94**	**0.35**
3	Mai Kala	Mai kala	7.5	920	0.0	367.22	0.72	82	367.22	47	n.a.	30.67	8.78	**85.88**	**0.4**
4	SahPur kala	Sahpur Kala	7.6	950	0.0	564.86	0.35	45	564.86	1	3.68	20.73	8.74	**94.43**	**1.2**
5	SahPur kala	Sahpur Kala	7.7	1020	0.0	524.6	0.96	54	524.6	21	n.a.	29.52	9.68	**61.15**	**2.33**
6	SahPur kala	Sahpur Kala	7.7	970	0.0	520.94	0.41	55	520.94	16	n.a.	35.57	9.25	**63.90**	**4.16**
7	Jhariyari	Jhariyari	7.5	1140	0.0	601.46	0.45	66	601.46	12	n.a.	11.77	7.49	**277.30**	**1.39**
8	Jhariyari	Jhariyari	7.8	2200	0.0	677.1	0.55	211	677.1	59	n.a.	44.83	9.63	**31.52**	**1.49**
9	Kohrar	Kohrar	7.6	190	0.0	436.76	0.23	53	436.76	4	n.a.	37.14	8.43	**99.03**	**0.9**
10	Lal Tara	Lal Tara	7.7	1150	0.0	529.48	0.82	121	529.48	49	n.a.	36.79	8.98	**112.70**	**1.12**
11	Salaiya Khurd	Saliya Khurd	7.8	450	0.0	237.9	1.46	11	237.9	27	n.a.	48.90	7.51	**43.52**	**6.46**
12	Salaiya Kala	Salaiya Kala	7.2	340	0.0	198.86	1.61	10	198.86	5	n.a.	31.66	6.98	**25.56**	**1.87**
13	Salaiya Kala	Piparao	7.5	240	0.0	104.92	1.00	23	104.92	12	n.a.	20.34	4.71	**2.56**	**45.17**
14	Piparao	Dighalo	7.2	2500	0.0	639.28	1.78	242	639.28	170	n.a.	127.13	9.48	**87.35**	**334**
15	Dighalo	Khuta	7.4	570	0.0	329.4	1.28	33	329.4	8	n.a.	24.29	7.97	**57.91**	**3.1**
16	Dighalo	Khuta	7.3	1470	0.0	375.76	1.71	155	375.76	140	n.a.	109.51	9.04	**58.30**	**7.45**
17	Khuta	Kathauli	7.8	240	0.0	132.98	1.32	35	132.98	7	n.a.	51.87	7.48	**20.94**	**0.84**
18	Khuta	Dabar	7.9	1090	0.0	658.8	1.18	91	658.8	8	n.a.	16.95	8.92	**228.80**	**1.01**

19	Kathauli	Subhash	7.8	1170	0.0	584.38	2.36	83	584.38	25	n.a.	14.40	10.24	**51.61**	**24.14**
20	Dabar	Semarieha	7.60	1180	0.0	734.44	1.94	44	734.44	12	n.a.	3.18	8.33	**346.10**	**2.82**
21	Dabar	Koraon	7.2	5800	0.0	1293.2	0.33	596	1293.2	560	n.a.	13.31	11.14	**840.60**	**315.9**
22	Siyamlipur	Dasauti	7.7	350	0.0	229.36	0.02	18	229.36	1	n.a.	52.63	7.48	**24.87**	**7.62**
23	Semarieha	Itwakala	7.8	1010	0.0	551.44	0.45	63	551.44	29	n.a.	24.17	8.83	**80.20**	**1.76**
24	Koraon	Baghol	7.5	1120	0.0	505.08	0.34	102	505.08	21	n.a.	40.43	9.61	**72.19**	**2.99**
25	Dasauti	Saliya Khurd	7.5	990	0.0	535.58	0.95	79	535.58	43	n.a.	22.33	8.89	**82.66**	**1.4**
26	Itwakala	Chand Khamariya	7.6	1320	0.0	616.1	1.00	134	616.1	16	n.a.	14.10	9.35	**146.30**	**2.56**
27	Baghol	Pal Patti	7.5	1490	0.0	728.34	0.80	133	728.34	80	n.a.	18.51	8.85	**296.70**	**2.7**
28	Baghol	Jhariyari	7.5	520	0.0	225.7	0.21	28	225.7	34	n.a.	43.77	7.48	**48.35**	**8.15**
29	Chand khamariya	Ash Dyke	7.6	1330	0.0	408.7	0.30	182	408.7	25	n.a.	61.71	8.96	**176.20**	**1.8**
30	Pal patti	Dabar Paudhsala	6.5	110	0.0	84.18	0.33	15	84.18	3	n.a.	8.46	2.33	**4.38**	**3.66**
31	Jhariyari	Subhash	7.1	5400	0.0	545.34	1.08	660	545.34	470	n.a.	61.14	11.30	**751.80**	**138.9**
32	Ash Dyke	Ash Dyke	7.4	140	0.0	54.9	0.09	30	54.9	7	n.a.	11.87	4.57	**6.68**	**1.31**

(b) Metal Ion Parameters

Serial no.	Location	Source	Fe (mg/L)	Zn (ppb)	Cu (ppb)	As (ppb)	Pb (ppb)	Cd (ppb)	Cr (ppb)	Ni (ppb)
1	Ash Dyke	Ash Dyke	3.03	10.98	4.47	9.06	0.37	0.37	0.12	4.47
2	Patai	Patai	4.03	1.23	0.54	2.55	0.47	0.47	0.06	0.54
3	Mai Kala	Mai kala	4.8	2.15	4.73	7.17	0.8	0.8	1.56	4.73
4	SahPur kala	Sahpur Kala	0.27	3.17	0.13	0.04	0.4	0.4	9.89	0.13
5	SahPur kala	Sahpur Kala	2.33	2.14	1.23	2.67	0.5	0.5	7.89	1.23
6	SahPur kala	Sahpur Kala	4.18	2.46	7.47	6.59	0.55	0.55	7.17	7.47
7	Jhariyari	Jhariyari	0.31	0.92	0	10.41	0.42	0.42	1.69	0

8	Jhariyari	Jhariyari	0.08	1.12	0.4	1.1	0.32	0.32	1.67	0.4
9	Kohrar	Kohrar	0.5	2.76	0.47	4.61	0.53	0.53	1.61	0.47
10	Lal Tara	Lal Tara	0.48	1.51	0.96	5.63	0.44	0.44	0.94	0.96
11	Salaiya Khurd	Saliya Khurd	0.05	1.02	1.79	5.65	0.13	0.13	0.26	1.79
12	Salaiya Kala	Salaiya Kala	14.85	7.66	12.52	9.36	1.11	1.11	8.28	12.52
13	Salaiya Kala	Piparao	3.03	5.22	4.85	8.22	0.35	0.35	1.06	4.85
14	Piparao	Dighalo	0.55	2.65	2.5	10.89	1.27	1.27	1.69	2.5
15	Dighalo	Khuta	0.01	0.49	0.47	4.12	0.13	0.13	0.79	0.47
16	Dighalo	Khuta	0.03	7.09	3.36	9.05	4.52	4.52	0.64	3.36
17	Khuta	Kathauli	0.12	0.79	3.47	1.13	0.39	0.39	1.18	3.47
18	Khuta	Dabar	0.41	1.31	3.42	2.44	0.48	0.48	3.93	3.42
19	Kathauli	Subhash	0.56	0.9	1.09	9.44	0.5	0.5	0.17	1.09
20	Dabar	Semarieha	0.06	0.43	0.83	3.28	0.05	0.05	3.99	0.83
21	Dabar	Koraon	0.18	2.88	1.98	6.84	0.21	0.21	0.22	1.98
22	Siyamlipur	Dasauti	2.81	0.03	0.96	5.84	0.63	0.63	0.63	0.96
23	Semarieha	Itwakala	0.07	1.29	0.61	8.58	0.06	0.06	0.24	0.61
24	Koraon	Baghol	0.09	0.98	0.69	9.96	0.25	0.25	0.83	0.69
25	Dasauti	Saliya Khurd	0.07	0.12	0.33	6.57	0.15	0.15	0.87	0.33
26	Itwakala	Chand Khamariya	0.3	1.72	5.51	1.4	0.28	0.28	0.76	5.51
27	Baghol	Pal Patti	0.31	2.06	4.49	5.59	5.63	5.63	0.33	4.49
28	Baghol	Jhariyari	0.05	5.12	1.45	2.43	2.25	2.25	0.2	1.45
29	Chand khamariya	Ash Dyke	0.74	1.58	2.6	3.72	0.69	0.69	1.5	2.6
30	Pal patti	Dabar Paudhsala	0.38	7.73	2.26	9.74	1.96	1.96	0.67	2.26
31	Jhariyari	Subhash	2.04	3.08	6.78	0.65	0.61	0.61	1.48	6.78
32	Ash Dyke	Ash Dyke	0.06	1.26	5.01	8.26	0.16	0.16	0.04	5.01

(a) Physico-Chemical and Major Ion Parameters (May, 2022)

Serial no.	Location	Source	pH	EC (µS/cm)	CO_3^{-2} (mg/L)	HCO_3^- (mg/L)	F^- (mg/L)	Cl^- (mg/L)	SO_4^{--} (mg/L)	NO_3^- (mg/L)	NO_2^- (mg/L)	Ca^{++} (mg/L)	Mg^{++} (mg/L)	Na^+ (mg/L)	K^+ (mg/L)
1	Ash Dyke	Pond	7.62	1390	0.0	48.80	16.31	174.49	48.80	574.57	n.a.	93.77	8.44	193.70	31.32
2	Patai	Handpump	7.50	830	0.0	90.28	4.72	138.20	90.28	257.50	n.a.	96.31	6.92	59.52	0.52
3	Mai kala	Handpump	7.47	1470	0.0	342.82	n.a.	299.47	342.82	141.72	n.a.	83.70	8.49	272.50	0.65
4	Sahpur Kala	Handpump	7.64	860	0.0	503.86	0.43	82.46	503.86	0.11	3.68	49.27	7.99	88.04	1.29
5	Sahpur Kala	Handpump	7.52	1030	0.0	563.64	0.54	84.19	563.64	110.34	n.a.	49.18	8.86	78.30	2.71
6	Sahpur Kala	Handpump	7.51	810	0.0	494.10	n.a.	43.29	494.10	36.78	n.a.	57.35	8.43	59.53	4.47
7	Jhariyari	Handpump	7.46	710	0.0	309.88	0.03	63.75	309.88	30.37	n.a.	80.77	7.23	54.55	1.99
8	Jhariyari	Well	7.43	1290	0.0	535.58	0.27	144.45	535.58		n.a.	67.21	8.06	258.30	1.51
9	Kohrar	Handpump	7.53	530	0.0	322.08	n.a.	14.51	322.08	6.99	n.a.	39.03	5.43	63.46	1.01
10	Lal Tara	Handpump	7.66	680	0.0	387.96	0.84	29.05	387.96	25.73	n.a.	69.87	7.86	68.28	1.19
11	Saliya Khurd	Well	7.43	610	0.0	392.84	0.17	20.09	392.84	23.80	n.a.	76.66	7.39	59.92	6.05
12	Salaiya Kala	Handpump	7.42	430	0.0	259.86	n.a.	5.29	259.86	3.95	n.a.	45.62	6.10	31.53	2.91
13	Piparao	Handpump	7.50	550	0.0	313.54	n.a.	24.16	313.54	7.65	n.a.	45.13	7.08	55.37	3.47
14	Dighalo	Handpump	7.41	990	0.0	274.50	0.20	106.60	274.50	146.48	n.a.	96.77	7.92	76.14	44.44
15	Khuta	Handpump	7.66	710	0.0	522.16	0.33	23.39	522.16	18.61	n.a.	37.45	8.63	25.19	7.51
16	Khuta	Handpump	7.54	320	0.0	173.24	0.10	18.25	173.24	3.78	n.a.	29.90	5.56	25.59	23.03
17	Kathauli	Handpump	7.75	1010	0.0	584.38	0.45	41.77	584.38	8.70	n.a.	40.70	8.07	217.90	2.62
18	Dabar	Handpump	7.89	1210	0.0	773.48	0.47	26.05	773.48	16.65	n.a.	30.11	7.77	354.90	2.84
19	Subhash	Handpump	7.46	4900	0.0	866.20	n.a.	678.75	866.20	515.71	n.a.	90.86	9.94	808.10	97.13
20	Semarieha	Well	7.63	1000	0.0	472.14	n.a.	75.14	472.14	21.07	n.a.	44.48	7.90	173.50	1.89
21	Koraon	Handpump	7.56	890	0.0	550.22	0.05	77.96	550.22	30.83	n.a.	98.53	8.47	55.32	2.78

