एनटीपीसी
NTPC
एक महारत्न कंपनी

एनटीपीसी लिमिटेड
(भारत सरकार का उद्यम)
NTPC Limited
(A Govt. of India Enterprise)

गाडरवारा/ GADARWARA

NTPC-Gadarwara-HYC-2023 **Dated: 12.06.2023**

The Additional Chief Conservator of forest
Ministry of Environment, forest & Climate Change
Regional Office, MoEF (Western Zone),
Kendriya Paryavaran Bhavan,
E-5Arera Colony Link Road No.3,
Ravishankar Nagar, Bhopal (M.P.) - 462 016

Sub: Half yearly Compliance report of NTPC-Gadarwara (2 x 800 MW)

Dear Sir,
Please find enclosed Half Yearly Compliance (HYC) report of NTPC-Gadarwara (2 x 800 MW) for the period Oct'2022 to Mar'2023 in line with the guidelines as stipulated by MoEF & CC for kind perusal please.

Thanking you,

(Jeetendra Kr. Meena)

(Sr. Manager) Environment Group

GADARWARA SUPER THERMAL POWER PROJECT, STAGE-I (2X800 MW)
Compliance status of Environmental Clearance Vide Letter No: J-13012/125/2009-IA,II(T)
Dt:22/03/13
Period of Compliance Report – (01.10.2022 to 31.03.2023)

SL.NO.	MOEF STIPULATION	STATUS AS ON 31.03.2023
A. Specific Conditions:		
i	The project proponent shall set up the power project as a model plant demonstrating that ecology and development can co-exists in harmony and set examples for others to emulate similar practice.	NTPC Gadarwara has set up the power project as a model plant demonstrating that ecology and development can co-exist in harmony. *(Details furnished during HYC Oct-21 to Mar22)*
ii	Sulphur and ash contents in the coal to be use 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 the Ministry for suitable amendments to environmental clearance condition wherever necessary.	Noted NTPC-Gadarwara shall approach MoEF & CC for any variation in coal quality.
iii	Bi-flue stack of 275 m height with flue gas velocity not less than 22 m/s shall be installed and provided with continuous online monitoring equipment's for SOx, NOx and PM2.5 & PM. Mercury emissions from stack may also be monitored on periodic basis.	A bi-flue stack of 275 meters height constructed and minimum flue gas velocity of 22 m/sec ensured. Continuous stack monitoring facility for online measurement of SO_2, NOx and Particulate Matter (PM) is being done. Online Mercury level measurement is also being done. *(The photographs of the Stack and Technical Details of stack furnished during HYC Oct-21 to Mar22)*
iv	No mine void filling or filling up of low-lying areas with fly ash shall be undertaken.	No mine void filling shall be done. Whenever required, due permission is being sought from MPPCB. Abandoned stone query at Chawarpatha (approximately 50 km away from NTPC Gadarwara Plant) is being filled as per the latest guidelines and due permission of MPPCB.
v	COC of 5.0 shall be adopted	Closed cycle cooling system has been designed with COC of 5.0 for optimization of water requirement.
vi	Continuous monitoring of Narmada River water quality in its upstream and downstream of water tapping point shall be undertaken regularly and records maintained.	Continuously regular monitoring by third party of Narmada River water quality in its upstream and downstream of water tapping point is being undertaken regularly during operation phase of the project.
vii	The project proponent shall explore the possibility for storage of excess monsoon water for use during lean season. The same could be by construction of barrage at appropriate location which could be carried out in close consultation with the WRD, Govt. of Madhya Pradesh.	Gadarwara project has constructed weir on Narmada River in consultation with WRD, Government of Madhya Pradesh. Scheme has been approved to collect storm water from plant premises and store in reservoir. Rainwater harvesting Scheme is being implemented.

viii	The ash pond design shall be such that no breach takes place even in the worst case of natural calamity. Since the geology of the area indicates sandy loam and loamy soil, the ash pond need to be appropriately lined with appropriate impermeable media.	All the engineering practices have been followed for the construction of Ash Dyke. It has been designed with adequate factor of Safety. The design of ash dyke also takes into consideration the seismic parameters. Regular monitoring and inspection of ash dykes will ensure no risks of failure. In addition, ash pond lined with suitable impermeable material like Bentonite blended clay. Moreover, the Fly Ash Disposal System for the project envisages the use of High Concentration Slurry Disposal (HCSD) System, which leads to solidification of the layers of ash slurry within 1-2 days. The solidified layers of ash shall be self-supporting and there will be no risk of ash flowing in the surrounding areas. For disposal of bottom ash, a conventional slurry disposal system with ash water recirculation has been adopted. However, NTPC Gadarwara is committed to 100% ash utilization.
ix	Ash pond for Stage-II (400 acres) can be considered only after the first ash pond is dispensed with by filling up of bottom ash and demonstration of 100% fly ash utilization established within four years of commissioning of the plant. The 2nd ash pond for Stage-II (400 acres) requirement should not arise and land earmarked can be converted for green belt and or water storage.	Noted and shall be complied. Noted
x	Long term study shall be carried to assess impact on the ecology of the river Narmada downstream of the present project site at a different location especially at tapping points for drinking water supply and irrigation. The study shall be carried out by an institute of repute like IIT, Roorkee preferably within six months and report submitted to the Ministry. Thereafter the study shall be repeated after commissioning of both units of 2x800 MW and report subsequently submitted to the Ministry.	Study on impact of water intake due to Gadarwara STPP on Ecology of Narmada River is being carried out by Central Inland Fisheries Research Institute (CIFRI) since December 2022. (*Copy of the interim report is enclosed as Annexure- I)*
xi	The project proponent shall explore setting up of R.O System to treat cooling tower blow down discharge of about 5 cusecs and the R.O system shall be so designed so as to take care of drinking water supply for the nearest few villages.	Cooling towers blow down water is being reused for ash handling system, fire water, service water etc. within the plant. However, drinking water has been provided in nearby villages.

xii	The village ponds / surface water bodies located within 5 kms radius of the project site shall be regenerated in the as part of its social welfare activities.	Under Various community CSR-CD works following initiatives were undertaken: Four ponds in project affected villages (PAVs) were identified for deepening out of which, work has been completed in three villages (Ghat Pipariya, Chor Barhata & Gangai). One Pond in Kudari village have been identified for deepening as a special project by district administration. The work is being undertaken by the district administration and is under progress
B. General Conditions		
(i)	Vision document specifying prospective plan for thesite shall be formulated and submitted to the Regional Office of the Ministry within six months.	NTPC vide letter dated 08.04.2013 has already submitted the Project Vision Document to the Regional Office (Western Zone) of the Ministry of Environment and Forest & Climate Change (MOEF&CC), Bhopal. *(Copy of vision document furnished during HYC Oct-21 to Mar-22 also)*
(ii)	Scheme for implementation for harnessing solar power within the premises of the plant particularly at available roof tops shall be formulated and status of implementation shall be submitted periodically to the Regional Office of the Ministry.	Installation and Commissioning of 1200KW of Rooftop Solar PV panels is completed at all potential buildings.
(iii)	Provision for installation of FGD shall be provided for future use.	Installation of FGD work is in progress, Contract awarded to ISGEC Heavy Eng. Ltd. on 26/09/2018, scheduled completion date for Unit#1 is 31/12/2023 and for Unit#2 is 30/06/2024 as per newly defined timelines as Gadarwara falls under Category “C”
(iv)	Coal transportation to plant site shall be undertaken by rail and no road transportation shall be permitted.	Coal transportation to plant site is being done by rail through dedicated railway siding.
(v)	A long term study of radio activity and heavy metals contents on coal to be used shall be carried out through a reputed institute. Thereafter mechanism for an in- built continuous monitoring for Radio activity and heavy metals in coal and fly ash (including bottom ash) be put in place.	‘The radio activity study BARC’ for analyzing natural background radiation monitoring at Gadarwara project has been carried out by BARC.
(vi)	Utilization of 100% Fly Ash generated shall be made from 4th year of operation. Status of implementation shall be reported to the Regional Office of the Ministry from time to time.	Ash is being supplied to NHAI Road projects (NH47 near Harda, Sagar), Cement industries, filling up abandoned sone query at Chawarpatha with due permission of MPPCB. Fly ash utilization was 81% in 2022-23. NTPC Gadarwara is committed to 100% ash utilization. Status of implementation is being sent to Regional Office time to time. *(Copy of latest report to RO attached as Annexure-II)*

(vii)	High Efficiency Electrostatic Precipitators (ESPs) shall be installed to ensure that particulate emission does not exceed 50 mg/Nm3.	The High Efficiency Electrostatic Precipitators (ESP) are designed and installed for achieving guaranteed efficiency of 99.99 %. *(Details of ESP design parameters furnished during HYC Oct-21 to Marc-22)*
(viii)	Adequate dust extraction system such as cyclones / bag filters and water spray system in dusty areas such as in coal handling and ash handling points, transfer areas and other vulnerable dusty areas shall be provided.	Dust extraction system at Coal crusher house and adequate no. of dust suppression systems are provided in coal handling area including coal stock yard area, ash handling points, transfer points and other vulnerable dusty areas for control of fugitive dust Emissions. Dry fog dust suppression system has been provided at coal conveyor transfer Points. Water sprinklers installed at dust prone sites in order to attenuate fugitive dust emission i.e. Wagon Tipplers, Coal Yard, Ash dyke, water sprinkling at roads etc.
(ix)	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.) shall 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.	An ash management scheme has been implemented consisting of dry ash extraction system (DAES) for dry collection of fly ash with storage facility (silos). Supply of ash to entrepreneurs for utilization and promoting ash utilization to maximum possible extent and safe disposal of unused ash in the ashpond area. The plant shall have two different systems for ash disposal– conventional wet slurry disposal with ash water re-circulation for bottom ash and High Concentration Slurry Disposal (HCSD) for disposal of unused fly ash. Periodic monitoring for mercury & heavy metals in the bottom ash and water emanating from ash pond is being done. Ash shall be disposed off in low lying area with approval of MPPCB.
(x)	Ash pond shall be lined with HDPE/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 protect the ash dyke from getting breached. Ash pond water shall be re-circulated and utilized.	To avoid the ground water contamination from bottom ash slurry, one of the bottom ash lagoons is separated by a small temporary bund and is lined with impervious liner of 300 MM thickness. Ash pond is lined with suitable impermeable material like Bentonite blended clay or HCSD layer. All the engineering practices have been followed for the construction of Ash Dyke. It has been designed with adequate factor of Safety. The design of ash dyke also takes into consideration the seismic parameters. Regular monitoring and inspection of ash dykes will ensure no risks of failure. AWRS system has also been commissioned.

(xi)	Fugitive emissions shall be controlled to preventimpact on such that no agricultural / non-agricultural land. Impact to any land shall be mitigated and suitable compensation provided in consultation with the local Panchayat.	Adequate no. of dust suppression and extraction system have been provided in coal handling area including coal stock yard area, ash handling points, transfer areas and other vulnerable dusty areas for control of fugitive dust Emissions. Extensive plantation has been carried out in all available areas, selectively with Air Pollution Tolerant Index (APTI) plant species. More plantation shall be undertaken at available areas.
(xii)	Hydrogeology of the area shall be reviewed annually from an institute / organization of repute to assess impact of surface water and ground regime (especially around ash dyke). In case any deterioration is observed specific mitigation measures shall be undertaken and reports / data of water quality monitored regularly and maintained shall be submitted to the Regional Office of the Ministry.	During operation phase of the project the Hydrogeology of the area shall be reviewed annually from an institute / organization of repute to assess impact of surface water and ground regime (especially around ash dyke) and reports of water quality monitored shall be submitted to the Regional Office of the Ministry. Hydro-geological study for Gadarwara project has been carried out by National Institute of Hydrology (NIH) Roorkee. A copy of the report submitted to the Regional Office of the Ministry. *(Report furnished during HYC Oct-21 to Mar-22)* Hydro-geological study for Gadarwara project is being carried out by National Institute of Hydrology (NIH) Roorkee since January-22. Report shall be submitted to Regional Office)
(xiii)	No ground water shall be extracted for use in operation of the power plant even in lean season.	No ground water extraction has been ensured at Gadarwara STPS.
(xiv)	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 including natural drainage system of the area has been disturbed due to activities associated with the setting up of the power plant. Moreover, the said stipulation will also be complied during the operation phase of the project.
(xv)	Regular monitoring of ground water level shall be carried out by establishing a network of existing wells and constructing new piezometers. Monitoring around the ash pond area shall be carried out particularly for heavy metals (Hg, Cr, As, Pb) and records maintained and submitted to the Regional Office of this Ministry. The data so obtained should be compared with the baseline data so as to ensure that the ground water quality is not adversely affected due to the project.	Adequate nos. of piezometers are installed for regular monitoring of ground water level in and around ash pond area as per stipulation. Report will be submitted to Regional Office (Western Zone) of MOEF&CC at Bhopal at regular interval.
(xvi)	Monitoring surface water quality in the area shall also be regularly conducted and records maintained. The monitored data shall be submitted to the Ministry regularly. Further, monitoring points shall be located between the plant and drainage in the direction of flow of ground water and records maintained. Monitoring for heavy metals in ground water shall be undertaken.	Monitoring of surface water quality is being carried out regularly as per stipulations. Reports shall be submitted to Regional Office of MOEF&CC (Western Zone) at Bhopal. Monitoring for heavy metals in ground water is being done and it's record being maintained. *(Details are enclosed as Annexure-III)*
(xvii)	Minimum required environmental flow suggested by the Competent Authority of the state Govt. shall be maintained in the Channel / Rivers (as applicable) even in lean season.	Noted.