22	Dasauti	Well	7.59	960	0.0	372.10	n.a.	61.29	372.10	24.49	n.a.	65.99	8.35	79.71	0.69
23	Itwakala	Handpump	8.02	1360	0.0	567.30	0.77	183.10	567.30	17.86	n.a.	73.75	8.56	312.50	3.30
24	Baghol	Handpump	7.52	1200	0.0	445.30	0.83	80.81	445.30	49.97	n.a.	58.61	8.15	19.73	1.53
25	Saliya Khurd	Handpump	7.69	770	0.0	341.60	n.a.	51.07	341.60	49.47	n.a.	71.83	7.55	80.42	10.00
26	Chand Khamariya	Handpump	7.54	5400	0.0	575.84	n.a.	923.70	575.84	572.66	n.a.	142.80	10.24	73.62	136.00
27	Pal Patti	Handpump	7.28	1220	0.0	395.28	0.07	249.74	395.28	83.79	n.a.	113.43	8.30	175.50	2.02
28	Jhariyari	Handpump	7.67	840	0.0	390.40	0.26	48.41	390.40		n.a.	45.95	8.43	75.69	0.43
29	Ash Dyke	Pond	7.22	1600	0.0	92.72	2.45	336.80	92.72	627.21	n.a.	130.72	8.80	227.50	23.63
30	Dabar Paudhsala	Handpump	7.60	210	0.0	108.58	n.a.	42.06	108.58	72.70	n.a.	27.16	4.63	16.69	2.11
31	Subhash	Handpump	7.57	960	0.0	495.32	n.a.	46.99	495.32		n.a.	42.04	8.34	15.51	15.51
32	Ash Dyke	Pond	7.53	900	0.0	262.30	n.a.	96.95	262.30	109.56	n.a.	82.83	7.64	82.63	2.57
33	Ash Dyke	Well	7.54	1000	0.0	447.74	2.60	74.67	447.74	44.12	n.a.	80.84	7.65	74.96	0.60
34	Dighalo	Handpump	7.51	560	0.0	152.50	n.a.	62.88	152.50	54.29	n.a.	61.45	6.53	27.72	29.04
35	Shambholri Nagar	Handpump	7.05	420	0.0	122.00	n.a.	49.72	122.00	103.61	n.a.	67.46	7.04	41.79	2.75
36	Khamoriya	Pond	6.92	500	0.0	189.10	1.14	44.75	189.10	21.53	n.a.	13.89	4.30	83.39	18.08
37	Tons River	River	7.40	260	0.0	184.22	n.a.	33.93	184.22	14.68	n.a.	31.83	7.51	14.62	39.57

(b) Metal Ion Parameters

Serial no.	Location	Source	Fe (mg/L)	Zn (ppb)	Cu (ppb)	As (ppb)	Pb (ppb)	Cd (ppb)	Cr (ppb)	Ni (ppb)
1	Ash Dyke	Pond	0.5	19.62	5.28	14.08	1.39	1.39	3.68	5.28
2	Patai	Handpump	3.29	1.95	0.12	0.17	0.91	0.91	ND	0.12
3	Mai kala	Handpump	4.56	0.77	ND	8.14	0.86	0.86	0.11	ND
4	Sahpur Kala	Handpump	0.7	1.68	4.56	5.41	0.48	0.48	7.72	4.56
5	Sahpur Kala	Handpump	ND	3.87	ND	ND	0.54	0.54	ND	ND
6	Sahpur Kala	Handpump	0.24	ND	6.78	1.23	0.63	0.63	0.29	6.78
7	Jhariyari	Handpump	0.63	3.03	ND	ND	0.64	0.64	0.77	ND
8	Jhariyari	Well	ND	0.62	ND	3.58	0.49	0.49	ND	ND
9	Kohrar	Handpump	0.91	2.05	4.55	ND	0.59	0.59	0.35	4.55
10	Lal Tara	Handpump	0.62	2.91	1.9	ND	0.58	0.58	ND	1.9
11	Saliya Khurd	Well	0.31	1.56	1.51	24.45	0.46	0.46	ND	1.51
12	Salaiya Kala	Handpump	0.16	2.03	0.24	5.61	0.76	0.76	ND	0.24
13	Piparao	Handpump	0.12	5.66	3.01	3.65	0.74	0.74	ND	3.01
14	Dighalo	Handpump	0.18	31.71	1.21	10.07	10.6	10.6	ND	1.21
15	Khuta	Handpump	0.93	3.18	11.84	0.85	1.23	1.23	1.52	11.84
16	Khuta	Handpump	0.38	0.68	12.01	3.16	0.61	0.61	1.15	12.01
17	Kathauli	Handpump	ND	0.93	ND	2.8	0.58	0.58	ND	ND
18	Dabar	Handpump	0.21	0.93	8.13	ND	0.65	0.65	3.57	8.13
19	Subhash	Handpump	ND	3.19	ND	14.4	0.54	0.54	0.38	ND
20	Semarieha	Well	ND	0.4	ND	1.79	0.26	0.26	ND	ND
21	Koraon	Handpump	ND	0.45	ND	15.84	0.47	0.47	0.32	ND

22	Dasauti	Well	ND	1.86	ND	ND	0.66	0.66	ND	ND
23	Itwakala	Handpump	ND	2.81	ND	1.8	0.48	0.48	ND	ND
24	Baghol	Handpump	ND	2.06	ND	15.79	1.25	1.25	ND	ND
25	Saliya Khurd	Handpump	ND	4.28	ND	ND	1.29	1.29	0.16	ND
26	Chand Khamariya	Handpump	ND	10.38	ND	11.26	1.2	1.2	ND	ND
27	Pal Patti	Handpump	0.75	14.42	17.37	8.07	0.67	0.67	1.1	17.37
28	Jhariyari	Handpump	ND	1.51	ND	4.91	0.51	0.51	ND	ND
29	Ash Dyke	Pond	2.18	10.07	3.72	19.56	0.63	0.63	0.95	3.72
30	Dabar Paudhsala	Handpump	0.09	3.97	2.59	ND	1.35	1.35	ND	2.59
31	Subhash	Handpump	0.11	0.98	2.91	ND	0.67	0.67	3.31	2.91
32	Ash Dyke	Pond	1.13	4.94	5.4	2.81	0.41	0.41	1.01	5.4
33	Ash Dyke	Well	0.96	2.8	18.25	2.95	0.59	0.59	0.28	18.25
34	Dighalo	Handpump	3.19	11.3	18.35	13.03	40.01	40.01	3.72	18.35
35	Shambholri Nagar	Handpump	0.12	15.8	5.25	4.11	0.67	0.67	2.34	5.25
36	Khamoriya	Pond	0.71	3.69	17.29	5.23	1.08	1.08	3.35	17.29
37	Tons River	River	0.01	1.1	4.1	5.65	2.39	2.39	ND	4.1

(a) Physico-Chemical and Major Ion Parameters (August, 2022)

Serial no.	Location	Source	pH	EC (µS/cm)	CO_3^{-2} (mg/L)	HCO_3^- (mg/L)	F^- (mg/L)	Cl^- (mg/L)	SO_4^{--} (mg/L)	NO_3^- (mg/L)	NO_2^- (mg/L)	Ca^{++} (mg/L)	Mg^{++} (mg/L)	Na^+ (mg/L)	K^+ (mg/L)
1	Ash Dyke	Pond	6.95	1350	0.0	96.38	12.98	156.772	96.38	594.214	n.a.	93.77	8.44	193.70	31.32
2	Patai	Handpump	6.80	860	0.0	169.58	0.509	91.317	169.58	258.95	n.a.	96.31	6.92	59.52	0.52
3	Mai kala	Handpump	7.20	1310	0.0	418.46	0.068	225.659	418.46	116.286	n.a.	83.70	8.49	272.50	0.65
4	Sahpur Kala	Handpump	7.10	860	0.0	479.46	0.322	77.842	479.46	11.329	3.68	49.27	7.99	88.04	1.29
5	Sahpur Kala	Handpump	7.60	980	0.0	495.32	0.002	9.124	495.32	8.742	n.a.	49.18	8.86	78.30	2.71
6	Sahpur Kala	Handpump	6.98	1060	0.0	541.68	0.286	42.033	541.68	19.24	n.a.	57.35	8.43	59.53	4.47
7	Kohrar	Handpump	7.20	490	0.0	353.80	0.092	52.801	353.80	18.014	n.a.	80.77	7.23	54.55	1.99
8	Lal Tara	well	7.20	1080	0.0	462.38	0.030	10.542	462.38	5.817	n.a.	67.21	8.06	258.30	1.51
9	Saliya Khurd	Well	7.30	640	0.0	285.48	0.85	66.587	285.48	108.878	n.a.	39.03	5.43	63.46	1.01
10	Salaiya Kala	Handpump	6.80	110	0.0	39.04	0.114	44.287	39.04	72.082	n.a.	69.87	7.86	68.28	1.19
11	Salaiya Kala	Handpump	6.65	80	0.0	130.54	0.055	3.182	130.54	7.333	n.a.	76.66	7.39	59.92	6.05
12	Piparao	Handpump	7.40	550	0.0	683.20	0.760	59.3778	683.20	19.07	n.a.	45.62	6.10	31.53	2.91
13	Dighalo	Handpump	7.20	1140	0.0	335.50	0	96.415	335.50	124.56	n.a.	45.13	7.08	55.37	3.47
14	Dighalo	Handpump	7.10	860	0.0	334.28	0	71.655	334.28	79.323	n.a.	96.77	7.92	76.14	44.44
15	Khuta	Handpump	7.20	1270	0.0	557.54	1.868	146.231	557.54	37.702	n.a.	37.45	8.63	25.19	7.51
16	Khuta	Handpump	8.10	210	0.0	185.44	0.378	11.085	185.44	9.152	n.a.	29.90	5.56	25.59	23.03
17	Kathauli	Handpump	6.98	590	0.0	378.20	0	30.542	378.20	8.136	n.a.	40.70	8.07	217.90	2.62
18	Dabar	Handpump	7.10	1190	0.0	835.70	0.028	22.624	835.70	18.041	n.a.	30.11	7.77	354.90	2.84
19	Subhash	Handpump	6.97	4500	0.0	978.44	0.48	283.31	978.44	277.58	n.a.	90.86	9.94	808.10	97.13
20	Shamlipur	Handpump	8.00	170	0.0	141.52	0.016	26.661	141.52	26.527	n.a.	44.48	7.90	173.50	1.89
21	Semarieha	well	7.80	970	0.0	459.94	0.371	74.363	459.94	30.046	n.a.	98.53	8.47	55.32	2.78

22	Koraon	Handpump	7.60	700	0.0	500.20	0	25.614	500.20	14.628	n.a.	65.99	8.35	79.71	0.69
23	Dasauti	well	7.20	3000	0.0	509.96	0.55	518.52	509.96	339.8	n.a.	73.75	8.56	312.50	3.30
24	Itwakala	Handpump	7.50	1450	0.0	425.78	0.061	184.042	425.78	43.436	n.a.	58.61	8.15	19.73	1.53
25	Baghol	Handpump	7.25	1290	0.0	557.54	0.063	102.751	557.54	106.502	n.a.	71.83	7.55	80.42	10.00
26	Saliya Khurd	Handpump	6.99	460	0.0	114.68	0.116	32.683	114.68	42.413	n.a.	142.80	10.24	73.62	136.00
27	Chand Khamariya	Handpump	7.60	1900	0.0	488.00	0	287.574	488.00	381.573	n.a.	113.43	8.30	175.50	2.02
28	Pal Patti	Handpump	7.50	1220	0.0	528.26	0.099	246.969	528.26	45.415	n.a.	45.95	8.43	75.69	0.43
29	Jhariyari	Handpump	6.68	840	0.0	170.80	0.047	18.22	170.80	4.418	n.a.	130.72	8.80	227.50	23.63
30	Ash Dyke	Pond	8.20	1500	0.0	111.02	0.833	225.802	111.02	550.26	n.a.	27.16	4.63	16.69	2.11
31	Dabar Paudhsala	Handpump	6.92	140	0.0	95.16	0.177	17.406	95.16	36.464	n.a.	42.04	8.34	15.51	15.51
32	Subhash	Handpump	7.47	950	0.0	584.38	0.185	42.699	584.38	28.175	n.a.	82.83	7.64	82.63	2.57
33	Ash Dyke	Pond	7.70	470	0.0	187.88	0.035	31.438	187.88	49.538	n.a.	80.84	7.65	74.96	0.60
34	Jhadiyahi	Handpump	7.40	340	0.0	201.30	0.356	18.859	201.30	38.381	n.a.	61.45	6.53	27.72	29.04
35	Dighalo	Handpump	6.95	740	0.0	233.02	0.228	107.603	233.02	63.604	n.a.	67.46	7.04	41.79	2.75
36	Shambri	Handpump	6.80	310	0.0	107.36	0.064	14.924	107.36	48.179	n.a.	13.89	4.30	83.39	18.08
37	Khamoriya	pond	8.20	160	0.0	114.68	0.009	14.727	114.68	4.817	n.a.	31.83	7.51	14.62	39.57
38	Tons River	river	8.00	250	0.0	150.06	0.135	10.88	150.06	32.446	n.a.				
39	Lal Tara	Hand pump	7.70	900	0.0	425.78	2.099	63.896	425.78	34.681	n.a.				
40	Pal Patti	Hand pump	7.75	860	0.0	446.52	0.018	98.979	446.52	17.52	n.a.				