(xviii)	The treated effluents conforming to the prescribed standards only shall be re- circulated and reused within the plant. Arrangements shall be made that effluents and storm water do not get mixed.	The project shall have an integrated scheme for treatment, re-cycle and re use of effluents. Provision has been made to re-circulate cooling water and ash pond effluent. The cooling tower blow down is being used fully for ash handling, service water system, coal handling & firefighting etc. Provision is being kept for treatment, recirculation & reuse of entire quantity of coal handling plant effluents & service water effluents is being done. The effluent treatment system comprising of neutralization pit for DM plant regeneration waste, oil separator/skimmers for oily waste, coal slurry settling pond for coal handling plant effluents,
		lamella clarifier for service water effluents and cooling towers for hot water etc have been provided. The effluents shall be treated adequately conforming to the stipulated regulatory standards. An independent plant effluent drainage system is constructed to ensure that plant effluents do not mix with storm water drainage. Plant is ZLD complied.
(xix)	Waste water generated from the plant shall be treated before discharge to comply limits prescribed by the SPCB/CPCB.	Plant is ZLD complied. No water is being discharged outside plant. NTPC has already revised its water requirement in order to comply with the latest notification by MOEF&CC for TPP dated 07.12.2015.
(xx)	A sewage treatment plant shall be provided (as applicable) and the treated sewage shall be used for raising green belt/plantation.	All domestic sewage emanating from plant and township is being treated in a sewage treatment plant. The treated sewage conforming to prescribed standards is being utilized for plantation & raising greenbelt to the extent possible. Capacity of STP is 1200KLD.
(xxi)	The project proponent shall undertake rainwater harvesting measures and shall develop water storage for use in operation of the plant. Rainwater harvesting system shall be put in place which shall comprise of rain water collection from the built up and open area in the plant premises. Action plan for implementation shall be submitted to the Regional Office of the Ministry.	Rainwater harvesting scheme is being developed inside plant and Township. The work is expected to be completed by June -23
(xxii)	Additional soil for leveling of the proposed site shall be generated within the site (to the extent possible) so that natural drainage system of the area is protected and improved.	All additional soil leveling of the project site has been done from within the sites only with all necessary precautions to protect natural drainage system of the area.
(xxiii)	Common property resource falling in the vicinity of the project area shall be identified and if any common property resource (such as grazing land, pond etc.) is falling within the plant area and is developed and handed over to the community.	There is no common property resource falling within the plant area.
(xxiv)	Adequate safety measures shall be provided in the plant area to check/minimize spontaneous fires in coal yard, especially during summer season. Copy of these measures with full details along with location plant layout	The entire fire system in NTPC Gadarwara plant is catered by - Pump for hydrant system – 03 nos electric motor driven.

	shall be submitted to the Ministry as well as to the Regional Office of the Ministry.	01 no diesel engine driven as standby. Pump for water spray system - 01 no electric motor driven. 01 no diesel engine driven as standby. Jockey pumps - 02 nos electric motor driven + 1 no main + 01 no standby Following areas are covered by Hydrant and Spray Systems for fire protection 1) Hydrant system : Through piping network and valves covers entire main plant and offsite area. 2) Hydrant Booster pumps : It is provided to supply adequate pressure in hydrant system of Boiler and elevated area like Bunker Transfer points
		3) High Velocity Sprinkler system : It has been provided in areas where Oil is being used transformers, Turbine Driven BFPs, Boiler burner floors, Turbine lube oil system, Oil canal, Generator seal oil units 4) Medium Velocity Sprinkler system: Coal conveyors and Transfer points, LDO Tanks, DG Sets, Cable galleries at various levels at TG Building
xxv	Well-designed acoustic enclosures for the DG sets and noise emitting equipment's to achieve the desirable insertion loss viz. 25 dB (A) should be provided.	Well-designed acoustic enclosures meeting the latest statutory norms for DG sets are provided. (*The Noise Monitoring report is enclosed as Annexure-IV)*
xxvi	Storage facilities for auxiliary liquid fuel such as LDO/HFO/LSHS shall be made in the plant area in consultation with department of Explosives, Nagpur; Sulphur content in the liquid fuel shall not exceed 0.5%. Disaster Management Plan shall be prepared to meet any eventuality in case of an accident taking place due to storage of oil.	Storage facilities for auxiliary liquid fuel LDO/HFO are designed conforming to the safety standards and where risk is minimal. A detailed Disaster Management Plan & Risk assessment including fire and explosion issues prepared and finalized in consultation with Department of Explosives, Nagpur and regular mock drills are being conducted as per plan in order to address any eventuality in case of an accident. Displayed on Gadarwara intranet. *(DMP is attached as Annexure-V)*
xxvii	First Aid and sanitation arrangements shall be made for the drivers and other contract workers during construction phase.	All arrangements related to first aid, health & safety and sanitation for workers during construction phase of the project have been kept under the scope of EPC contractor. However, NTPC shall ensure effective compliance of the said stipulations. Various measures implemented during construction phase through contractor are: Adequate infrastructure facilities, such as sanitation, fuel, restroom, medical facilities, safety, and suitable water supply are being provided at various stages of project construction to the labor colonies housing the work force during construction phase of the project. The sanitary waste from these areas shall be accorded suitable treatment.

		Safety equipment such as earplugs and earmuffs, Helmets, face shields, safety goggles etc. is being provided to workers engaged in high risk areas. A first aid center & ambulance have been established to provide immediate medical aid to the workers and their Family members. An ambulance service is available at site to transport injured workers to nearby hospitals.
xxviii	Noise levels emanating from turbines shall be limited to 85 dB (A) from source. For people working in the high noise area, requisite PPEs 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.	Design specification for the equipment's has been made to comply with the stipulation. Personal protective equipment has been arranged through contractors during construction phase. Periodic examination of workers is being done regularly. The workers of generator halls and other high noise area are being provided with appropriate ear protection devices.
xxix	Regular monitoring of ambient air ground level concentration of SO2, NOx, PM2.5 & PM10 and Hg shall be carried out in the impact zone and record 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.	Regular monitoring of AAQ shall be done during the operation of the plant. The four locations of AAQMS have been finalized in consultation with MPPCB. Three (3) no. of AAQMS equipment's have been installed at site for regular motoring of ambient air quality around plant premises and one (1) AAQMS has been shifted and installed at Narsinghpur as suggested by MPPCB and Collector office. Linking with CPCB done for real-time data submission to the CPCB and SPCB. The data also being put up on the website of NTPC.
xxx	Green Belt consisting of 3 tiers of plantations of native species around plant not less than 100m width shall be raised (except in areas not feasible). The density of trees shall not less than 2500per ha with survival rate not less than 80%.	Green Belt around the Main Plant area except transmission corridor shall be planted. Around 150 acres of land has been envisaged for the green belt development. Extensive afforestation has been undertaken at all available spaces in and around the project. Avenue Plantation along the Road is being done. The density of trees shall not less than 2500 per ha with all efforts to maintain the survival rate not less than 80%. Till date approximately 75000 trees have been planted around plant (inside and outside) under Green belt work, and road side plantation work. (*Detail furnished during HYC Oct-21 to Mar-22)*
xxxi	An Environmental Cell comprising of at-least one expert in environmental science / engineering, occupational health and a social scientist, shall be created preferably at the project site itself and shall be headed by an officer of appropriate superiority and qualification. It shall be ensured that the Head of the Cell shall directly report to the head of the organization who would be accountable for implementation of environmental regulations and social impact improvement / mitigation measures.	An Environment Management Group (EMG) has been set up at Gadarwara STPP. CGM (Head of Project) ↓ Senior Manager (E6) ↓ Assistant Officer(E0)

		The EMG will be responsible for implementing and monitoring the stipulations/ issues / statutory norms. EMG will have sufficient trained manpower and equipment for environmental monitoring and other environmental related activities to ensure compliance with statutory requirements. It shall interact regularly with the State Pollution Control Board.
xxxii	The project proponent shall also adequately contribute in the development of the neighboring villages. Special package with implementation schedule for providing potable drinking water supply in the nearby villages and schools shall be undertaken in a time bound manner.	Expenditure of Rs. 37.81 Crore has been done regarding Community Development works in the neighboring villages out of which, R&R Department has undertaken various community development focusing on areas such as education, health, sanitation, drinking water, women empowerment, skill development etc. Under drinking water, NTPC Gadarwara has installed water coolers in government schools, water supply pipeline and handpumps in 7 surrounding villages. A water ATM is also installed at Village Gangai.
xxxiii	CSR scheme shall be undertaken based on need based assessment in and around the villages within 5 km of the site and in constant consultation with the village Panchayat and the District Administration. As part of CSR employment of local youth after imparting relevant training as may be necessary shall be undertaken as committed.	As per NTPC's R&R Policy, all community developmen initiatives are need based and undertaken consultatio with the village Panchayat and the Distric Administration. Driving training of 55 local youth have been conducted by NTPC Gadarwara wherein employment have been ensured by providing opportunity for driving for various works in and around NTPC. A commercial driving training for around 70 girls (above 18 years of age) is being conducted in collaboration with RTO dept. which would be followed by ensuring employment opportunity for the same. Apart from this, skill-development training on stitchin and bag making have also been provided to loca women and girls and employment opportunities is also ensured from time-to-time. *(Details furnished during HYC Oct-21 to Marc-22)*
xxxiv	It shall be ensured that an in-built monitoring mechanism for the CSR 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. The achievements should be put on company's website.	Monitoring of R&R-CD activities are undertaken by Corporate CSR-R&R Dept. of NTPC annually. Apert from this, VDAC meetings are conducted from time to time and follow-ups are undertaken by the district administration regarding the status of implementation of various community development activities. A social impact evaluation is also conducted by third party agencies to understand the impact of various initiatives undertaken by NTPC Gadarwara.

xxv	Provision shall be made for the housing of construction labor (as applicable) within the site with all necessary infrastructures and facilities such as fuel for cooking, mobile toilets, mobile STP, safe drinking water, medical health care, crèche etc. The housing may be in the form of temporary structure to be removed after the completion of the project.	All construction agencies working at NTPC Gadarwara Project are providing temporary accommodation for their workers near to work site. The engaged contractors are responsible for providing facilities for housing of construction labor (as applicable) within the site with all necessary infrastructures and facilities such as fuel for cooking, mobile toilets, safe drinking water, medical health care etc.
xxxvi	The project proponent shall advertise in at least two local news papers 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 accorded environmental clearance and copies of clearance letter are available with the State Pollution Control Board/Committee and may seen at Website of the Ministry of Environment and Forests at http://envfor.nic.in.	The information of Environmental Clearance was published in Two newspapers widely circulated in the region; Dainik Bhaskar on 27.03.2013 (Hindi) Nayi Duniya on 23.03.2013 (Hindi)
xxxvii	A copy of the clearance letter shall be sent by the proponent to concerned Panchayat, Zila parishad/ Municipal Corporation, urban local body and the Local NGO, if any, from whom suggestions / representations, if any, received while processing the proposal. The clearance letter shall also be put on the website of the Company by the proponent.	The copy Environmental Clearance has been submitted to the following concerned offices. (1) Collector, Narsinghpur. (2) General Manager, District Trade & Industries Centre, Narsinghpur. (3) CEO, Zila Panchayat (4) Secretary, Gram Panchayat Gangai. (5) Secretary, Gram Panchayat Kudari. (6) Secretary, Gram Panchayat Chor Baretha. The Environmental Clearance has also been uploaded on the NTPC website.
xxxv iii	The proponent shall upload the status of compliance of the stipulated environmental clearance conditions, including results of monitored data on their website and shall update the same periodically. It shall simultaneously be sent to the Regional Office of MOEF, the respective Zonal Office of CPCB and the SPCB. The criteria pollutant levels namely, SPM, RSPM (PM2.5 & PM10), SO2, NOx (ambient levels as well as stack emissions) shall be displayed at a convenient location near the main gate of the company in the public domain	The latest HYC report of EC conditions is regularly being submitted to the Regional Office (Western Zone) of MOEF&CC at Bhopal and at the same time it is also uploaded on the NTPC website which is periodically being replaced with updated HYC report. Online continuous Stack Emission Monitoring System (CSEMS) for the parameters like particulate matter (PM) NOX, SO2, Mercury are commissioned. Linking with CPCB done for real-time data submission to the CPCB and SPCB. Parameters like SOx, NOx, PM are being displayed continuously at main gate (Plant Gate #2) of the company.
xxxix	The environment statement for each financial year ending 31st March in Form-V as is mandated to be submitted by the project proponent to the concerned State Pollution Control Board as prescribed under the Environment (protection) Rules, 1986, as amended subsequently, shall also be put on the website of the company along with the status of compliance of environmental clearance conditions and shall also be sent to the respective Regional Offices of the Ministry by e-mail.	The environment statement for each financial year ending 31st March in Form-V submitted to Madhya Pradesh Pollution Control Board (MPPCB).