(b) Metal Ion Parameters

Serial no.	Location	Source	Fe (mg/L)	Zn (ppb)	Cu (ppb)	As (ppb)	Pb (ppb)	Cd (ppb)	Cr (ppb)	Ni (ppb)
1	Ash Dyke	Pond	0.32	22.55	7.14	9.32	ND	ND	ND	7.14
2	Patai	Handpump	1.14	ND	ND	8.67	ND	ND	ND	ND
3	Mai kala	Handpump	3.38	ND	ND	9.37	ND	ND	ND	ND
4	Sahpur Kala	Handpump	0.29	ND	ND	6.97	ND	ND	6.03	ND
5	Sahpur Kala	Handpump	0.08	ND	ND	ND	ND	ND	5.02	ND
6	Sahpur Kala	Handpump	0.82	ND	4.57	8.48	ND	ND	ND	4.57
7	Kohrar	Handpump	0.93	ND	ND	ND	ND	ND	ND	ND
8	Lal Tara	well	0.32	ND	2.42	ND	ND	ND	ND	2.42
9	Saliya Khurd	Well	0.05	ND	ND	8.73	ND	ND	ND	ND
10	Salaiya Kala	Handpump	0.07	ND	ND	6.01	ND	ND	ND	ND
11	Salaiya Kala	Handpump	6.49	5.07	9.22	9.67	ND	ND	ND	9.22
12	Piparao	Handpump	ND	ND	ND	12.86	ND	ND	ND	ND
13	Dighalo	Handpump	0.02	ND	3.77	12.71	ND	ND	ND	3.77
14	Dighalo	Handpump	0.1	ND	6.91	14.6	ND	ND	ND	6.91
15	Khuta	Handpump	0.88	ND	2	8.39	ND	ND	ND	2
16	Khuta	Handpump	1.21	ND	3.96	12.57	ND	ND	ND	3.96
17	Kathauli	Handpump	0.09	ND	ND	8.44	ND	ND	ND	ND
18	Dabar	Handpump	0.39	ND	1.69	8.79	ND	ND	ND	1.69
19	Subhash	Handpump	ND	3.35	ND	11.19	ND	ND	ND	ND
20	Shamlipur	Handpump	0.11	ND	1.47	9.72	ND	ND	ND	1.47
21	Semarieha	well	ND	ND	ND	6.14	ND	ND	ND	ND

22	Koraon	Handpump	0.34	ND	1.32	12.46	ND	ND	ND	1.32
23	Dasauti	well	ND	44.33	1.46	6.71	ND	ND	ND	1.46
24	Itwakala	Handpump	0.42	ND	3.07	11.14	ND	ND	ND	3.07
25	Baghol	Handpump	0.36	ND	6.21	72.1	2.34	2.34	ND	6.21
26	Saliya Khurd	Handpump	0.06	ND	4.07	25.29	ND	ND	ND	4.07
27	Chand Khamariya	Handpump	ND	5.26	ND	50.75	ND	ND	ND	ND
28	Pal Patti	Handpump	ND	ND	ND	14.74	ND	ND	ND	ND
29	Jhariyari	Handpump	6.69	10.44	1.96	8.94	ND	ND	ND	1.96
30	Ash Dyke	Pond	0.18	ND	ND	18.59	ND	ND	ND	ND
31	Dabar Paudhsala	Handpump	0.19	ND	ND	ND	ND	ND	ND	ND
32	Subhash	Handpump	0.16	ND	1.23	11.24	ND	ND	ND	1.23
33	Ash Dyke	Pond	0.53	ND	ND	13.66	ND	ND	ND	ND
34	Jhadiyahi	Handpump	0.13	ND	ND	11.36	ND	ND	ND	ND
35	Dighalo	Handpump	3.83	2.88	2.2	ND	17.8	17.8	ND	2.2
36	Shambri	Handpump	0.07	3.81	ND	ND	ND	ND	ND	ND
37	Khamoriya	pond	0.19	ND	1.42	13.31	ND	ND	ND	1.42

Drilling Logs:

Location	Depth (ft)	Lithology	
Near Shiv Baba Temple/ Ash Dyke (Meja) 25.120573/81.932327	0-20	Whitish brown laminated Sandstone (Arenite), 90% Quartz, with5% feldspar and traces of mafic minerals, Sub rounded to rounded grains showing grains to grain contact filled with silicic matrix intruded with pottasic alteration , with 8-10% porosity.	
	20-40	Very fine grained light brownish Sandstone (Arenite) composed of 95% quartz, 3-4% Feldspar and <1% mafic minerals. Showing alternatic lamination, Sub rounded to rounded Qtz. Grains cemented with silicic material, hard and compact.	
	40-60	Arkosic Sandstone light pinkish in colour, composed 80% Qtz, 10-15% Feldspar and 2-3 % mafic minerals, showing >10% porosity , bounded by silicic matrix, occasionally feldspar altered to Clay (Kaolinite)	
	60-80	Light Pink compact arkosic siltstone consisting 85% qtz, 15-18% feldspar and 2-5% mafic minerals, rounded to well rounded, well sorted grains with low porosity, feldspar altered to clay (Kaolinite)	
	80-100	Light Pink compact arkosic siltstone consisting 85% qtz, 12-15% feldspar and 5-8% mafic minerals, rounded to well rounded, well sorted grains with low porosity, feldspar altered to clay (Kaolinite)	
	100-120	Lithic arenite (sandstone) contains 80% Quartz, 10 feldspar and 10% lithic fragments, greyish in colour due to feldspar alteration into clay, showing low porosity.	
	120-140	Greyish soft lithic arenite (sandstone) contains 80% Quartz, 10 feldspar and 10% lithic fragments, greyish in colour due to feldspar alteration into clay, showing low porosity.	
	140-160	Yellowish to light brown very fine grained calcareous sandstone, composed of 90% quartz, 2-3 %lithic fragments, <1% mica, cemented with calcareous matrix, sub rounded to rounded grains showing <10% porosity.	
	160-180	Light yellowish friable (soft) clayey sandstone, fine to very fine grained, composed of 80-85% quartz, 10-12% feldspar and 2-3 % mafic minerals bounded with calcareous clay.	
	180-200	Brownish, medium to coarse grained Sandstone with >25% porosity, composed of 90% Quartz, 10% feldspar, bounded by calcareous matrix, secondary porosity observed due to removal of binding material resulting increase in porosity and permeability.	
	200-220	Light brown, med. to fine grained sandstone, composed of sand to silt size particles, compact bounded by calcareous matrix, showing low porosity.	
	220- 240	Greyish to milkish white Sandstone, composed of fine to very fine grained sandstone, composed of 80% Qtz, 10-12% feldspar and 2-5% mafic minerals, bounded by calcareous matrices, secondary porosity developed in vugs resulting increased porosity and permeability.	

ANALYTICAL REPORT ON SURFACE WATER QUALITY

Name of Industry	:	Meja Thermal Power Project, Meja, Prayagraj
Study Code No.	:	SSP-481
Date of Sample Collection	:	12th August 2025
Method of Analysis	:	As per APHA/AWWA
Date of sample received	:	13-08-2025
Date of completion of testing	:	15-09-2025
Season & Weather	:	Monsoon and Clear Sky

Test Results:

Physico-chemical Analysis

Sl.No.	Parameters	Unit	SW-1	SW-2	SW-3
1.	pH	-	7.2	7.1	7.0
2.	Conductivity	µmhos/cm	440	271	445
3.	Temperature	°C	30	30	29
4.	TSS	mg/l	48	31	36
5.	TDS	mg/l	236	144	228
6.	Dissolve Phosphate	mg/l	0.48	0.25	0.31
7.	Oil & Grease	mg/l	2.4	1.5	1.7
8.	D. O.	mg/l	6.2	4.6	5.3
9.	BOD at 20^0C	mg/l	3.6	1.8	3.2
10.	COD	mg/l	48	32	36
11.	Total hardness	mg/	160	188	234

Metal Concentration

Sl. No.	Parameters	Unit	SW-1	SW-2	SW-3	Detection Limit
1.	Iron (Fe)	mg/l	0.273	0.166	0.559	0.020
2.	Zinc (Zn)	mg/l	0.116	0.089	0.038	0.030
3.	Copper (Cu)	mg/l	<0.025	<0.025	<0.025	0.025
4.	Lead (Pb)	mg/l	0.032	0.039	<0.025	0.025
5.	Total Chromium (Cr)	mg/l	0.051	0.038	<0.025	0.025
6.	Cadmium (Cd)	mg/l	<0.020	<0.020	<0.020	0.020
7.	Arsenic (As)	mg/l	<0.005	<0.005	<0.005	0.005
8.	Mercury (Hg)	mg/l	<0.001	<0.001	<0.001	0.001

SW-1 → Tons River (Downstream), SW-2 → Reservoir, SW-3 → Natural Drain (Near Ash Dyke)

16/9/2025

(Dr. Abhay Raj)
Principal Scientist
Environmental Monitoring Laboratory

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ANALYTICAL REPORT ON SURFACE WATER QUALITY

Name of Industry	:	Meja Thermal Power Project, Meja, Prayagraj
Study Code No.	:	SSP-481
Date of Sample Collection	:	21st July, 2025 to 26th July, 2025
Method of Analysis	:	As per APHA/AWWA; 22rd Edition
Date of sample received	:	27-07-2025
Date of completion of testing	:	28-08-2025
Season & Weather	:	Monsoon & Clear Day

Test Results:

Physico-chemical Analysis

Sl.No.	Parameters	Unit	SW-4	SW-5	SW-6
1.	pH	-	6.9	6.7	7.3
2.	Conductivity	µmhos/cm	390	381	474
3.	Temperature	°C	30	31	29
4.	TSS	mg/l	37	32	30
5.	TDS	mg/l	209	203	253
6.	Dissolve Phosphate	mg/l	0.45	0.38	0.27
7.	Oil & Grease	mg/l	1.4	1.1	1.3
8.	D. O.	mg/l	4.8	4.4	5.2
9.	BOD at 20^0C	mg/l	3.6	4.0	3.8
10.	COD	mg/l	32	40	36
11.	Total hardness	mg/l	154	177	169

Metal Concentration

Sl. No.	Parameters	Unit	SW-4	SW-5	SW-6	Detection Limit
1.	Iron (Fe)	mg/l	0.435	0.416	0.267	0.020
2.	Zinc (Zn)	mg/l	0.046	0.055	0.029	0.025
3.	Copper (Cu)	mg/l	<0.025	<0.025	<0.025	0.025
4.	Lead (Pb)	mg/l	<0.025	<0.025	<0.025	0.025
5.	Total Chromium (Cr)	mg/l	0.036	0.041	<0.025	0.025
6.	Cadmium (Cd)	mg/l	<0.020	<0.020	<0.020	0.020
7.	Arsenic (As)	mg/l	<0.005	<0.005	<0.005	0.005
8.	Mercury (Hg)	mg/l	<0.001	<0.001	<0.001	0.001

SW-4 →Reservoir-1, SW-5 → Reservoir-2, SW-6 → Natural Drain (Near Ash Dyke)