xl	The project proponent shall submit six monthly reports on the status of the implementations 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 environment of the environmental clearance conditions on their website and update the same periodically and simultaneously send the same by email to Regional office, Ministry of Environment and Forests.	Latest Six monthly reports on the status of the implementations of the stipulated environmental safeguards is regularly being submitted to the MOEF&CC/MPPCB/Regional Office (Western Zone, Bhopal) and at the same time and it is also uploaded on the NTPC website which is periodically being replaced with updated HYC report.
xli	Regional office of the Environment & Forests shall 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 shall up-load 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.	A complete set of documents including Environmental Impact Assessment (EIA) Report and Environment Management Plan (EMP) along with the additional information / clarifications were forwarded on 10.03.2014 to the Regional Office (Western Region) of MOEF&CC at Bhopal.
xlii	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 measures shall not be diverted for other purpose and year-wise expenditure should be reported to the ministry.	The requisite funds for environmental mitigation measures have been included in the project cost. Financial provision stipulated towards environmental mitigate measures shall not be diverted for other purposes.
xliii	The project authorities shall inform the Regional Office as well as the Ministry regarding the date of financial closure and final approval of the project by the concerned authorities and the dates of start of land development work and commissioning of plant.	Complied.
xliv	Full cooperation shall be extended to the Scientists/officers from the Ministry / Regional Office of the Ministry/ CPCB /SPCB who would be monitoring the compliance of environmental status.	Full cooperation shall be extended to the Scientists / officers from the Ministry / Regional Office of the Ministry at Bhopal (Western Region) / the CPCB / the MPPCB during monitoring of the project.
xlv	The Ministry of Environment and Forests reserves the right to revoke the clearance if conditions stipulated are not implemented to the satisfaction of the Ministry. The Ministry may also impose additional environmental conditions of modify the existing ones, if necessary.	Noted.
xlvi	The environmental clearance accorded shall be valid for a period of 5 years to start operations by the power plant	Noted.
xlvii	Concealing factual data or submission of false/fabricated data and failure to comply with any of the conditions mentioned above may result in withdrawal of this clearance and attract action under the provisions of Environment (Protection) Act, 1986.	Noted.
xlviii	In case of any deviation or alteration in the project proposed including coal transportation system from those submitted to this Ministry for clearance, a fresh reference should be made to the Ministry to assess the adequacy of the condition(s) imposed and to add additional environmental protection measures required, if any.	Noted.

INITIAL SURVEY-CUM-SAMPLING REPORT – NTPC, GADARWARA CONSULTANCY PROJECT
(PERIOD OF STUDY 21 DECEMBER TO 29 DECEMBER 2022)

According to the ToR of the above mentioned Consultancy Project, initial tour-cum-sampling at Gadarwara was planned from 21 to 29 December 2022. The primary objective of the tour was (i) To interact with concerned NTPC officers, (ii)To perform physical survey of the targeted stretches of rivers and to select the suitable sampling sites and (iii) To collect samples from selected sites for chemical, biological and microbiological analyses.

The study team consisted of Dr. S.K. Das, Principal Scientist; Dr. Vaisakh G., Scientist, Sri Subrata Das, Technical Officer and Sri J.K. Solanki, Technical Officer. After reaching Gadarwara, Madhya Pradesh on 21 December 2022, the team interacted Senior Manager, Mr. Jeetendra Meena and AGM, Fly Ash Utilization, Mr. Dhananjay Srikhande for a full-length discussion about the project requirements, planning for the work program, etc. Additionally, conversation was made about some basic data requirements by ICAR-CIFRI team in relation to the water flow associated baseline figures of river Narmada prior to the water withdrawal initiation for the NTPC Gadarwara project. The NTPC officers were convinced during discussion and Mr. Meena assured CIFRI team for providing the data and information, whatever feasible for NTPC.

The CIFRI team then visited the place, Kakraghat, where water is drawn from Narmada and sent to the power plant for its use. This place is about 35 kms away from the power plant. A restriction weir was raised across the river and water was being drawn from upstream side through a pump and after settling the sediments in tanks the water was sent through pipeline by use of another pump. This site has been marked as the first sampling site (S1).

The second place visited was '*Sangam*'. This was located at Sokalpur, downstream from the water intake site and at that place *Shakkar*, a small tributary, meets Narmada and known as a holy place amongst the local people. People were seen performing religious rituals on the bank of the river here and for a certain length of the river in the stretch, fishing is banned by a local religious '*Guru*'. Looking into the importance of the place in relation to the earnings of daily livelihood of fisher community, the sangam stretch has been selected as the second sampling location (S2).

The study team searched for any other point on the river near to the NTPC water withdrawal site where water was drawn for either irrigation or drinking purpose but failed to find any such point. Then at a distance from Sangam point downstream in Narmada, the team reached Usray ghat (Tuiyapani), MP, where another water withdrawing pump was installed for BLA power generating station (a smaller private owned power plant with 90 MW capacity). The team interacted with the pump supervisor and came to know that the pump was installed much before the NTPC, Gadarwara started their water intake from Narmada. The supervisor informed the CIFRI Team that they didn't face any significant problem in their pumping operations due to the establishment of NTPC pump. The Usray ghat stretch was selected as the third sampling station (S3) for the study.

NTPC, Gadarwara is a 'zero' discharge plant, but during monsoon rains the 'run-off' water from the area is carried through a 'pucca' drain constructed by NTPC which then opens in a natural slope which carries the water ultimately to 'Sitareva' (or Chitarwara as written in ToR document), a small tributary of 'Shakkar' river. During the survey period, the NTPC drain was found completely dry due to lack of any discharge at that time. But anticipating the monsoon discharge, the expected outflow, zone of mixing of discharge water with the river, the fourth sampling site was selected (S4).

Sampling was done from all the four selected sites. Field analysis of water samples showed no adverse effect. Water was very transparent with high dissolved oxygen (8-12 ppm) and optimum pH (8.1-8.6). Some macrophytes were found which were mostly terrestrial or semi-submerged type and occurrence was restricted to the river banksides. Water flow was also good and apparently no significant effect of the barrier and water withdrawal was seen. Flow velocity was measured relatively higher at Usray ghat. In this season the river was not very wide, but as per the baseline information received, the river becomes much wider during monsoon months. River was shallow and 'bottom-visible' at some places. Sediment was mostly sandy in nature and river bed contains pebbles and boulders also near the water withdrawal site. Sitareva river condition was different from Narmada and formed 'deep pool' and thus, created a different habitat. Flow was very much variable in the sampling stretch, and it was measured up to 1.2 m/s at some points whereas the same was very negligible at some other point. Specific conductivity, total alkalinity, total hardness, TDS, and the nitrate-N were higher in the sampling site of Sitareva than the other three sampling sites located in river Narmada, which indicated some other source of contamination for this river as NTPC drain had no flow.

Besides the water and sediment, samples for biological analyses, viz., plankton, benthos, macrophytes were collected from all the sites. Fish samples were taken either from fishermen's catch and by experimental fishing, where regular fishing was not being practiced.

Before leaving Gadarwara on 27th December 2022 afternoon, the team met Mr B.G. Setty, AGM (EMG) and Mr. Jitendra Meena, Sr. Manager and apprised about ICAR-CIFRI team's work progress during the tour. A courtesy meeting was also made with Mr. Kamalesh Soni, Project Head and Chief General Manager.

The laboratory analyses of the collected samples have been completed and the results are attached.

Brief description of sampling stations – NTPC, Gadarwara Consultancy Project

The winter sampling was conducted with four major sampling stations in the river stretch viz. Kakraghat Above Weir (S1AW) and Below Weir (S1BW) ; Sangam, Sokalpur (S2); Tuiyapani / Usray Ghat (S3) and Discharge point of NTPC on Sitareva River (S4).

The River Narmada in general, is greatly affected by the low water flow, lesser water depth and exposed river beds, predominantly during the dry seasons. In the present study (post-monsoon), sampling stations were mostly characterised by pool and run habitat types. A low gradient habitat is observed in the Sitareva River (S4), where the water level was too low and the bottom substrate characterised by partially submerged cobbles and pebbles, with boulders observed in the exposed area. The anthropogenic stresses observed in different sampling stations were *viz.* water abstraction for power plant and agriculture activities, pollution from domestic sewages and religious rituals, fishing, and habitat modification (Table 1). Agricultural activities were observed on the banks of Narmada, Shakkar and Sitareva rivers at the study areas. A sparse riparian vegetation cover observed near the weir. The rest of the sites were characterised with riparian vegetation dominated by the grasses and marginal weeds with lesser number of trees and shrubs. Shallow pools and low flow areas were characterised with varying intensities of submerged aquatic plants cover during the study period.

Table 1: Details of Fish sampling sites and habitat types

Stretch		Station code	Habitat types	Anthropogenic stress
Kakraghat	Above weir	S1AW	Pool and run, Boulder and cobble formed the major substrate	Water abstraction for power plant, Habitat modification
	Below weir	S1BW	Pool and run, river substrate formed by cobble, gravel and sand	Waste disposal from religious rituals, Fishing, Water abstraction for agriculture
Sangam-Sokalpur		S2	Run; Confluence point of Narmada river and Shakkar river	Waste disposal from religious rituals and domestic sewages, Fishing

Usray Ghat-Tuiyapani	S3	Run, river bed formed by boulder, cobble, gravel and sand	Water abstraction for power plant, Fishing, Water abstraction for agriculture
Sitareva river- Discharge point	S4	Pool, run and low gradient riffle, substrate featured with cobbles, pebbles and gravels	Water abstraction for agriculture, Fishing, Habitat modification

Some more details of the sampling sites

Sampling Site S1. Kakraghat: This place is about 35 kms away from the power station. The river is about 220 m wide. Pump houses and settling tank of NTPC were constructed on the left bank of the river. A barrier weir was seen across the river here to help diverting water towards the water withdrawal channel; at the time of team's visit, water was flowing just over the weir. The riverbank was covered with boulders and riverbed also contained stones which was creating difficulty in operation of the fishing net in this river stretch. The flow measured downstream was 0.3 m/s. A variety of macrophytes were found mostly on the shore, some were submerged, but restricted near the shore.

Sampling Site S2. Sangam (Narmada-Shakkar confluence), **Sokalpur**: This is located at the downstream the water intake site, where a smaller tributary, Shakkar meets Narmada from left side. There is a temple at the confluence point and another temple was seen on the right bank of the river. As the site is considered as holy place by local people, various puja and religious activities were observed on riverbank and many people were taking bath in the confluence point. River width was about 300 m near the confluence zone. The flow was more near the centre point (0.30-0.37 m/s), but near the left bank, the flow was less (0.15-0.24 m/s). The fishing activity at this site was forbidden by one religious '*guru*'. Macrophytes were less prevalent at this place, might be because of more human activities. Riverbed is mostly sandy.

Sampling Site S3. Usray Ghat, Tuiyapani: This place is situated downstream from Sangam. Here, another pumphouse is installed on left bank of Narmada. This pumping facility was established before the NTPC-pumphouse at Kakraghat and used for drawing and supplying water to BLA power generating station (a smaller private owned power plant with 90 MW capacity). The supervisor informed the ICAR-CIFRI Team that they didn't face any significant problem in their pumping operations due to the establishment of NTPC pumping station. The river bank has macrophytes grown on it. The river was about 140 m wide at this place. Water flow velocity was measured as 0.47-0.51 m/s, which means there was a good flow at this place. Fishing activities here was generally practiced in early morning hours and gill net was the major fishing gear.