ANALYTICAL REPORT ON GROUND WATER QUALITY

Name of Industry	:	Meja Thermal Power Project, Meja, Prayagraj
Study Code No.	:	SSP-481
Date of Sample Collection	:	21st July, 2025 to 26th July, 2025
Method of Analysis	:	As per APHA/AWWA; 22rd Edition
Date of sample received	:	27-07-2025
Date of completion of testing	:	28-08-2025
Season & Weather	:	Monsoon & Clear Day

Test Results:

Physico-chemical Analysis

Sl.No.	Parameters	Unit	GW-1	GW-2	GW-3	GW-4
1.	pH	-	7.3	7.2	7.2	6.1
2.	Conductivity	µmhos/cm	864	979	981	997
3.	Temperature	°C	29	28	29	29
4.	TSS	mg/l	21	18	14	15
5.	TDS	mg/l	463	525	453	757
6.	Dissolve Phosphate	mg/l	0.13	0.17	0.14	0.09
7.	D. O.	mg/l	2.0	2.4	1.4	2.9
8.	BOD at 20^0C	mg/l	1.3	1.6	1.2	2.0
9.	COD	mg/l	12	24	16	28
10.	Total hardness	mg/l	164	187	213	145
11.	Total Coliform MPN	Coliform/ 100 ml	<1.8	<1.8	<1.8	<1.8

Metal Concentration

Sl. No.	Parameters	Unit	GW-1	GW-2	GW-3	GW-4	Detection Limit
1.	Iron as Fe	mg/l	0.291	0.338	0.437	0.522	0.020
2.	Zinc as Zn	mg/l	0.059	0.064	0.093	0.048	0.025
3.	Copper as Cu	mg/l	<0.025	<0.025	<0.025	<0.025	0.025
4.	Lead as Pb	mg/l	<0.025	<0.025	<0.025	<0.025	0.025
5.	Total Chromium as Cr	mg/l	<0.025	<0.025	<0.025	<0.025	0.025
6.	Cadmium as Cd	mg/l	<0.020	<0.020	<0.020	<0.020	0.020
7.	Arsenic as As	mg/l	<0.005	<0.005	<0.005	<0.005	0.005
8.	Mercury as Hg	mg/l	<0.001	<0.001	<0.001	<0.001	0.001

GW-1→Kohdar Village, GW-2→Sonbarsi Village, GW-3→Maikalan Village
GW-4→Esauta Village

ANALYTICAL REPORT ON GROUND WATER QUALITY

Name of Industry	:	Meja Thermal Power Project, Meja, Prayagraj
Study Code No.	:	SSP-481
Date of Sample Collection	:	21st July, 2025 to 26th July, 2025
Method of Analysis	:	As per APHA/AWWA; 22rd Edition
Date of sample received	:	27-07-2025
Date of completion of testing	:	28-08-2025
Season & Weather	:	Monsoon & Clear Day

Test Results:

Physico-chemical Analysis

Sl.No.	Parameters	Unit	GW-5	GW-6	GW-7	GW-8
1.	pH	-	7.3	7.6	6.8	6.7
2.	Conductivity	µmhos/cm	429	322	688	702
3.	Temperature	°C	29	29	28	30
4.	TSS	mg/l	12	17	20	23
5.	TDS	mg/l	228	102	368	376
6.	Dissolve Phosphate	mg/l	0.13	0.15	0.19	0.20
7.	D. O.	mg/l	2.2	1.9	2.4	3.0
8.	BOD at 20^{0}C	mg/l	1.4	1.0	1.4	1.6
9.	COD	mg/l	20	12	16	28
10.	Total hardness	mg/l	127	182	154	225
11.	Total Coliform MPN	Coliform/ 100 ml	<1.8	<1.8	<1.8	<1.8

Metal Concentration

Sl. No.	Parameters	Unit	GW-5	GW-6	GW-7	GW-8	Detection Limit
1.	Iron as Fe	mg/l	0.362	0.473	0.281	1.262	0.020
2.	Zinc as Zn	mg/l	0.056	0.041	0.038	0.046	0.025
3.	Copper as Cu	mg/l	<0.025	<0.025	<0.025	<0.025	0.025
4.	Lead as Pb	mg/l	<0.025	<0.025	<0.025	<0.025	0.025
5.	Total Chromium as Cr	mg/l	<0.025	<0.025	<0.025	<0.025	0.025
6.	Cadmium as Cd	mg/l	<0.020	<0.020	<0.020	<0.020	0.020
7.	Arsenic as As	mg/l	<0.005	<0.005	<0.005	<0.005	0.005
8.	Mercury as Hg	mg/l	<0.001	<0.001	<0.001	<0.001	0.001

GW-5→Township, GW-6→Near Ash Dyke-I, GW-7→ Near Ash Dyke-II
GW-8→ Near Ash Dyke-III

ANALYTICAL REPORT ON EFFLUENT WATER QUALITY

Name of Industry	:	Meja Thermal Power Project, Meja, Prayagraj
Study Code No.	:	SSP-481
Date of Sample Collection	:	21st July, 2025 to 26th July, 2025
Method of Analysis	:	As per APHA/AWWA; 22rd Edition
Date of sample received	:	27-07-2025
Date of completion of testing	:	28-08-2025
Season & Weather	:	Monsoon & Clear Day

Test Results:

Physico-chemical Analysis

Sl.No.	Parameters	Unit	EW-1	EW-2	STP-1
1.	pH	-	7.6	7.4	6.8
2.	Conductivity	µmhos/cm	1117	809	575
3.	Temperature	°C	30	32	30
4.	TSS	mg/l	35	52	31
5.	TDS	mg/l	597	432	306
6.	Dissolve Phosphate	mg/l	*	0.13	0.28
7.	Oil & Grease	mg/l	4.7	3.8	4.0
8.	D. O.	mg/l	4.6	4.2	5.4
9.	BOD at 20^0C	mg/l	12.3	10.8	12.0
10.	COD	mg/l	44	48	34

Metal Concentration

Sl. No.	Parameters	Unit	EW-1	EW-2	STP-1	Detection Limit
1.	Iron as Fe	mg/l	0.571	0.835	0.369	0.020
2.	Zinc as Zn	mg/l	0.058	0.040	0.036	0.025
3.	Copper as Cu	mg/l	<0.025	<0.025	<0.025	0.025
4.	Lead as Pb	mg/l	<0.025	<0.025	<0.025	0.025
5.	Total Chromium as Cr	mg/l	<0.025	0.030	<0.025	0.025
6.	Cadmium as Cd	mg/l	<0.020	<0.020	<0.020	0.020
7.	Arsenic as As	mg/l	<0.005	<0.005	<0.005	0.005
8.	Mercury as Hg	mg/l	<0.001	<0.001	<0.001	0.001

EW-1 →Plant Effluent, EW-2 → Ash Pond Effluent, STP-1 → Township Sewage Water
*Not in work scope

10/9/2025

(Dr. Abhay Raj)
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Environmental Monitoring Laboratory

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STUDY REPORT
ON
GROUND WATER LEVEL IN 10 KM RADIUS
OF
M/S MEJA URJA NIGAM PRIVATE LIMITED (MUNPL) AT MEJA TEHSIL IN PRAYAGRAJ DISTRICT, UTTAR PRADESH
(PRE- MONSOON 2025)

Duration of Monitoring	**18-19, Jan 2025**	
Monitoring Done By:	**Mr. Asheesh & Mr. Umakant**	
Report Prepared By :	**Dr. Divya Misra** **Managing Director**	
	Dr. Anant Prasad Dubey **Vice President (Lab)**	

M/s Prakriti Consultant Services

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Table of Content:

1.0 INTRODUCTION:

Groundwater on account of its universal availability, dependability and low capital cost, is the major source of water to meet the requirement of various sector in India. However, with a rapid growth of population and all-round development, there is incessant pressure on the ground water withdrawal resulting in compulsive awakening in terms of both the quality and quantity. Ground water has an important role in meeting the water requirements of agriculture, industrial and domestic sectors in the State. About 78% percent of irrigation requirements in the Uttar Pradesh state are being met from ground water resources. If the present trend of the increasing demand remains incontrollable, the resource may become as strategic as are the minerals resources. Though in contrast to this, the groundwater resource as a part of hydrologic cycle is replenish able.

The State of Uttar Pradesh is covered with rich fertile soil and underlain by a large thickness of alluvium making it one of the richest ground water repositories of the world. The State being the most populous in the country with a population density of 649 persons per sq. km and a high rate of population growth (26%), its demand for water is soaring. Also due to industrialization, urbanization and modern farming practices, its quality is also at stake. To meet this high irrigational requirement, water resources are being increasingly developed. Ground water contributes to about 71% of the irrigation needs of the State. The indiscriminate development of ground water has resulted in depletion of groundwater storage and lowering of water levels in certain areas on one hand. On other side, the surface water canals in areas having shallow water level has resulted in water logging and soil salinization.

Measurement of periodic ground water level is the primary step to understand the variation over time, hydrologic stresses on recharge, discharge and storage, to develop groundwater models and to suggest the management practices (Harun and Kamaruddin 2016).Usually, long term data are necessary to systematically assess the hydrological condition of the aquifers. The importance of ground water level monitoring has been appreciated, and several studies have performed in this direction. Ground water level can be measured from the selected wells in the monitoring network using conventional measurements tapes, electronic water level indicators, air line pressure methods, acoustic method and automatic recording methods.

Increased uses of geographical information system in the water resources managements are found to be very effective, especially in the spatial data interpretation and visualization.

The aim of this study is to understand the ground water level fluctuation surrounding the MUNPL MEJA Power Plant. The seasonal variation ground water level fluctuation will be carried in future for critically analysis. This is a preliminary study of this kind and will be useful for ground water management in the future.

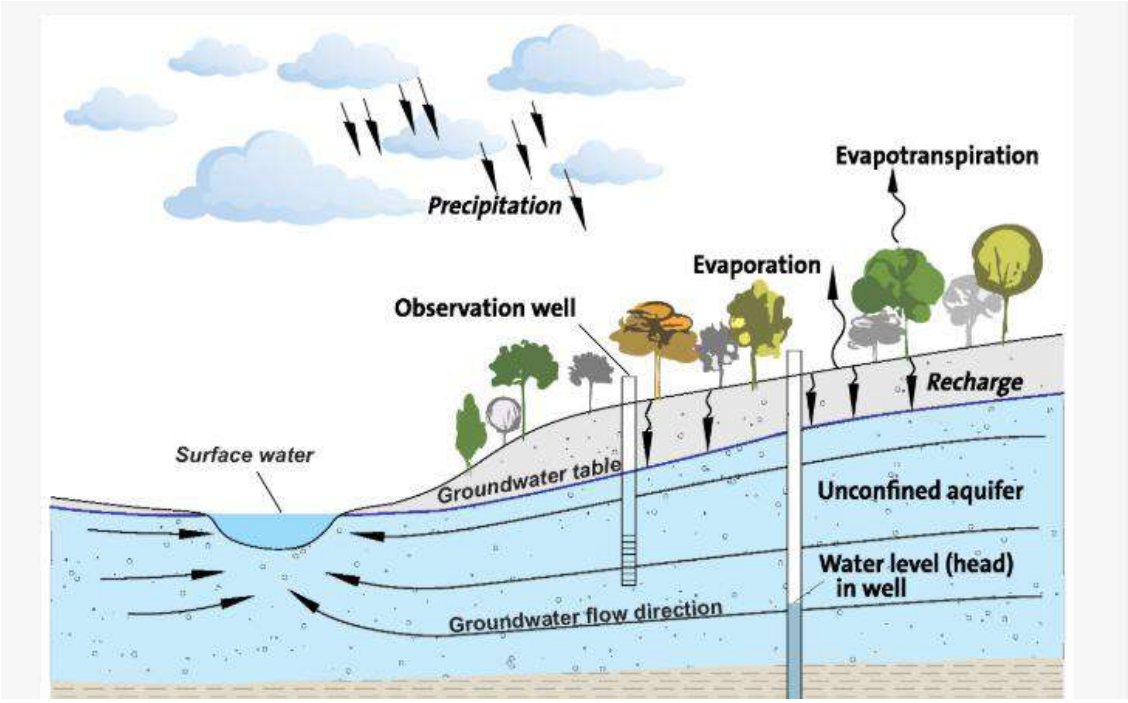


Figure 1: Cross-section of a typical groundwater flow system

2.0 OBJECTIVE OF WORK:

Generation of scientific databases for recording groundwater fluctuation at a fixed location will assist in understand the variations in groundwater levels across different seasons. This could be achieved only after careful monitoring of various inputs of hydrological system. These temporal variations in the ground water levels will further support to study in a scientific manner using various interpretation tools.