Sampling Site S4. Sitareva river (Discharge site): NTPC, Gadarwara is a 'zero' discharge plant, but during monsoon rain the 'run-off' water from the area is carried through a '*pucca*' drain constructed by NTPC which opens in a natural slope. It carries the water ultimately to '*Sitareva*' (or *Chitarwara* as written in ToR document), a small tributary of 'Shakkar' river. During our survey period, we found the NTPC drain completely dry due to lack of any discharge at that time. The sampling site on Sitareva was below the road bridge. At the time of sampling, the river had different habitat type, having an area with relatively more water depth, created near the base of the bridge where there was no flow. River width

was very less, 25-29 m; flow was variable, at some points it was 0.9-1.2 m/s, but at other places it was quite low and in the deep pool it was stagnant. The river was mostly shallow (0.8 m), but higher depth was observed in other place (1-2 m). The river was sandy and at some places it was stony. Macrophytes were found on the sandy river bed and also inside water. Specific conductivity, total alkalinity, total hardness, TDS, and the nitrate-N were higher in the sampling site of Sitareva than the other three sampling sites located in river Narmada, which indicated some other source of contamination for this river as NTPC drain had no flow.

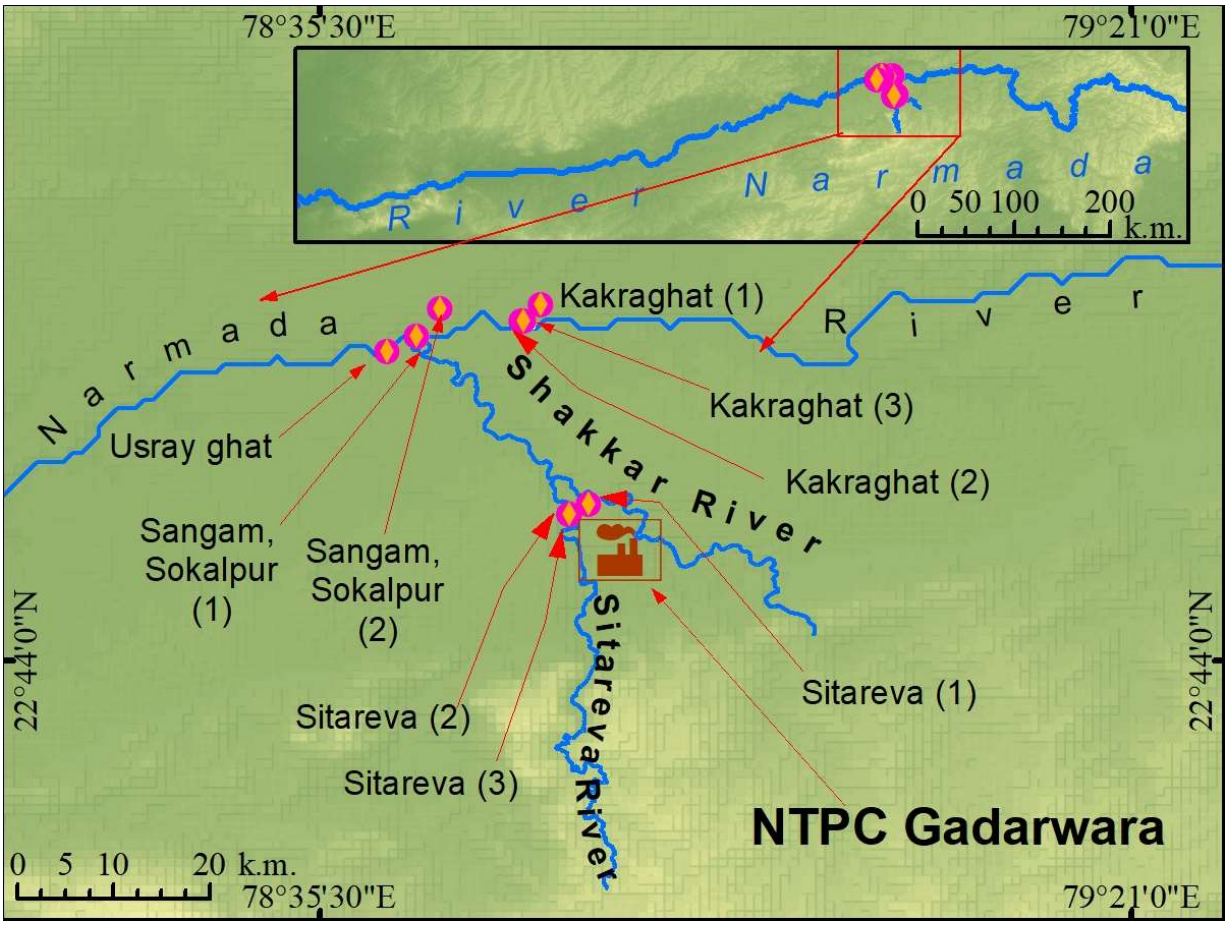


Fig. 1. Map showing location of all the sampling sites and the NTPC plant

Fig. 2. Sampling Site S1. Kakraghat

Fig. 3. Sampling Site S2. Sangam, Sokalpur

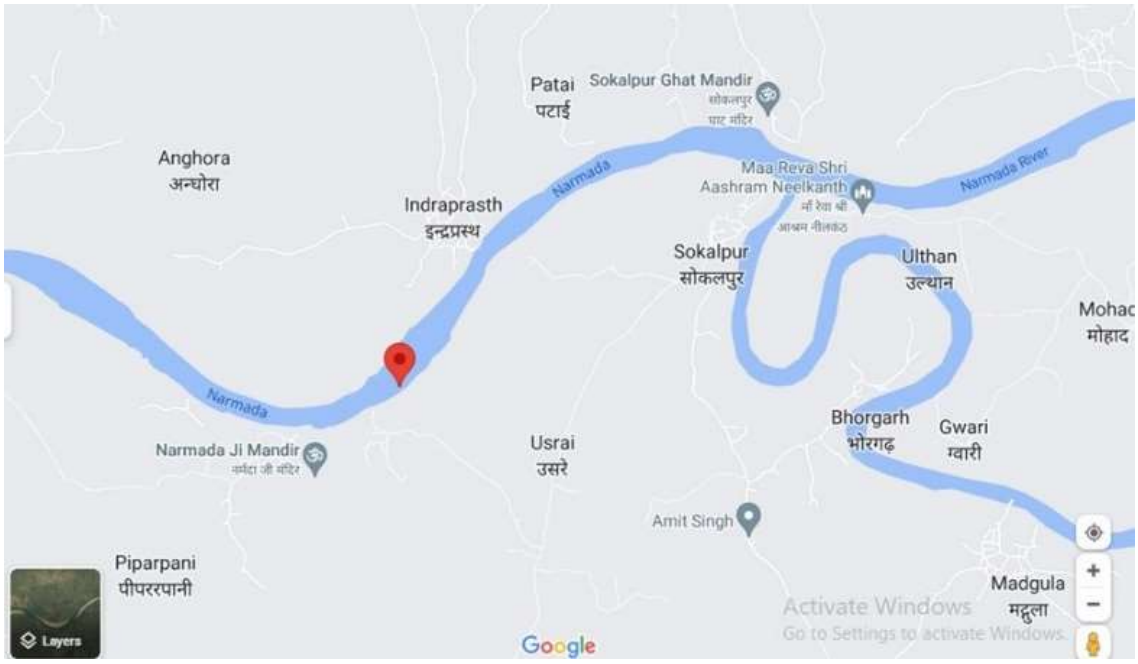


Fig. 4. Sampling Site S3. Usrai ghat, Tuiyapani

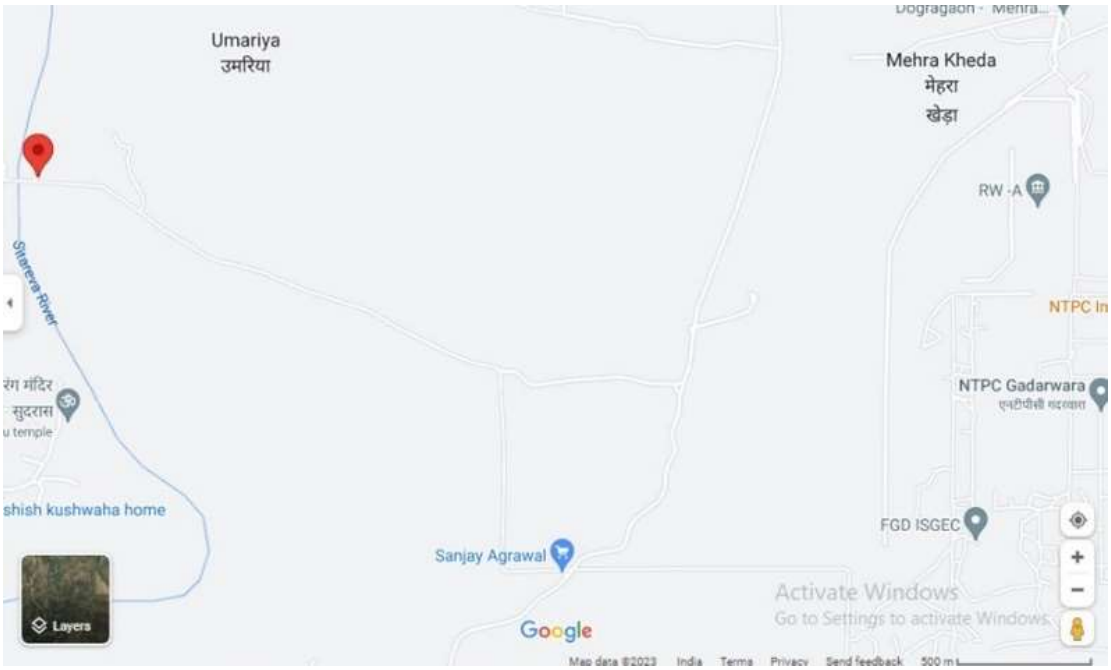


Fig. 5. Sampling Site S4. Sitareva river (Discharge site)

Water and soil quality aspects of the designated four sampling stations

Water samples drawn from all the four stations in triplicate were analysed following the methods described in earlier section and mean values obtained for various parameters are presented in table 2. It was observed that in post-monsoon season, depth of Narmada River was very much variable and dissolved oxygen content were towards higher side in all the stations (8.3-11.0 ppm). Water was alkaline (8.3-8.6), rest of the parameters including the nutrient contents were well within normal range. The noted point is that values of some parameters,

viz., specific conductivity, TDS, salinity, total alkalinity, total hardness and nitrate-N in S4 Sitareva river sampling site were higher than Narmada indicating some pollution. But in the season, the discharge drain of NTPC was totally dry, so the source of pollution, was different and nothing was contributed by NTPC power plant.

Table 2. Water Quality Parameters in post monsoon season (2022) from different stations on Narmada and Sitareva rivers (Mean Values)

Parameters / Stations	Depth (m)	Transp. (cm)	Temp Air (°C)	Temp Water (°C)	pH	Sp. cond. (µS/cm)	D.O. (ppm)	Free CO_2 (ppm)	TDS (ppm)	Salinity (ppm)
Kakraghat	0.43 (±0.06)	40.7 (±4.2)	29.1 (±0.4)	22.7 (±0.4)	8.4 (±0.2)	325.7 (±3.5)	8.3 (±0.1)	NIL	227.3 (±3.1)	154.67 (±2.31)
Sokalpur	2.57 (±2.47)	87.0 (±38.5)	25.5 (±0.4)	22.6 (±0.4)	8.5 (±0.2)	328.0 (±13.0)	9.5 (±0.2)	NIL	237.3 (±2.1)	158.67 (±3.21)
Usrai Ghat, Tuiyapani	1.10 (±0.92)	109.3 (±60.2)	18.3 (±0.3)	21.7 (±0.6)	8.6 (±0.1)	331.7 (±3.1)	11.0 (±1.4)	NIL	236.0 (±1.0)	159.33 (±1.15)
Sitareva River	0.85 (±0.63)	26.7 (±7.6)	19.1 (±1.3)	20.1 (±1.1)	8.3 (±0.2)	484.0 (±18.5)	8.5 (±0.6)	NIL	343.0 (±13.2)	232.00 (±9.64)

Parameters / Stations	Total Alkalinity (ppm)	Total Hardness (ppm)	Ca ++ ppm)	Mg ++ (ppm)	Nitrate-N (ppm)	Silicate-Si (ppm)	Phosphate-P (ppm)	Total P (ppm)
Kakraghat	108.7 (±1.2)	158.7 (±6.1)	38.23 (±1.22)	15.37 (±1.98)	0.090 (±0.017)	7.40 (±1.68)	0.053 (±0.06)	0.068 (±0.06)
Sokalpur	156.7 (±1.2)	150.0 (±3.5)	35.30 (±1.60)	15.00 (±0.50)	0.110 (±0.040)	8.23 (±1.88)	0.043 (±0.006)	0.085 (±0.030)
Usrai Ghat, Tuiyapani	164.0 (±2.0)	154.7 (±6.1)	36.90 (±1.60)	15.17 (±1.15)	0.100 (±0.026)	8.43 (±1.47)	0.033 (±0.006)	0.167 (±0.061)
Sitareva River	234.0 (±6.0)	232.0 (±8.0)	62.03 (±1.79)	18.73 (±2.22)	0.250 (±0.139)	9.83 (±0.23)	0.040 (±0.010)	0.143 (±0.072)

(Values in parentheses describe standard deviations from mean values)

The analysis results of composite soil samples collected from three stations on river Narmada and one station on river Sitareva showed that all samples were neutral to slightly alkaline in nature with normal specific conductivity. Organic carbon contents were low to very low in all the stations except the Usrai Ghat station where organic carbon content was medium. Soil textures of Sokalpur and Sitareva river were of very high sand contents whereas a little more silt and clay were observed in other two stations. The higher silt content at Kankraghat was also seen from the settling tank of NTPC.