The main objective of this study to monitor the water level surrounding to the Power Plant to understand the ground water level. Further capturing seasonal variation in ground water level will assist in better understand the dynamic behavior of groundwater system throughout different seasons and conditions.

3.0 SCOPE OF STUDY:

- Identification of open wells in surrounding to the Power Plant.
- Information about the use of the water of identified open wells (drinking, irrigation etc).
- Information about various water recharge sources.
- Measurement of water level in identified source (open well).
- Preparation of compiled report of ground water level.
- The overall scope of study is prepared in the form of flow chart.

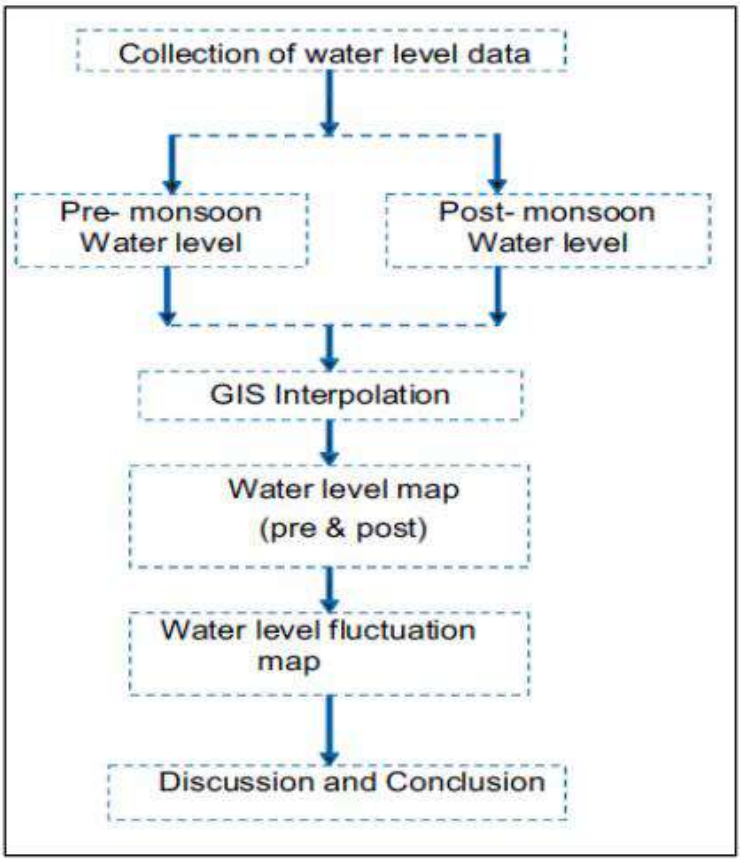


Figure 2: Flow Chart of Scope of Study

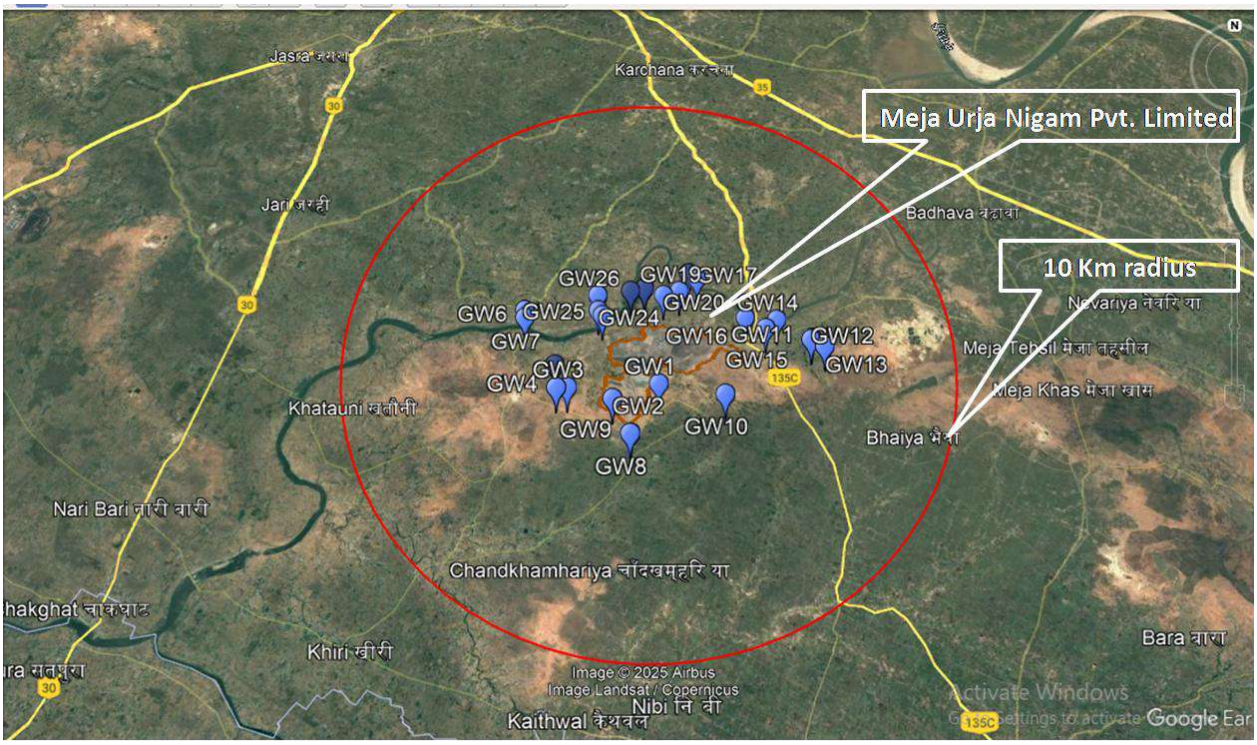
4.0 SITE SELECTION:

M/s Meja Urja Nigam Private Limited (MUNPL) is located in Meja Tehsil in Prayagraj district, Uttar Pradesh. Geographically, Prayagraj is located at 25.45°N 81.84°E in the southern part of the Uttar Pradesh.

In the present study 27 wells in 14 villages surrounding the Power Plant are identified based on Hydrogeology map of the area. Efforts are taken to choose wells to get the maximum spatial representation of the areas. Handheld GPS was used to mark the latitude and longitude of the study area. Measurement has been taken in pre monsoon 2025 and will be carried in future to capture seasonal data for water levels fluctuations. The details of identified locations/monitoring points are mentioned in the table below:

Sr. No	Monitoring Location Code	Village	Aerial Distance from Plant Boundary (Km)	Direction from MUNPL plant	GPS Coordinates
1.	GW1	Salaiya Khurd	0.58	South	25.118381° N , 81.941683° E
2.	GW2		0.40	South	25.112283N , 81.922936 E
3.	GW3	Salaiyakalan	1.38	South	25.116705 N,81.904545 E
4.	GW4		1.77	South	25.116580 N, 81.900057 E
5.	GW5	Piparau	1.99	West	25.125707 N , 81.899168 E
6.	GW6	Dhaduva	3.77	West	25.14538 N , 81.885893 E
7.	GW7		3.95	North-West	25.148555 N , 81.885606 E
8.	GW8	Dausati	1.55	South	25.09861 N ,81.930257 E
9.	GW9		1.50	South	25.098632 N, 81.930301 E
10.	GW10	Son Barsi	2.50	East	25.114370 N , 81.968590 E
11.	GW11	Mudpela	2.88	East	25.137505 N , 81.004956 E
12.	GW12		2.85	East	25.137027 N, 82.004686 E
13.	GW13		3.44	East	25.134194 N , 82.010186 E
14.	GW14	Kohdar	1.41	East	25.145214 N , 81.990865 E
15.	GW15		0.90	East	25.141577 N , 81.986094 E
16.	GW16		0.40	North	25.145942 N, 81.977733 E
17.	GW17	Isawta	1.53	North-East	25.162681 N , 81.957853 E
18.	GW18	Patai Dandi	1.67	North	25.165064 N , 81.954321 E
19.	GW19		1.11	North	25.157283 N ,81.950313 E
20.	GW20	Mai kala	1.58	East	25.155437 N, 81.943611E
21.	GW21		2.46	East	25.158336 N, 81.935622 E

22.	GW22	Mai khurdh	0.59	East	25.15835 N, 81.935641 E
23.	GW23		0.87	West	25.157204 N, 81.929852 E
24.	GW24	Jhadiyahi	0.77	West	25.14866 N, 81.916363 E
25.	GW25		0.48	West	25.146556 N, 81.918122 E
26.	GW26	Kulhawa	1.40	West	25.155271 N, 81.915991 E
27.	GW27		1.38	West	25.154884 N, 81.91601 E



GROUND WATER LEVEL MONITORING LOCATIONS (GW =GROUND WATER)

Figure 3: Google Map Showing Monitoring location in 10 Km radius of MUNPL

5.0 PERIOD OF STUDY:

The ground water level monitoring study has been carried out in pre-monsoon period (18/01/2025 to 19/01/2025) at different identified locations/monitoring points.

6.0 METHDOLOGY OF WATER LEVEL MONITORING:

Ground water level can be measured using variety of methods including tapes, plungers, and pressure transducers and geo physical methods. In the present study a Ruler Tape Piezometer is used for measuring of water level in the wells. This device is used to measure the water level in the wells. It uses a ruler scale to measure the water level. Slowly lower the sensor probe into the water. When the probe touches the water it generates a potential. The circuit processes the potential and issues instructions with sound and light. Read the height difference between the ground and the surface from the ruler.

Figure 4: Monitoring of Water level in the well using Ruler Tape Piezometer

7.0 MONITORING DATA:

Total 27 wells in 14 villages in radius of 10 Km of Power Plant was surveyed and selected for current and future studies. The water levels were measured using Ruler Tape Piezometers. The Monitoring results are depicted in table 1 & 2, graph 1 & 2.

Table 1: Monitoring Data

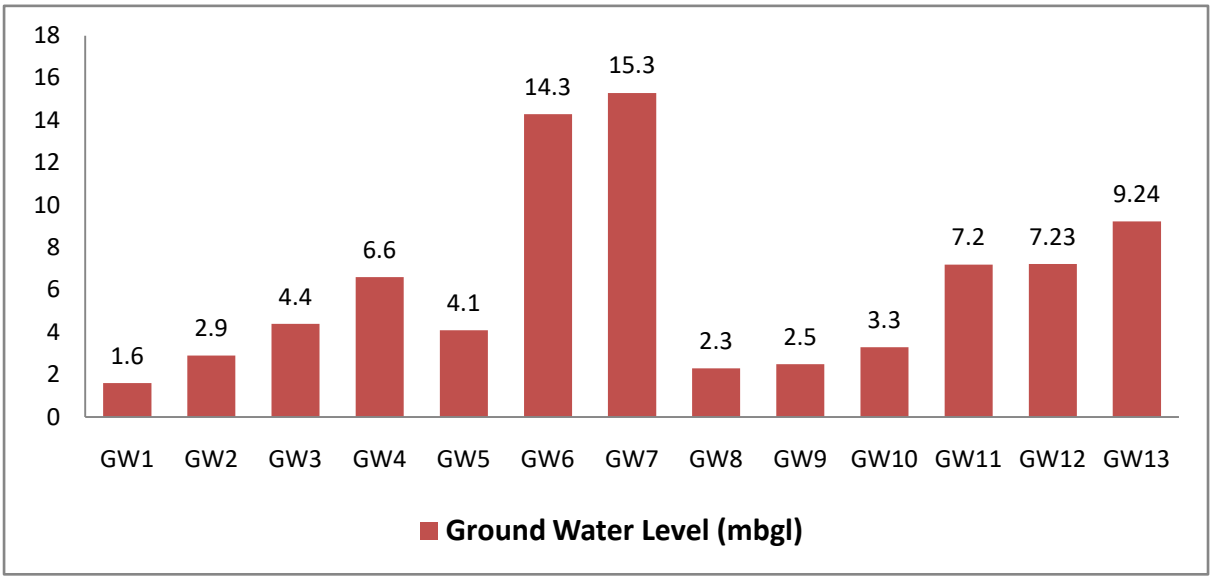
Monitoring Location Code	Inner dia on top of well (meter)	Use of water from well	Type of well	Source of water recharge	Landmark of well	Ground water level (mbgl)
GW1	5.6	Domestic/ Irrigation	Open well	Natural/Canal which is 700 m away	Left side of triveni road	1.6
GW2	6.0	Domestic/ Irrigation	Open well	Natural/Canal which is 200 m away	Right side of triveni road	2.9
GW3	4.7	Domestic/ Irrigation	Open well	Natural	Salaiyakalan bus stand/near gram pradhan house	4.4
GW4	5.2	Domestic/ Irrigation	Open well	Natural/canal which is 60 m away	Triveni road/Near Musahar Basti	6.6
GW5	5.12	Irrigation	Open well	Natural	In front of Piparau primary school /Shivkumar house	4.1
GW6	2.25	Domestic/ Irrigation	Open well	Natural/Tons which is 700 m away	In front of Kaluram Prajapati house	14.30
GW7	2.0	No use	Open well	Natural/Tons river which is 200 m away	Near of Bholaramprajapati house	15.30
GW8	2.85	Domestic/ Irrigation	Open well	Natural	Behind CHC hospital Dasauti(Laltara)/Ramsagivan Prajapati land	2.30
GW9	3.2	Domestic/ Irrigation	Open well	Natural	Near Munnilal Prajapati house/Kohadarkhiri road	2.5
GW10	2.25	Domestic/ Irrigation	Open well	Natural/sidhauli canal	Backside of Shyamraj house	3.3
GW11	2.0	Domestic/ Irrigation	Open well	Natural	Infront of Shiv Temple (Shreenath Kushwaha house)	7.20
GW12	3.0	Domestic/ Irrigation	Open well	Natural	Infront of Arvind Kushwaha house/Ramsumer Kushwaha	7.23
GW13	1.67	Domestic/ Irrigation	Open well	Natural	In front of Rishu Kushwaha house/Pahadhadgad road	9.24
GW14	3.65	Domestic/ Irrigation	Open well	Natural	In front of Kallan house/Kohdarberi road	11.38
GW15	1.95	Domestic/ Irrigation	Open well	Natural	In fron of Jain Mandir/NTPC solar water booth	11.90

GW16	2.13	Irrigation	Open well	Natural	Near Santlal Nishad house/isawta road	6.60
GW17	1.9	Irrigation	Open well	Natural	In front Odkamla Shankar Mishra house/NTPC solar water booth	14.40
GW18	1.78	Domestic/ Irrigation	Open well	Natural/Tons river which is 250 m away	Near Kamla Shankar Dwivedi house/Shiv mandir	17.22
GW19	1.68	Domestic/ Irrigation	Open well	Natural	In front of Dilip Kumar house/road side	10.40
GW20	1.83	Domestic/ Irrigation	Open well	Natural	In front of Bhaiyaram house/left side road	9.25
GW21	1.93	Domestic/ Irrigation	Open well	Natural/Nagranalah which is 200 m away	In front of Ramesh Chand Sukla house/right side of main road	8.47
GW22	1.78	Domestic/ Irrigation	Open well	Natural	In front of Sankatmochan Hanumanmandir/Rajprataptiwari house(pradhan)	15.15
GW23	1.77	No use	Open well	Natural	Infront of Gajraj Singh house	13.80
GW24	1.78	Domestic/ Irrigation	Open well	Natural/Tons River which is 500 m away	Infront of Mahadev Temple/Rajnarayan Nishad house	18.40
GW25	2.13	Domestic/ Irrigation	Open well	Natural/Tons River which is 500 m away	Infront of Lalla Nishad house	16.15
GW26	1.51	No use	Open well	Natural/Tons which is 500 m away	Infront of Vindhyavasini Mishra house/Shiv Mandir	15.0
GW27	1.87	No use	Open well	Natural/Tons River which is 500 m away	Infront of Lalmohan Pandey/road side	14.60

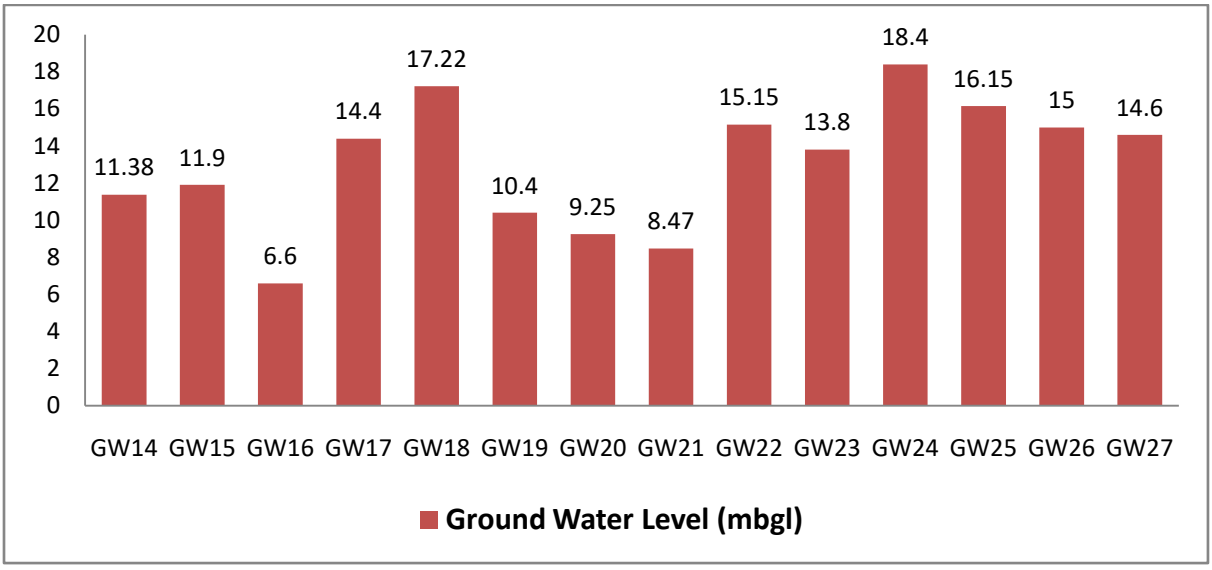
Table 2: Village wise Sampling Location and Status of Ground water Level

Sl. No.	Name of Village	Monitoring Location Code	Ground Water Level (mbgl)
1.	Salaiya Khurd	GW1	1.6
		GW2	2.9
2.	Salaiyakalan	GW3	4.4
		GW4	6.6
3.	Piparau	GW5	4.1
4.	Dhaduva	GW6	14.30
		GW7	15.30
5.	Dausati	GW8	2.30
		GW9	2.5
6.	Son Barsi	GW10	3.3
7.	Mudpela	GW11	7.20
		GW12	7.23
		GW13	9.24
8.	Kohdar	GW14	11.38
		GW15	11.90
		GW16	6.60
9.	Isawta	GW17	14.40
10.	Patai Dandi	GW18	17.22
		GW19	10.40
11.	Mai kala	GW20	9.25
		GW21	8.47
12.	Mai khurdh	GW22	15.15
		GW23	13.80
13.	Jhadiyahi	GW24	18.40
		GW25	16.15
14.	Kulhawa	GW26	15.0
		GW27	14.60

GRAPHICAL PRESENTATION OF GROUND WATER LEVEL AT DIFFERENT MONITORED LOCATIONS:

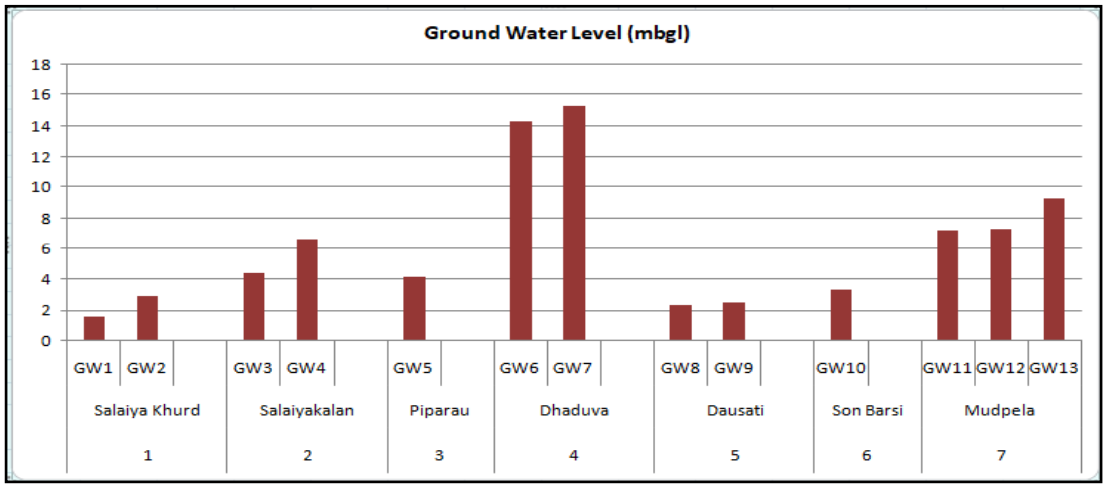


Graph 1(a): Graphical Presentation Ground Water Level at different Monitored Locations

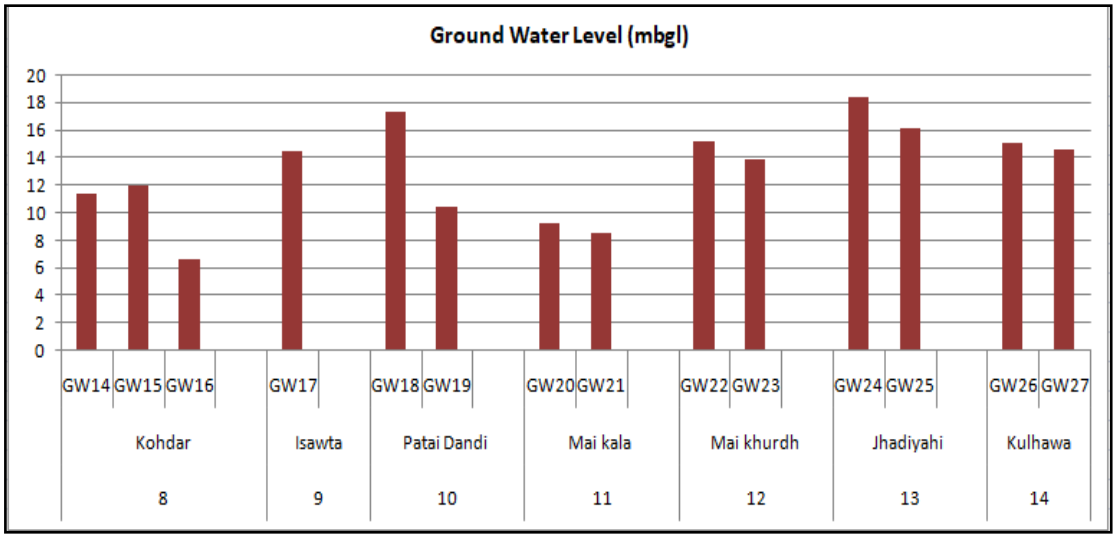


Graph 1(b): Graphical Presentation Ground Water Level at different Monitored Locations

7.0 (i) Village Wise Comparative Status of Ground Water Level:



Graph 2(a): Village Wise Comparative Status of Ground Water Level



Graph 2(b): Village Wise Comparative Status of Ground

8.0 RESULT & DISCUSSION:

- A total 27 Wells in 14 villages around the buffer zone of 10 Km area around the Power Plant were surveyed and selected for current and future studies. The locations were selected to get the maximum spatial representation of the area.
- Water Levels were measured manually using Ruler Tape Piezometer.
- Out of 27 measured wells, the ground water level ranged from 1.6 mbgl to 18.40 mbgl. Minimum value of water level 1.6 mbgl is found at Salaiya Khurdand maximum value of water level is found 18.40 mbgl at Jhadiyahi. Details are depicted in table 1 & 2.
- The depth to Water level from 1-10 mbgl is found in 14 wells (52 %) and 10 -18.40 mbgl is found in 13 wells (48%).

- Variations in the depth to the water level is found in different wells in the same village (table 1 & 2, graph 1 & 2).
- This is a preliminary study in pre-monsoon season of 2025, the seasonal variations ground water level fluctuations will be carried out in consecutive years.