Table 3. Soil Parameters of different sampling stations on Narmada and Sitareva rivers

Parameters / Stations	pH	Specific Conductivity (µS/cm)	Organic Carbon (%)	Available P (mg/100 g)	Texture (%)		
					Sand	Silt	Clay
Kakraghat	7.6	192.5	0.28	0.32	84	9	7
Sokalpur	7.8	106.0	0.08	0.11	96	1	3
Usrai Ghat, Tuiyapani	7.7	135.0	0.63	0.05	80	11	9
Sitareva River	7.0	83.0	0.06	0.75	98	1	1

Plankton and Periphyton

In this project, samples were collected from 3 different location of river Narmada and 1 from its tributary. The sampling stations are - Kakraghat, Sokalpur, Tuniyapani on river Narmada and Sitareva on river Sitareva

The plankton samples were analysed qualitatively and also quantitively. The available phytoplankton are - *Oscillatoria* sp., *Spirulina* sp. of Cyanophyceae; *Pediastrum* sp., *Botryococcus* sp., *Coelestrum* sp., *Spirogyra* sp., *Protococcus* sp., *Chroccous* sp., *Crucigenia* sp. of Chlorophyceae; *Fragilaria* sp., *Diatoma* sp., *Cymbella* sp., *Navicula* sp., *Nitzschia* sp., *Gomphonema* sp., *Synedra* sp., *Diploneis* sp. of Bacillariophyceae; *Closterium* sp., *Cosmarium* sp of Desmidiaceae.

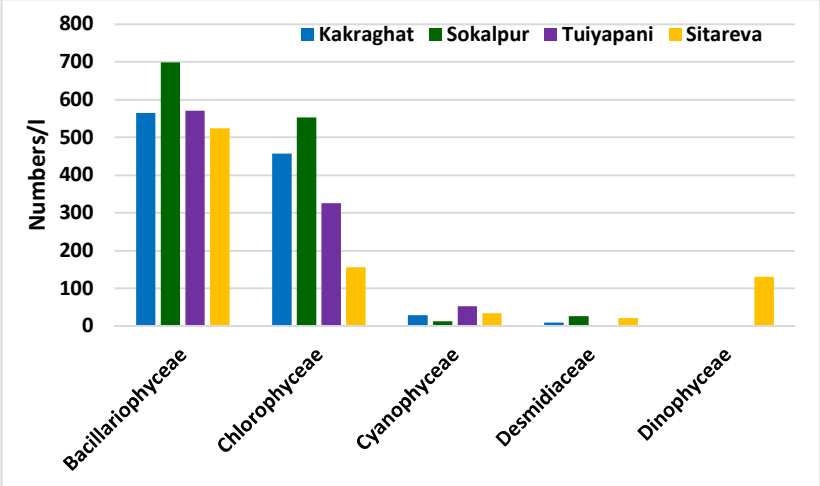


Fig.6. Diversity of different family of phytoplankton at the sampling stations

The dominance of Bacillariophyceae and Chlorophyceae was recorded in all the sites. Cyanophyceae was at lower level indicating less dominance of organic matter associated pollution.

The zooplankton community include - *Cyclops* sp. of Copepoda; *Keratella* sp., *Polyarthra* sp., *Nothlca* sp. of Rotifera. Zooplankton population was found in significant number. Interestingly, it was high at Sitareva site.

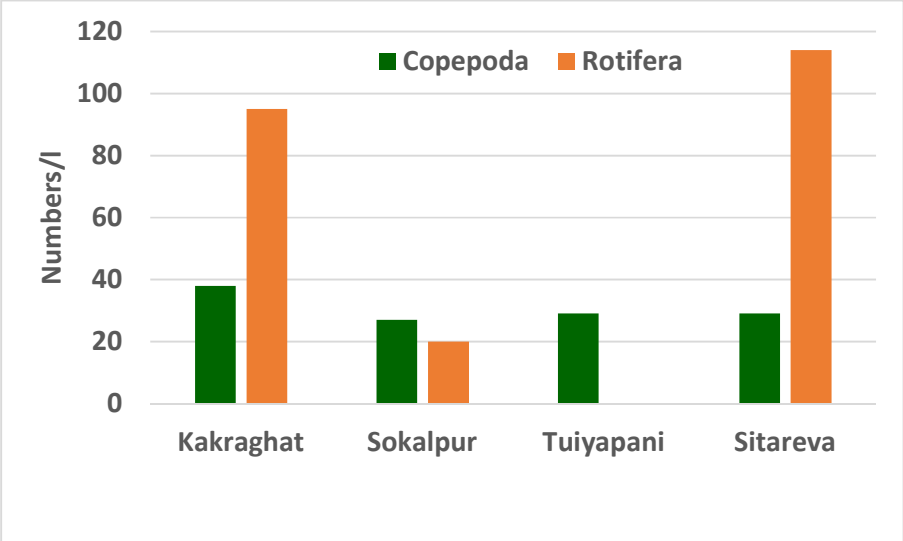


Fig. 7. Diversity different phylum of zooplankton at the sampling stations.

Periphyton

Periphyton samples were collected from the 2 stations: 1.Tuiyapani and 2. Sitareva.

The available periphytic organisms are - *Oscillatoria* sp., *Spirulina* sp. and *Merismopedium* sp. of Cyanophyceae; *Scenedesmus* sp. of Chlorophyceae; *Cosmarium* sp. of Desmidiaceae; *Fragilaria* sp., *Cymbella* sp., *Cocconeis* sp., *Pinnularia* sp., *Diatoma* sp. and *Synedra* sp. of Bacillariophyceae

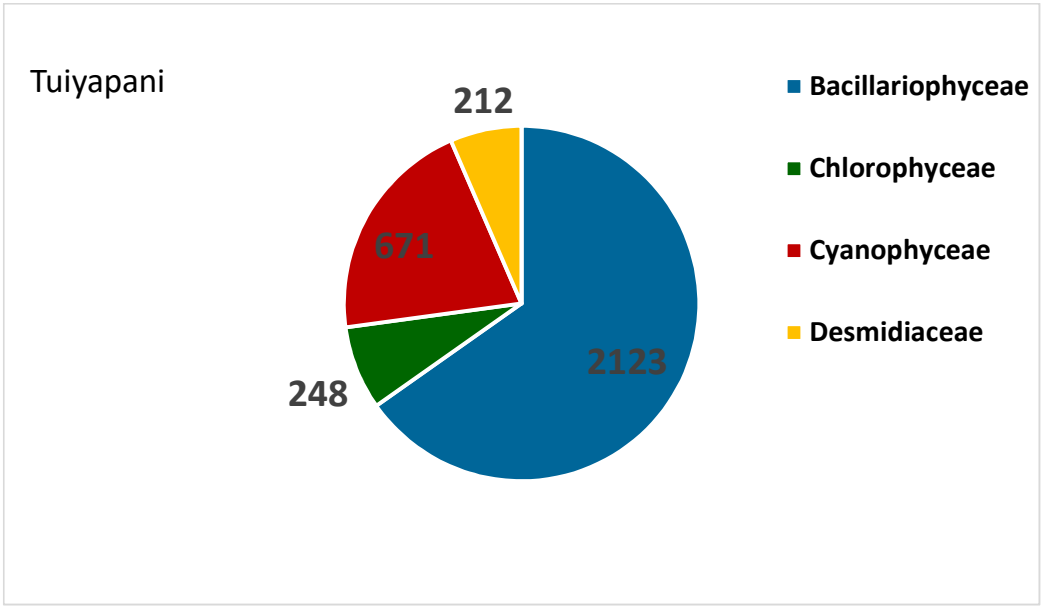


Fig. 8. Different class of periphytic community at Tuiyapani.

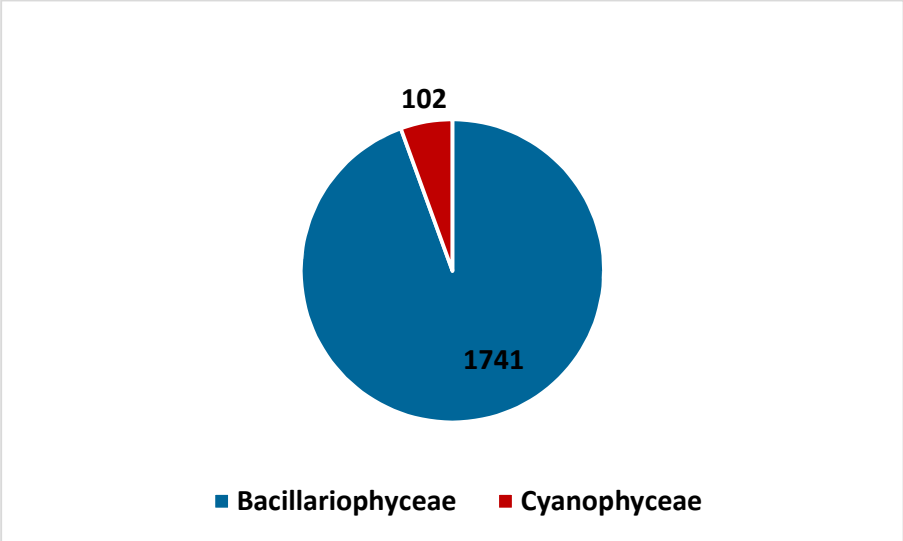


Fig.9. Different classes of periphytic community at Sitareva

Benthic Diversity

Hydrological and chemical alterations have a prolonged effect on the riverine biota that could be accessed through continuous monitoring surveys. Macrobenthic fauna, settled in the sediment of an aquatic ecosystem are regarded as the key indicating species for environmental pollution. These organisms are often used as biomarkers of the environment to detect the pollution status of the river. Based on the availability of the common macrobenthic invertebrates in the Narmada river, the bioindicators were identified. A detailed description about the benthic community has been depicted in the present study.

Materials and Methods:

Numerical abundance of the samples was performed using a quantitative analysis by simple counting and then converting it to a square meter area(Welch, 1948).

$$N = \frac{O}{A \times S} \times 10{,}000$$

Where N = No. of macro-benthic organisms/m^2

O = No. of organisms counted

A = Area of a sampler in cm^2

S = No. of grab samples collected at each station

The benthic diversity was analysed from 3 sampling stations viz. Kakaraghat, Sokalpur and Tuiyapani of Narmada River, and 1 sampling station from Sitareva covering total of 10 sites.

The abundance of five gastropod species were recorded from each site, representing four families i.e. Viviparidae, Thiaridae, Lymnaeidae and Bithyniidae, showing maximum abundance of *Melanoides tuberculata* (191 ind./m^2) followed by *Tarebia granifer*a (144 ind./m^2) among the gastropods. Minimum abundance of *Filopaludina bengalensis* (14 ind./m^2) was recorded from Kakaraghat. Two important freshwater bivalves, *Corbicula bensoni* (185

ind./m^2), *Lamellidens marginalis* (14 ind./m^2), were reported from the river. The abundance of the species is represented in Fig. 10. The abundance of *Chironomid* larvae (up to 12,317 ind./m^2) was reported from river bed (Fig. 11).