9.0 REFERENCES

- Ground Water Year Book Uttar Pradesh (2021 -2022) September, 2022.
- GIS-based mapping of water-level fluctuations (WLF) and its impact on groundwater in an Agrarian District in Tamil Nadu, India Published: 16 June 2021 Volume 24, pages 994–1009, (2022)

10.0 PHOTOGRAPHS OF GROUND WATER LEVEL MONITORING:

Photo 1: Salaiya Khurd

Photo 2:Salaiya Khurd

Photo 3: Salaiya Kalan

Photo 4: Salaiya Kalan

Photo 5 : Piparau

Photo 6 : Piparau

Photo 7: Dhaduva

Photo 8: Dhaduva

Photo 9: Dausati

Photo 10: Dausati

Photo 11: Son Barsi

Photo 12: Son Barsi

Photo 13: Mudpela

Photo 14: Mudpela

Photo 15:Kohdar

Photo 16:Kohdar

Photo 17: Isawta

Photo 18: Isawta

Photo 19: Patai Dandi

Photo 20: Patai Dandi

Photo 21: Mai Kala

Photo 22: Mai Kala

Photo 23: Mai khurdh

Photo 24: Mai khurdh

Photo 25:Jhadiyahi

Photo 26:Jhadiyahi

Photo 27: Kulhawa

Photo 28: Kulhawa

Photo 29 Piparau

****

TEST REPORT ON AMBIENT AIR QUALITY

Name of Industry	:	Meja Thermal Power Project, Meja, Prayagraj
Study Code No.	:	SSP-481
Date of Sample Collection	:	15th April, 2025 to 19th April, 2025
Type of Sampling	:	24 hourly basis
Date of sample received	:	19-04-2025
Date of completion of testing	:	13-05-2025
Season & Weather	:	Summer & Clear Day

Test Results:

S. No.	Location and Date	Code	Parameter	Concentration ($\mu g/m^3$)
1.	Kohdar Village 15th April 2025	AQ-1	$PM_{2.5}$	53.4
			PM_{10}	79.9
			SPM	186.6
			SO_2	8.4
			NO_2	14.6
2.	Sonbarsi Village 19th April 2025	AQ-2	$PM_{2.5}$	43.8
			PM_{10}	72.1
			SPM	147.9
			SO_2	5.7
			NO_2	13.4
3.	Maikalan Village 17th April 2025	AQ-3	$PM_{2.5}$	57.4
			PM_{10}	76.8
			SPM	157.6
			SO_2	7.2
			NO_2	13.0
4.	Township 18th April 2025	AQ-4	$PM_{2.5}$	49.3
			PM_{10}	61.1
			SPM	119.3
			SO_2	6.6
			NO_2	15.6
5.	Plant Area 16th April 2025	AQ-5	$PM_{2.5}$	58.4
			PM_{10}	83.9
			SPM	210.1
			SO_2	10.1
			NO_2	21.4

13/05/2025

(Dr. Abhay Raj)
Principal Scientist
Environmental Monitoring Laboratory

Notes:

(i) The above results relate only to the tests requested by sponsorer.

(ii) The report shall not be reproduced in fragments without the written approval of Director, CSIR- IITR, Lucknow.

(iii) This report shall not be used for any purpose other than environmental management related activities of the plant/ site by the sponsorer. "CSIR-IITR is not regulatory and certifying agency hence no part of this report should be used for legal purposes under any circumstances".

TEST REPORT ON AMBIENT AIR QUALITY

Name of Industry	:	Meja Thermal Power Project, Meja, Prayagraj
Study Code No.	:	SSP-481
Date of Sample Collection	:	21st July, 2025 to 25th July, 2025
Type of Sampling	:	24 hourly basis
Date of sample received	:	27-07-2025
Date of completion of testing	:	28-08-2025
Season & Weather	:	Monsoon & Clear Day

Test Results:

S. No.	Location and Date	Code	Parameter	Concentration ($\mu g/m^3$)
1.	Kohdar Village 23rd July 2025	AQ-1	$PM_{2.5}$	58.6
			PM_{10}	83.5
			SPM	206.4
			SO_2	6.5
			NO_2	12.7
2.	Sonbarsi Village 24th July 2025	AQ-2	$PM_{2.5}$	45.5
			PM_{10}	68.5
			SPM	155.8
			SO_2	7.3
			NO_2	10.8
3.	Maikalan Village 25th July 2025	AQ-3	$PM_{2.5}$	50.9
			PM_{10}	78.2
			SPM	192.9
			SO_2	8.0
			NO_2	12.0
4.	Township 21st July 2025	AQ-4	$PM_{2.5}$	40.4
			PM_{10}	70.9
			SPM	129.8
			SO_2	5.9
			NO_2	13.3
5.	Plant Area 22nd July 2025	AQ-5	$PM_{2.5}$	56.6
			PM_{10}	89.1
			SPM	174.9
			SO_2	9.6
			NO_2	23.8

10/9/2025

(Dr. Abhay Raj)
Senior Principal Scientist
Environmental Monitoring Laboratory

Notes:

(i) The above results relate only to the tests requested by sponsorer.

(ii) The report shall not be reproduced in fragments without the written approval of Director, CSIR- IITR, Lucknow.

(iii) This report shall not be used for any purpose other than environmental management related activities of the plant/ site by the sponsorer. "CSIR-IITR is not regulatory and certifying agency hence no part of this report should be used for legal purposes under any circumstances".

ANNEXURE - VI

No. 11/24/2022-Th.II
Government of India
Ministry of Power

Shram Shakti Bhawan, Rafi Marg,
New Delhi, dated 10th January, 2023

OFFICE MEMORANDUM

Subject: Minutes of Meeting chaired by Secretary (Power) on 28.12.2022 at 11:00 AM in Shram Shakti Bhawan, Ministry of Power in Hybrid mode on use of STP water in Thermal Power Plants -reg

The undersigned is directed to forward herewith Minutes of Meeting held under the Chairmanship of Secretary, Ministry of Power on 28.12.2022 at 11:00 AM to discuss the use of Sewage Treated Water by Thermal Power Plants for information and further necessary action.

10/1/23

(J.Misra)
Under Secretary to Govt. of India
Tele: 23063746

To,

1. Chairperson, CEA [chair@nic.in]
2. CMD, NTPC[cmd@ntpc.co.in]
3. DG, NMCG[dg@nmcg.nic.in]
4. Principal Secretary (Energy), Govt. of Haryana [powersecy-hp@nic.in]
5. Principal Secretary (Energy), Govt. of UP [psenergyup@gmail.com]
6. Principal Secretary (Energy), Govt. of Jharkhand [psec.energy@gmail.com]
7. Principal Secretary (Energy), Delhi [pcpower@nic.in]
8. Principal Secretary (Energy), Bihar [energy@bihar.gov.in]
9. Principal Secretary (Energy), West Bengal [powersecy@wb.gov.in]
10. Principal Secretary (Energy), Govt. of Chhatisgarh [secy-energy.cg@gov.in]
11. Principal Secretary (Water Resources), Govt. of Haryana [fciwrd@gmail.com]
12. Principal Secretary (Water Resources), Govt. of UP [psecup.irrig@nic.in]

13. Principal Secretary (Water Resources), Govt. of Jharkhand [sec_wrd_jhr@nic.in]
14. Principal Secretary (Water Resources), Delhi [ceodelhi.djb@nic.in]
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16. Principal Secretary (Water Resources), West Bengal [psecy.wridd-wb@gov.in]
17. Principal Secretary (Water Resources), Govt. of Chhatisgarh [secy-wrd.cg@gov.in]
18. CMD, IPGCL (For Pragati CCGP and Pragati-III CCGP), Delhi [mukeshipj@yahoo.co.in]
19. CMD, HPGCL, Haryana[md@hpgcl.org.in]
20. CMD, THDC [cmd@thdc.co.in]
21. CMD, UPRUVNL, UP [cmd@upruvnl.org]
22. CMD, NUPPL, UP (For Ghatampur TPP)[cmd@nlc.india.in, ceo.nuppl@nlcindia.in]
23. CMD, CESC, West Bengal [bhaskar.ganguly@rpsg.in]
24. CMD, Aparva-CLP, Haryana (For Mahatma Gandhi TPS) [jaya.sharma@clpindia.in]
25. CMD, RVUNL, Rajasthan (For Kota TPS) [fmzktps@rediffmail.com]
26. Chairman, DVC, Kolkata (For Bokaro B TPS) [chairman@dvc.gov.in]
27. CMD, WBPDCL, West Bengal (For Sargadighi, Bandel, Kolaghat and Southern Repl. TPS)[s.maity@wbpdcl.co.in]
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29. CMD, Adhunik Power (For Mahadev Prasad TPS), Jharkhand [subhashjetly@gmail.com]
30. CMD, SJVNL (For Buxar TPP, Bihar) [sectt.cmd@sjvn.nic.in]
31. Tata Power JV (For Prajyagraj Bara, TPS), UP[brajesh.singh@tatapower.com]
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33. JMD, Uttar Pradesh Jal Nigam [jmdnagarupjn@gmail.com]
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37. MD, JUIDCO [juidcolmited@gmail.com]
38. PD (Technical), JUIDCO [pdt.juidco@gmail.com]
39. CEO, KMDA [ceokmda@gmail.com]
40. Chief Engineer, PHED, Haryana [eicphed@phedharyana.gov.in]

Copy to:

Sr. PPS to Secretary (Power)/ PS to JS (Thermal)/ DS (DVC/Th.)

Minutes of Meeting chaired by Secretary (Power) on 28.12.2022 at 11:00 AM in Shram Shakti Bhawan, Ministry of Power in Hybrid mode on use of STP water in Thermal Power Plants

List of participants is **annexed**.

2. Secretary (Power) welcomed the participants. At the outset, Secretary (Power) mentioned that as per National Tariff Policy, all Thermal Power Plants were mandated to use STP water if located within 50 KM radius of STP. Any exemption could be considered only on the basis of technical constraint or exorbitantly high cost making tariff unsustainable. He further emphasized that Clean Ganga is a National Mission and Thermal Power Plants should actively play their part in making river Ganga cleaner. He also briefed that the Hon'ble Prime Minister shall be reviewing the progress on the matter on 30th December 2022.

3. Sewage Treatment Plant (STP) and Thermal Power Station (TPS)-wise discussions were held as follows:

i) **Name of TPS**: Barh TPS St-II (NTPC Ltd)

Name of STP: Barh STP

Status and Recommendation:

It was informed that STP was being renovated by BUIDCO to increase the capacity from present 4MLD to 8 MLD (Cap 11MLD after 15 years) to meet NGT guidelines. BUIDCO prepared and submitted the DPR to link STP and TPP to NTPC. NTPC had some observations on DPR w.r.t. Opex.

Secretary (P) directed NTPC to use the available water from STP. Further, it was directed that senior officials of NTPC must visit BUIDCO and **finalize the DPR and sign MoU by 15th Jan 2023.** NTPC can then make payment to BUIDCO to initiate construction activities for the 4 km linkage between STP and TPP. **Targeted work completion date is 1st April 2025.**

BUIDCO mentioned that there were two more STPs within 50 km at Mokama and Bakhtiyarpur which could also be linked with Barh. Secretary(P) directed to examine their feasibility separately.

ii) **Name of TPS: Prayagraj Bara TPS (Tata Power-JV)**

Name of STP: Naini STP

Status and Recommendation:

It was informed that PFR prepared by UP Jal Nigam was sent to Genco and pending for approval of Genco. Secretary (P) advised Genco to approve the PFR by 1st week of Jan 23 and then Discom to give consent by end of Jan 23.

Construction activities to start by Apr '23 and usage of STP water to start by Apr '25.

iii) **Name of TPS**: Meja TPS (NTPC-Jv)

Name of STP: Naini STP

Status and Recommendation:

- It emerged that available water from Naini STP would be used in Bara TPS which is located closer to STP than Meja. Further, Meja TPS is located across the river from STP whereas, Bara and STP are in same side of the river. Taking into consideration these facts, it was recommended that **Meja TPS may be exempted from linking with the STP.**

iv) **Name of TPS:** DCR Yamunanagar TPS (HPGCL)

Name of STP: Parwalo & Badi Majra STPs

Status and Recommendation:

- It was informed that GoHR has mandated all TPSs in Haryana to use STP water and asked PHED to supply STP water at TPS door step.
- PHED informed that DPR preparation is under progress and is expected by June '23.
- It was clarified that prior approval of SERC is not required.
- **Work completion of linking STPs with TPS at Yamuna Nagar by December 2025.**

v) **Name of TPS:** Panipat TPS

Name of STP: Panipat STP

- Secretary (P) advised PHED to examine feasibility in Panipat TPS as the unit residual time was less than 10yrs.

vi) **Name of TPS:** CLP Jhajjar- Aprava TPS

Name of STP: Chakri Dadri STP

- It was observed that approximate available STP water was very less (3.5 MLD against requirement of 100 MLD). Therefore, it was recommended that **CLP-Jhajjar may be exempted from linking with the STP.**

vii) **Name of TPS:** Indira Gandhi- NTPC JV Jhajjar TPS

Name of STP: Kosli STP

- It was informed that water availability is only 3.5% of requirement. Therefore **NTPC Jhajjar may be exempted from linking with the STP.**

- **Secretary (P) further directed Thermal div. to write a letter to CERC, informing that no permission was required to be given by CERC to TPSs for tariff revision on account of costs borne by TPS for STP linkage as this was already mandated in Tariff Policy.**

viii) **Name of TPS:** Panki TPS (UPRVUNL)

Name of STP: Bingawan STP

Status and Recommendation:

- STP is operational and TTP is expected to be available by March 2023.
- COD for the TPS is expected in July,2023. **Therefore, use of STP water is expected by July 2023.**

ix) **Name of TPS**: Korba TPS (NTPC Ltd)

Name of STP: Korba STP

Status and Recommendation:

- Commissioner, Korba informed that the DPR was approved and has been sent for State Govt approval. MoU with NTPC is expected to be signed within 1st week of Jan 2023, work order issue by Aug'23 and **expected completion of work by 1st April 2025.**

x) **Name of TPS**: Ghatampur TPP (NUPPL)

Name of STP: Bingawan STP

Status and Recommendation:

- Due to river crossing, **Ghatampur TPP may be exempted from linking with STP.**

xi) **Name of TPS**: Kahalgaon TPS (NTPC Ltd)

Name of STP: Bhagalpur STP

Status and Recommendation:

- It was informed that existing STP was being dismantled and new STP would be constructed. NTPC mentioned that as per estimates, tariff may rise by 20.20 paise/Kwh as land acquisition would be involved. Further, highway/Rail/city crossings are involved.

- **Secretary (P) opined that decision on this may be taken after PFR is available in April 2023.**

xii) Name of TPS: Khurja TPS (THDC Ltd)

Name of STP: Bulandshahar STP

Status and Recommendation:

- 20 MLD available from STP (Cap: 40MLD)
- **Secretary (P) instructed Khurja TPS to sign MoU and make payment to UP Jal Board for DPR preparation by 7th Jan 2023.**
- **DPR is to be prepared by March 2023 and project completion by 1st July 2025.**

xiii) Name of TPS: Harduaganj TPS (UPRVUNL)
Name of STP: Aligarh STP

Status and Recommendation:

- UP Jal Nigam informed that the 1st STP of 40 MLD will be completed by March 2023. Approval for 2nd STP is with NMCG
- Secretary (P) advised NMCG to fast-track the 2nd STP approval. The revised DPR by Jal Nigam may include both the STPs and TTPs to be implemented in a phased manner. **Target date for completion is June 2025.**

xiv) Name of TPS: Budge-Budge TPS (CESC)
Name of STP: Maheshthala STP

Status and Recommendation:

- KMDA informed that route from STP to TPS is very congested due to lines from other utilities.
- 2 units have completed 25 years.
- Due to path congestion and huge RoW issue, it was recommended that **Budge-Budge TPS may be exempted from linking with the STP.**

xv) Name of TPS: Kota TPS (RVUNL)

Name of STP: Sajidhera STP

Status and Recommendation:

- As the TPS is on the other side of the river, **therefore Kota TPS may be exempted from linking with the STP.**

xvi) Name of TPS: Dadri TPS (NTPC)

Name of STP: NOIDA STP

Status and Recommendation:

- It was informed that laying pipeline would disproportionately increase cost as one river crossing, 2 Highway crossings, Rail crossing and densely populated area would be involved. Cost increase is expected to be 30 P/Kwh. Considering all factors, it was recommended that **Dadri TPS may be exempted from linking with the STP.**

xvii) Name of TPS: Bokaro B TPS (DVC)

Name of STP: BOKARO STP

Status and Recommendation:

- It was informed that linking with nearest STP involves hilly terrain of 56KM which also includes crossing Damodar river. As a result, cost increase would be 27p/Kwh.

- It was recommended that **Bokaro TPS may be exempted from linking with the STP.**

xviii) Name of TPS: Rosa TPS (Reliance Power)

Name of STP: Shahjahanpur STP

Status and Recommendation:

- UP Jal Nigam shared that the STP was under construction and is expected to be operational by March 2023.
- Secretary (P) advised that **PFR may be submitted by 31st March 2023 to TPS by Jal Nigam.**

xix) Name of TPS: Mahadev Prasad TPS (Adhunik Power)

Name of STP: Adityapur STP

Status and Recommendation:

STP is located at 20 km distance from the TPS and expected to be ready by June 2024.
Secretary (P) advised JUIDCO to undertake feasibility study and share it with TPS by March '23.

xx) Name of TPS: Sagardighi TPS (WBPDCL)

Name of STP: Berhampore STP

Status and Recommendation:

- As the TPS is on the other side of the river, **therefore Sagardighi TPS may be exempted from linking with the STP.**

xxi) Name of TPS: Bandel TPS (WBPDCL)

Name of STP: Bhatpara STP

As the units are more than 30 years old, it was recommended to exempt Bandel TPS.

xxii) Name of TPS: Kolaghat TPS (WBPDCL)

Name of STP: Howrah STP

WBPDCL informed that units are more than 30 years old. Further, river crossing is involved. Considering the above, it was recommended to exempt Kolaghat TPS.

xxiii) Name of TPS: Southern Repl TPS (CESC)

Name of STP: Garden Reach STP

As units are more than 30 years old, it was recommended to exempt this TPS.

4. Further, UP Jal Nigam submitted that Jawaharpur TPS (UPRVUNL) and Unchachar TPS (NTPC) have been approached by them for linkage from Etah STP and Raibareilly STP respectively. TPSs have not reverted. Secretary (P) advised NMCG to take note and co-ordinate with the agencies. He further advised that NMCG may consider taking into account all the STPs which are operational or under construction in Ganga basin, irrespective of who is funding it so that all infomation is available at a single place which could be used to map TPSs within 50 KM and share the information with MoP for further action.

Meeting ended with the Vote of Thanks to Chair.

****

List of Participants

Annexure

1. Shri Alok Kumar, Secretary (Power), MoP.....In chair
2. Shri Piyush Singh, Joint Secretary (Thermal), MoP
3. Shri Suman Majumdar, Deputy Secretary, MoP
4. Shri Ghanshyam Prasad, Chairperson, CEA
5. Shri Praveen Gupta, Member (Thermal), CEA
6. Shri U K Bhattacharya, Director (Projects), NTPC
7. Shri Madhava Kumar R, Economic and Financial Advisor, NMCG
8. Sh. Mohammed Shayin, MD, HPGCL, Haryana
9. Shri Kumar Sharad, CGM, THDC
10. Shri P Guruprasad,MD, UPRUVNL
11. Shri Santosh C S, CEO, NUPPL
12. Shri Avijit Hazra, CESC
13. Shri Prabhakar Pandey, Commissioner, Korba
14. Shri Rajan Tiwari, Aprava-CLP
15. Shri Virendra Singh, RVUNL, Rajasthan
16. Shri R N Singh, Chairman, DVC, Kolkata
17. Shri Sourav Nayak, WBPDCL
18. Shri Rakesh Kumar Bansal, Director (Electrical), SJVNL
19. Shri Sanjay Bhargava, Tata Power
20. Shri Anil Kumar, MD, Uttar Pradesh Jal Nigam
21. Shri Pankaj Ranjan Jha, Uttar Pradesh Jal Nigam
22. Shri Dharmendra Singh, MD, BUIDCO, Bihar
23. Shri Alok Kumar Mandal, DGM, JUIDCO
24. Shri Prantik Ray, CE (Gas Sector), KMDA
25. Shri Rakesh Kumar,Chief Engineer, PHED, Haryana
26. Shri I C Thakur, Engineer In Chief, WRD, Bihar
27. Shri Ashok Kumar Khewaria, EE, UP Jal Nigam

ANNEXURE: 6

STACK EMISSION (UNIT WISE)													
MONTH: April'25													
UNIT_NO	**Installed Capacity (MW)**	**PM (mg/Nm³)**			**SO_2 (mg/Nm³)**			**NOx (mg/Nm³)**			**Mercury (Hg) Emission(mg/Nm³)**		
			Actual Value			**Actual Value**			**Actual Value**			**Actual Value**	
		Applicable Norm *	**Average Value for the month**	**Max. Value for the month**	**Applicable Norm ***	**Average Value for the month**	**Max. Value for the month**	**Applicable Norm ***	**Average Value for the month**	**Max. Value for the month**	**Applicable Norm ***	**Average Value for the month**	**Max. Value for the month**
1	**660**	**30**	12.51	28.93	**100**	26	102.32	**100**	139.07	383.47	0.03	0.00039	
2	**660**	**30**	0.00	0.00	**100**	0.00	0.00	**100**	0.00	0.00	0.03	0.000321	
	# Unit-2 is shut down from Feb-2025 for overhauling												
MONTH: May'25													
1	**660**	**30**	14		**100**	28		**100**	178		0.03	0.00039	
2	**660**	**30**	26		**100**	575**		**100**	390		0.03	0.000321	
	**: Unit-2 was under shut down for overhaul till 10/05/2025. FGD of Unit-2 was taken back after stabilization of Unit & associated systems on 20/05/25. U2 FGD was in service since 20/05/25. Hence, Month's average SOX value was high.												
MONTH: June'25													
1	**660**	**30**	1.5		**100**	19		**100**	345.00		0.03	0.000513	
2	**660**	**30**	7.10		**100**	22.80		**100**	204.00		0.03	-	
MONTH: July'25													
1	**660**	**30**	0.66		**100**	13.59		**100**	351.00		0.03	0.000513	
2	**660**	**30**	2.40		**100**	15.59		**100**	359.00		0.03	-	
MONTH: August'25													
1	**660**	**30**	4.1		**100**	9.8		**100**	193.2		0.03	0.000513	
2	**660**	**30**	5.5		**100**	11.7		**100**	123.3		0.03	–	
MONTH: September'25													
1	**660**	**30**	2.0		**100**	18.11		**100**	174.18		0.03	0.000513	
2	**660**	**30**	2.12		**100**	9.66		**100**	149.65		0.03	–	

CSR ACTIVITY CALENDAR FOR FY 2025-26

Sl.NO.	Name of the Activity	Budget Estimate (in Lacs) 2025 26
A	**Education**	
1	Distribution of Stationary Kits, Benches, educational materials, sports items etc. to Schools in nearby villages	12
2	Augmenting educational infrastructure in Govt. Rural Schools/ITI-Naini, Installation of Smart classes for Improving Learning Levels of children studying in the nearby rural schools/Solar Panel with battery backup in Govt. Rural Schools	190
3	Giri Empowerment Mission (GEM) including education including payment of education. fees of GEM girls inducted into MUNPL Township Schools	40
4	Other Education Related Activities	10
	TOTAL (A)	**252**
B	**Health & Nutrition**	
1	Conducting Specialized Health camps in the nearby villages	15
2	Organizing Awareness campaigns through agencies/NGOs/Other agencies	2
3	Other Health Related Activities	75
	TOTAL (B)	**92**
C	**Infrastructure & Connectivity**	
1	Construction of Roads (CC/Interlocking/Bituminous), drains, toilets etc and renovation of infrastructures in the associated villages	150
2	Installation of Solar Street Lights/Solar High Mast Lights in the associated villages and outside areas, as per requirement	100
	TOTAL (C)	**250**
D	**Water**	
1	Installation of Handpumps and development of water supply systems for the local/outside areas	150
	TOTAL (D)	**150**
E	**Capacity Building**	
1	CIPET Training & CRISP Training/Other Skill Enhancement Programmes for local youth incl. rural women	170
	TOTAL (E)	**170**
F	**Misc. Activities**	
1	Mainstreaming the Specially abled people (Divyang) by providing them with aids and appliances	70
2	Organizing and promoting sports activities in adjoining areas	5
3	Distribution of Blankets	12
4	Other activities of strategic nature such as Live stock development ,Career Counselling, PHC upgradation, SHG plus Entrepreneurship etc.	150
	TOTAL (F)	**237**
	GRAND TOTAL (A+B+C+D+E+F)	**1151.00**