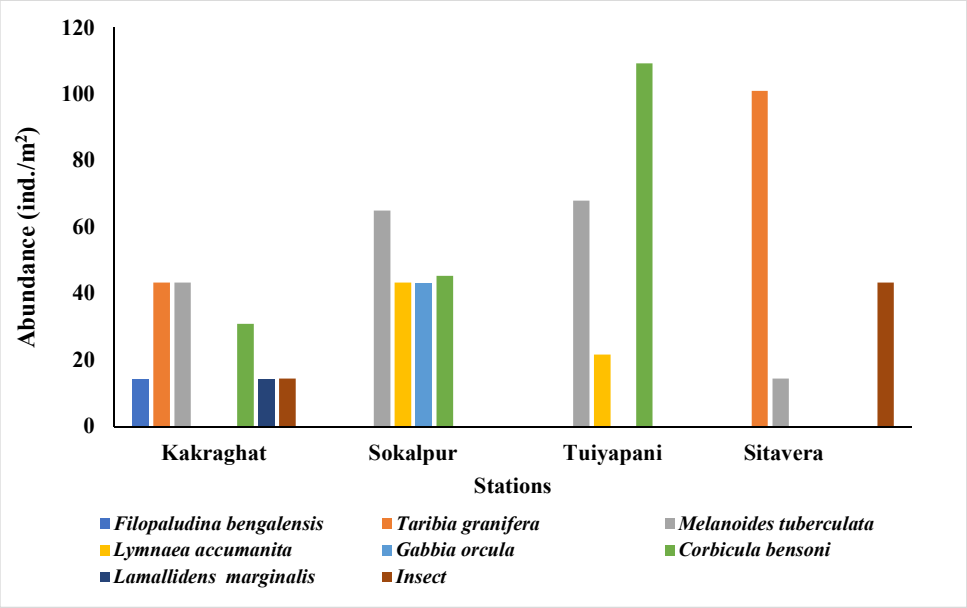


Fig 10: Representation of the abundance of benthic diversity

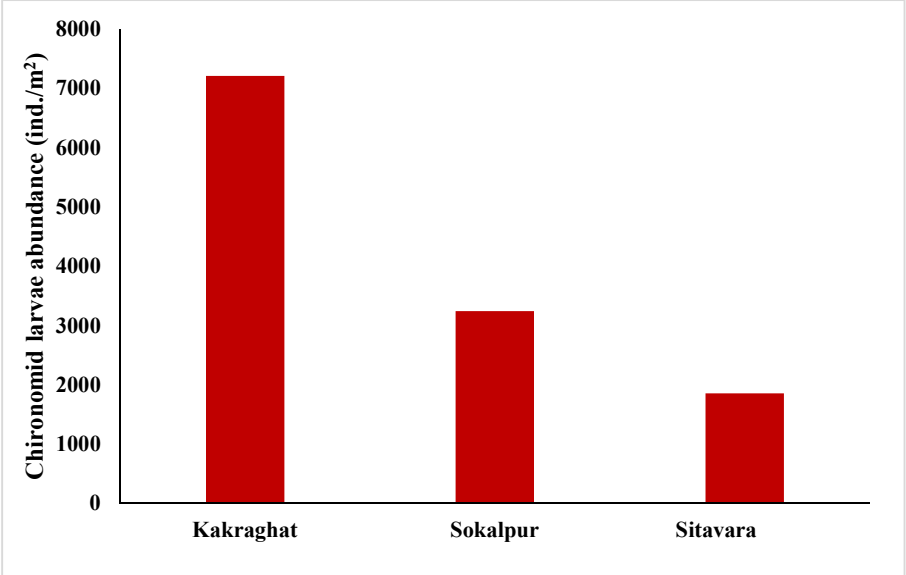


Fig. 11. Abundance of *Chironomid* larvae at different stations

Diversity indices at different stations of Narmada River was depicted in Fig. 12. Tuiyapani showed higher range of all the indices than other sites. No significant differences were observed within the stations. The Shannon-Weiner diversity (*H'*) ranged from 0.937 (Tuiyapani) - 0.141(Kakraghat), while species richness (Margalef index *(d')*) was highest at Kakraghat (0673); Evenness index (*J'*) was maximum at Tuiyapani followed by Sitavera.

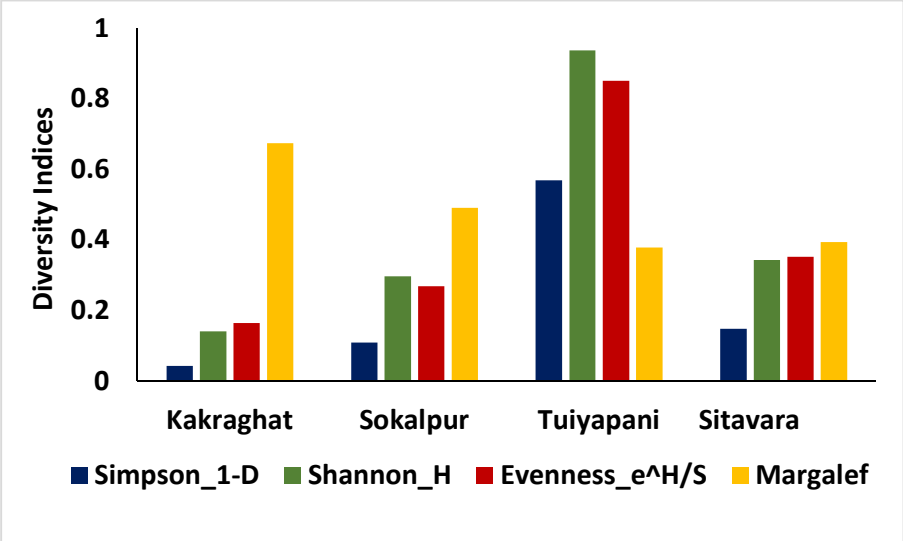


Fig. 12. Diversity indices of macrobenthic species at different stations

Benthic organisms are major bioindicators of lentic and lotic waters and immediately shows physiological alterations towards environmental changes. The availability of chironomid larvae signified an accumulation of organic load in the sediment especially at Kakraghat due to the impact of constructed weir. The presence of *Melanoides tuberculate, Tarebia granifera* and *Corbicula bensoni* are higher tolerant towards pollution. The freshwater macrobenthic communities of large riverine systems play an important role as indicators and monitoring of river health and as a whole, representing moderately good health of the studied river stretch.

Fish biodiversity and fisheries

Fish diversity

A total of 46 fish species belonging to 13 families were recorded from the Narmada River stretch during the present study. More than 50% of the species yielded from the river stretch belongs to the family cyprinidae (33 Nos.), followed by the family bagridae (Bagrid catfishes). Among the 4 sampling stations maximum numbers of species were recorded from the river stretch downstream to the weir at Sangam-Sokalpur (S2) followed by the Usray Ghat-Tuiyapani station, (S3) (Figure 13). At the discharge point station of Sitareva River (S4) 14 fish species were recorded. The fish species recorded was comparatively low near the weir site. The mahseer species recorded from the river stretch was *Tor tor*, which forms a notable fishery at S2 and S3. The exotic fish species, *Cyprinus carpio* and *Ctenopharyngodon idella* were also recorded from the sampling stations S2 and S3. The list of fish species and its occurrence at different sampling stations were detailed in the Table 4.

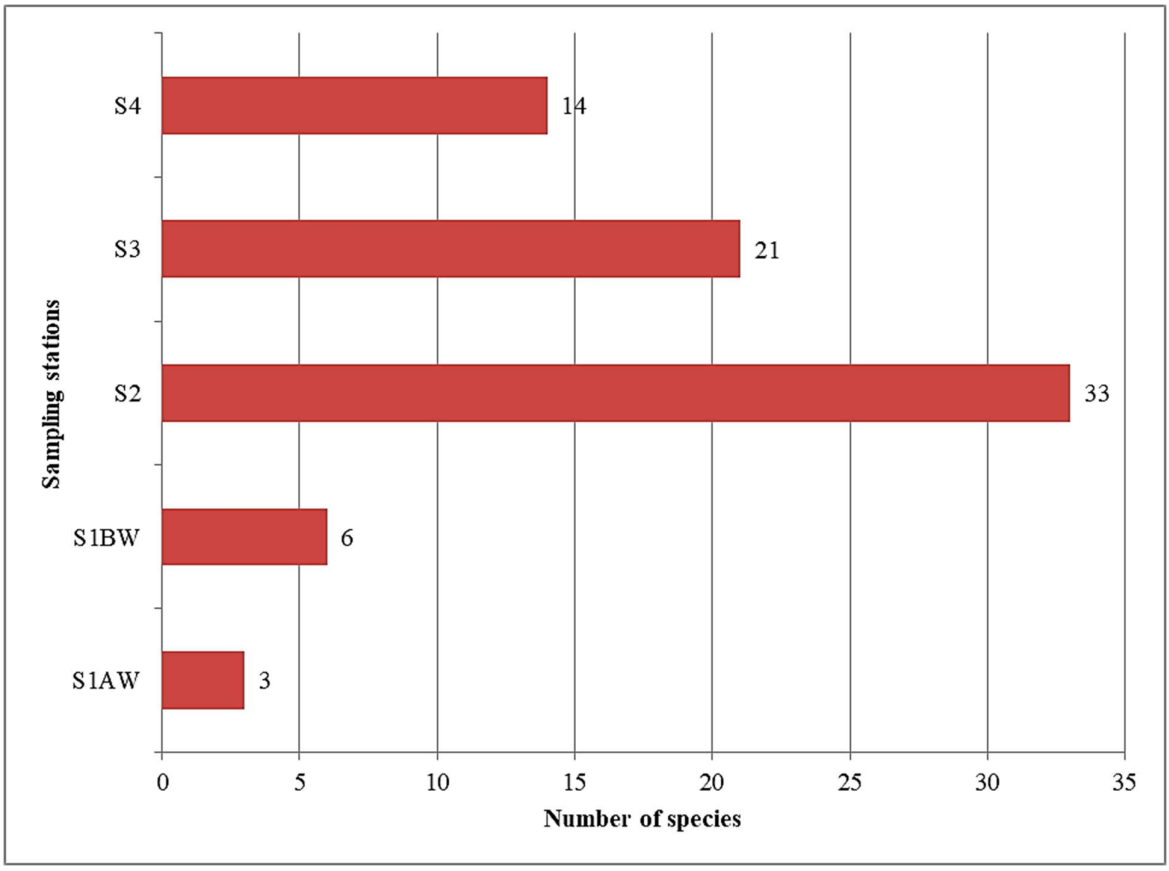


Figure 13: Number of species obtained during winter sampling from different sampling stations

Table 4. Details of the fish species documented from the study area

Family	Fish species	Feeding guild	S1AW	S1BW	S2	S3	S4
Notopteridae	*Chitala chitala*	CR	-	-	+	+	-
Cyprinidae	*Labeo boggut*	HR	-	+	+	+	-
	Systomus sarana	OR	-	-	+	+	-
	Labeo angra	HR	-	-	-	+	-
	Puntius sophore	OR	-	-	-	+	+
	Rasbora daniconius	OR	+	-	-	+	-
	Esomus danricus	OR	-	-	-	+	-
	Cirrhinus mrigala	OR	-	-	+	+	-
	Bengala elanga	OR	-	-	+	+	-
	Pethia ticto	OR	-	-	+	+	-

	Rasbora sp.	OR	-	-	+	+	-
	Barilius sp.	OR	-	-	-	+	-
	Tor tor	OR	-	-	-	+	-
	Labeo gonius	HR	-	+	-	+	-
	Labeo dyocheilus	OR	-	+	-	-	-
	Cyprinus carpio	OR	-	-	+	+	-
	Ctenopharyngodon idella	HR	-	-	+	+	-
	Barilius barna	HR	-	-	+	-	+
	Salmostoma bacaila	OR	-	-	+	-	-
	Salmophasia phulo	HR	-	-	+	-	-
	Puntius amphibius	OR	-	-	+	-	-
	Hypselobarbus jerdoni	OR	-	-	+	-	-
	Labeo calbasu	HR	-	+	-	-	+
	Garra gotyla/G. lamta	HR	-	+	-	-	-
	Garra mullya	HR	-	+	-	-	-
	Danio rario	OR	-	-	-	-	+
	Cirrhinus reba	HR	+	+	+	+	-
Nemacheilidae	*Schistura multifasciata*	OR	-	-	+	-	+
	Acanthocobitis botia	OR	-	-	+	-	-
Cobitidae	*Lepidocephalichthys guntea*	OR	-	-	+	-	+
Siluridae	*Wallago attu*	CR	-	+	+	+	-
	Ompok malabaricus	OR	-	-	+	+	-
Ambassidae	*Parambassis ranga*	CR	-	-	+	-	-
Bagridae	*Sperata seenghala*	CR	-	+	+	-	-
	Mystus cavasius	OR	+	-	+	-	-
	Mystus oculatus	OR	-	-	+	-	-
	Rita gogra	CR	-	-	+	-	+
	Olyra horae	OR	-	-	+	-	+
Ailiidae	*Clupisoma garua*	OR	-	-	+	+	-

Sisoridae	*Gagata cenia*	OR	-	-	+	-	-
Gobiidae	*Glossogobius giuris*	CR	-	-	-	+	+
	Glossogobius sp.	CR	-	-	-	-	+
Mastacembelidae	*Mastacembelus armatus*	CR	-	-	+	+	+
	Macrognathus pancalus	CR	-	-	+	-	+
Channidae	*Channa striatus*	CR	-	-	+	-	+
	Channna marulius	CR	-	-	+	+	-

CR- Carnivorous; HR- Herbivorous; OR- Omnivorous

Fish species recorded in the river stretch were categorised into three feeding guilds *viz.*, carnivorous (CR), herbivorous (HR) and omnivorous (OR) based on the feeding habits of the adult fish species (Table 4). Among the three feeding guilds more number of fish species belonging to OR feeding guild in comparison to HR and CR (Table 5). The relative abundance of the feeding guilds varied spatially among the different sampling stations.

The fish species documented during sampling are categorised into nine major fish groups (Table 6). BML (Barbs, Minnows and Loaches), which mainly includes small indigenous fishes, formed the major group with 23 species recorded during the study period followed by Minor and Peninsular Carps (MPC). The other major groups that contributed mostly to the fishery along the studied river stretch by quantity were Indian major carps (IMC), mahseer (MAH), catfishes (CTF) and murrels (MUR). The eels (EEL) and featherbacks (FBK) were represented by two and one fish species, respectively, while these species have significant economic importance. The MPC and CTF have a noticeable representation in all the study sites, except S5 and S1, respectively. Mahseer (*T. tor*) was recorded only from the zone 3, downstream to the weir. The IMC group was represented only by *C. mrigala* in all the study sites (Table 4). The details of fish diversity noted at different sampling stations, are detailed below;

Table 5: Details of fish species belonging to different feeding guilds (FG)

FG	Fish species	Number
Carnivorous	*Chitala chitala, Wallago attu, Parambassis ranga, Sperata seenghala, Rita gogra, Glossogobius giuris, Glossogobius* sp.*, Mastacembelus armatus, Macrognathus pancalus, Channa striatus* and *Channna marulius*	11
Herbivorous	*Labeo boggut, Labeo angra, Labeo gonius, Ctenopharyngodon idella, Barilius barna, Salmophasia phulo, Labeo calbasu, Garra gotyla, Garra mullya and Cirrhinus reba*	10
Omnivorous	*Systomus sarana, Puntius sophore, Rasbora daniconius, Esomus danricus, Cirrhinus mrigala, Bengala elanga, Pethia ticto, Rasbora* sp.*, Barilius* sp.*, Tor tor, Labeo dyocheilus, Cyprinus carpio, Salmostoma bacaila, Puntius amphibious, Hypselobarbus jerdoni, Danio rario, Schistura multifasciata, Acanthocobitis botia, Lepidocephalichthys guntea, Ompok*	25

	malabaricus, Mystus cavasius, Mystus oculatus, Olyra horae, Clupisoma garua, Gagata cenia

Table 6: Fish groups observed during the winter sampling at different stations

Sl. No.	Groups	Code	Species
1.	Indian major carps	IMC	*Cirrhinus mrigala*
2.	Mahseer	MAH	*Tor tor*
3.	Minor and peninsular carps	MPC	*Cirrhinus reba, Labeo calbasu, L. dyocheilus, L. angra, L. boggut, L. gonius, Hypselobarbus jerdoni, Hypselobarbus mussullah, Systomus sarana*
4.	Catfishes	CTF	*Wallago atut, Sperata seenghala, Rita gogra, Mystus cavasius, Mystus oculatus, Clupisoma garua,*
5.	Murrels	MUR	*Channa striatus, Channna marulius*
6.	Eels	EEL	*Macrognathus pancalu, Mastacembelus armatus*
7.	Featherbacks	FBK	*Notopterus chitala*
8.	Barbs, Minnows and Loaches	BML	*Acanthocobitis botia, Barilius sp, Barilius barna, Bengala elanga, Danio rario, Esomus danricus, Gagata cenia, Garra gotyla, G. lamta, G. mullya, Glossogobius giuris, Lepidocephalichthys guntea, Olyra horae, Parambassis ranga, Pethia ticto, Puntius amphibius, Puntius sophore, Rasbora daniconius, Rasbora sp., Salmophasia phulo, Salmostoma bacaila, Schistura multifasciata*
9.	Exotics	EXO	*Cyprinus carpio, Ctenopharyngodon idella*

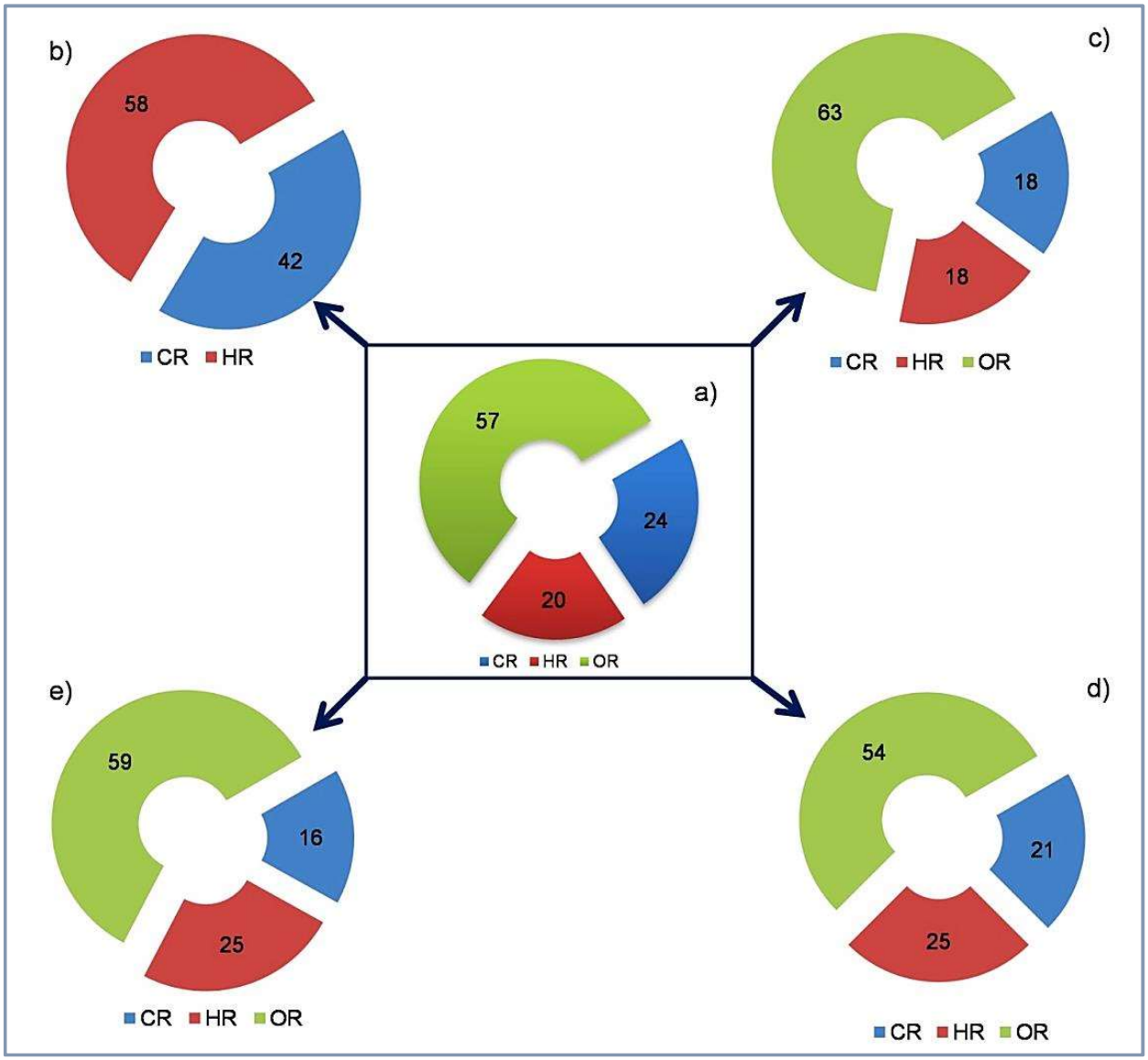


Fig. 14. Relative abundance of feeding guilds in the river stretches: a) overall abundance in the study area; b) Kakraghat below weir (S1BW); c) Sangam-Sokalpur (S2); d) Usray Ghat-Tuiyapani pump house (S3); e) Sitareva River NTPC discharge point (S4). (*S1AW was not included here due to lesser number of species)

Table 7: Diversity indices at different sampling stations

Indices	S1BW	S2	S3	S4
Dominance_D	0.211*	0.085	0.061	0.139
Shannon_H	1.642	2.962*	2.923*	2.241
Evenness_e^H/S	0.861*	0.585	0.886*	0.672
Margalef	1.456	5.524*	4.647*	3.061

*Higher values of indices; (S1AW was not included here due to lesser number of species)

Kakraghat (S1)

Two sampling stations were selected above and below the weir, respectively. The weir is constructed for maintaining water level in the Narmada River for continuous water intake for the NTPC power plant. One sampling station (S1AW) was selected above the weir and another station was selected below the weir (S1BW), to depict fish diversity in the river stretch due to habitat modification. Below the weir (S1BW), relative abundance of catfishes CTF was higher followed by IMC (figure 15). Above the Weir (S1AW), the small Barbs, Minnows and Loaches (BML) were more abundant compared to other major fish groups. The fishing using the gill nets above the weir was difficult due to large boulders and cobbles at river bed, left after the construction of weir. Below the weir (S1BW), the recorded fish species could be classified into carnivore (CR) and herbivore (HR) feeding guilds with significant abundance of CR (figure 14). The fish species belonging to feeding guild omnivore (OR) were not recorded from the sampling site. About 60% of the fish catch in S1BW was contributed by catfishes (CTF) and Minor Peninsular Carps (MPC). The major species under the CTF were *W. attu* and *S. seengala* and that of MPC were *C. reba*, *L. boggut*, *L. gonius*, and *S. sarana*. The Dominance index value is found more at S1BW with a low Shannon H index value, compared to other stations (Table 7), which depicted a lesser diversity at this zone. Further seasonal samplings could portray a clear trend in the fish diversity in this stretch.

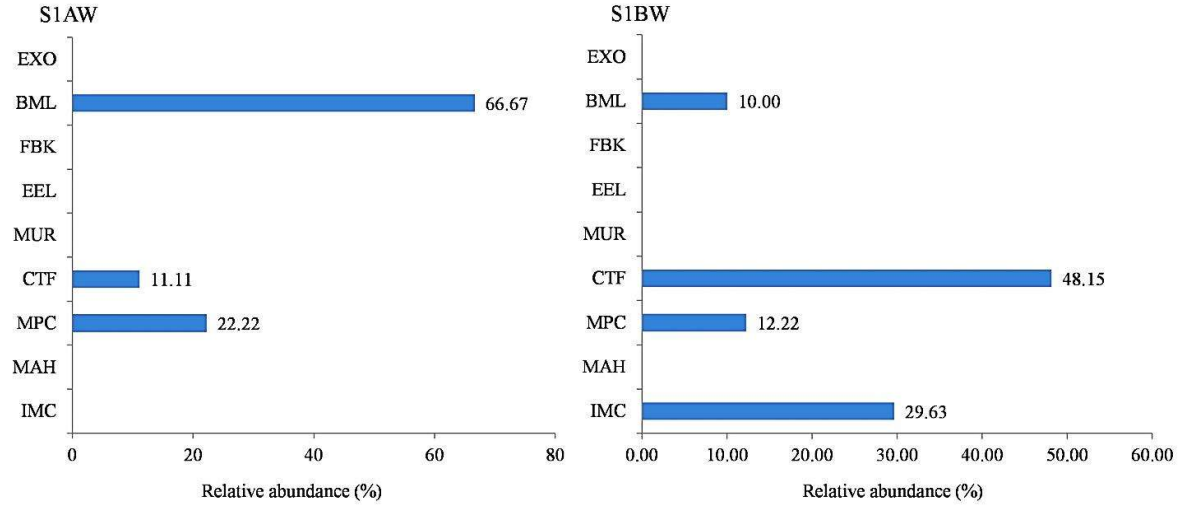


Figure 15: Relative abundance of major fish groups at S1AW (left) and S1BW (right) (IMC- Indian major carp; MAH- Mahseer; MPC- Minor and Peninsular carps; CTF- Catfishes; MUR- Murrels; EEL- Eels; FBK- Featherbacks; BML- Barbs, Minnows and Loaches; EXO- Exotics)

Downstream stretches Sangam-Sokalpur (S2) and Ushray Ghat-Tuiyapani (S3)

The sampling stretches were Sangam-Sokalpur (S2) and Ushray Ghat-Tuiyapani (S3). The Sokalpur station, which is a confluence point of Shakkar River with the Narmada River, has more ecological significance. The station S3 is about 5 km downstream of S2 and another water pumping station was found installed there for a private power plant. The Shannon H index and the Margalef's species richness index were considerably higher at these two stations, whereas evenness index was far higher at S3. These values depicted further diverse nature of

the sites. The confluence of the tributary (Shakkar river) into the Narmada River might contribute to the fish diversity at S2, as tributaries play a major role in augmenting the fish diversity of main channel. The exotic carps (*C. carpio and C. idella*) were recorded from the stations, with comparatively higher contribution in S2. The major gears operated in these stations were gill net and the seine nets.

At the station S2, relative abundance of BML, which includes the small indigenous fishes, was more followed by CTF and MPC (figure 15). The CTF and MPC together portrayed a relative abundance of 30%. The catches of MPC contributed 40%, Murrels and Mahseer formed about 20% of the total catch and the BML and EEL formed 20% of the landings in S2. The major species that contributed to the fishery under CTF were *W. attu*, *S. seenghala*, *Mystus cavasius*, and *Ompok malabaricus* and that of the MPC were *C. reba* and *Labeo boggut*. The major species observed under the murrels were *C. striatus* and *C. marulius*. The catch per unit effort (CPUE) value of different gears ranges from 0.6-8.0 kg/fishermen/day at S2. The feeding guild composition indicated a higher relative abundance of OR, with an equal contribution of HR and CR (figures 14).

At S3, relative abundance of BML was 33% with an increase in the abundance of MPC, CTF and IMC compared to S2 (figure 16). The combined relative abundance of CTF, IMC and MPC was more than 30%, which is even higher than the abundance of small sized BML. The abundance of other groups such as MAH, FBK and EEL was also higher in S3 compared to S2 (figure 16). The increased abundance of different fish groups was evident from the higher evenness value at S3. The fish catch at the station S3 was contributed mainly by MPC (30%), CTF (20%), MAH and IMC (10%) and BML (10%). Under IMC, *C. mrigala* formed the major fishery in the station. The major gear observed at the station was gill net with mesh size varied from 5 mm to 50 mm. The CPUE ranges from 1.5-5.0 kg/fishermen/day. The relative abundance of OR guild was lesser compared to S2, with an increased contribution of HR followed by CR (figure 14).

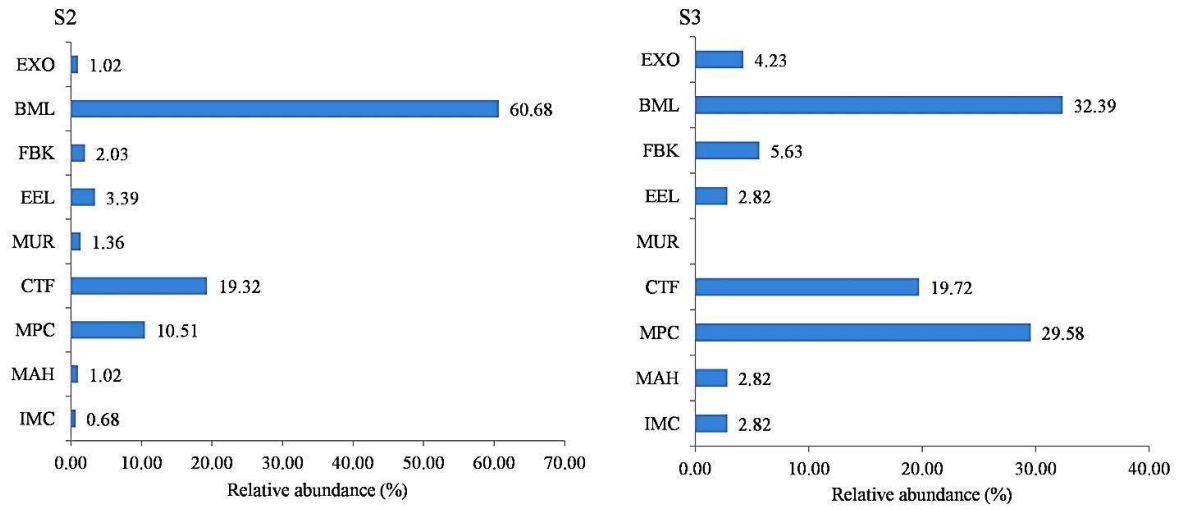


Figure 16: Relative abundance of major fish groups at S2 (left) and S3 (right) (IMC-Indian major carp; MAH- Mahseer; MPC- Minor and Peninsular carps; CTF- Catfishes; MUR- Murrels; EEL- Eels; FBK- Featherbacks; BML- Barbs, Minnows and Loaches; EXO- Exotics)

Sitareva NTPC Discharge point (S4)

The discharge point of the thermal power plant is located in the Sitareva river stretch and the sampling station in the zone is S4. The major portion of the river stretch, except pools, was characterised by a very low water level during the study period. Fishing in the river stretch was low. The Shannon H index and the Margalef's richness index values in the zones were lesser compared to S2 and S3 (Table 4), but better compared to the S1. The relative abundance study depicted a predominance of the Barbs, Minnows and Loaches (BML) (figure 17). This might be due to the lesser water discharge and subsequent lower depth in the station compared to other sites. The combined relative abundance of CTF, MAH and IMC together found less than 5%. Eels formed a relative abundance of more than 7% and comprised of two species *viz.*, *M. pancalus* and *M. armatus*. The fish catch from the station was very meagre with a CPUE of 0.5 kg/fisherman/day. The catch was comprised of BML (>80%) and very less representation of MPC, IMC and CTF. The lesser water depth leads to the use of fine meshed bag nets and massive extraction of the juveniles of catfishes and other carp species. The feeding guild assemblage analysis indicated a higher relative abundance of OR followed by HR and CR (figure 14).

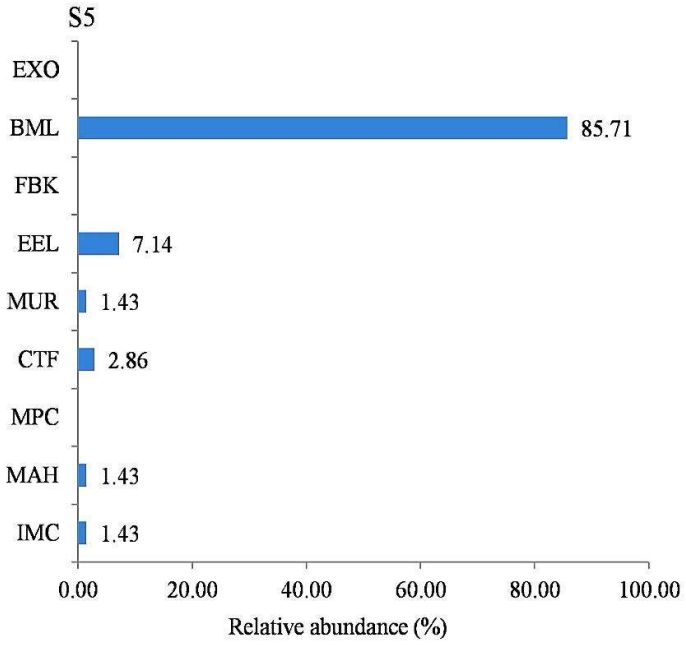
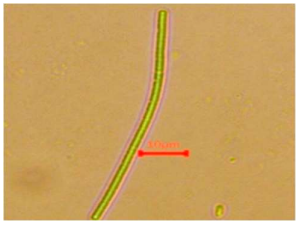
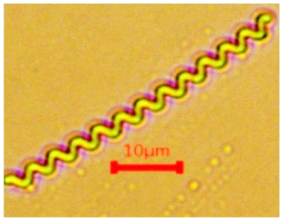


Figure 17: Relative abundance of major fish groups at S4 (IMC-Indian major carp; MAH-Mahseer; MPC- Minor and Peninsular carps; CTF- Catfishes; MUR- Murrels; EEL- Eels; FBK- Featherbacks; BML- Barbs, Minnows and Loaches; EXO- Exotics)

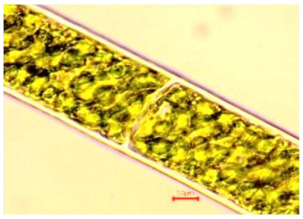
Phytoplankton of the sampling sites



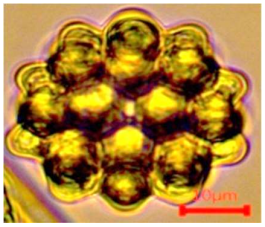
***Oscillatoria* sp.**



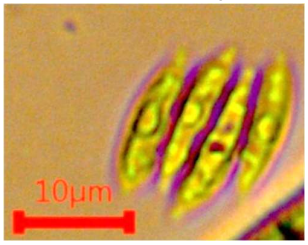
***Spirulina* sp.**



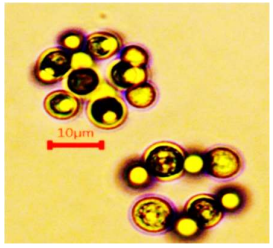
***Spirogyra* sp.**



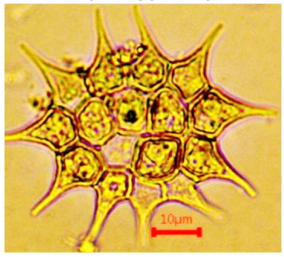
***Coelestrum* sp.**



***Scenedesmus* sp.**



***Protococcus* sp.**



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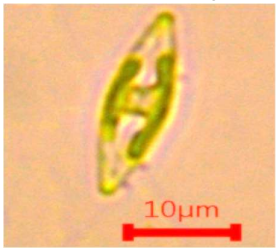
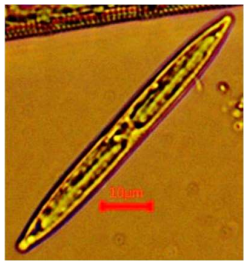


***Navicula* sp.**



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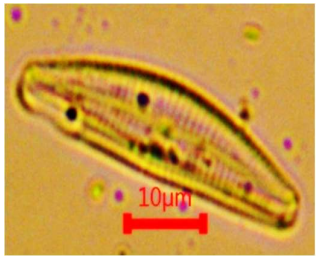

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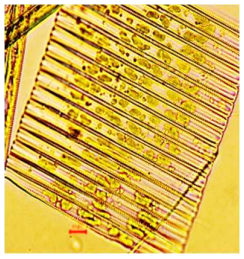

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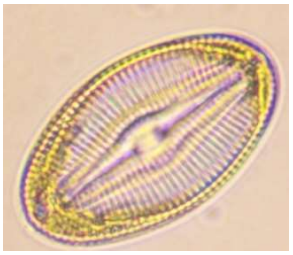

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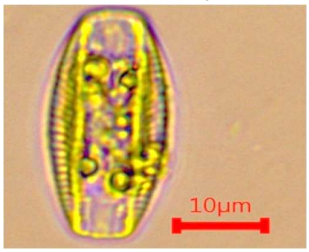

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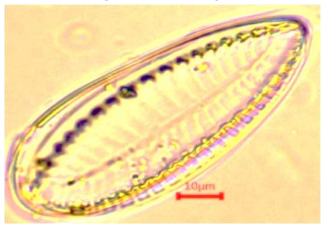

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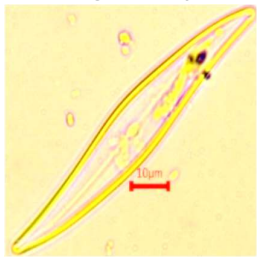

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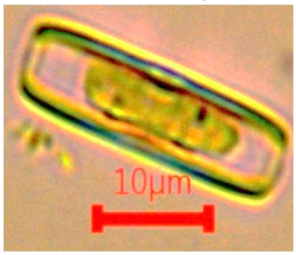

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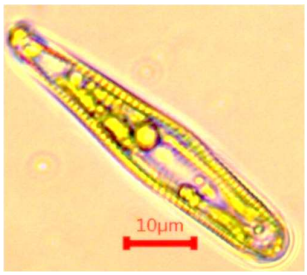

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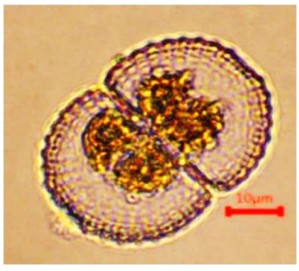
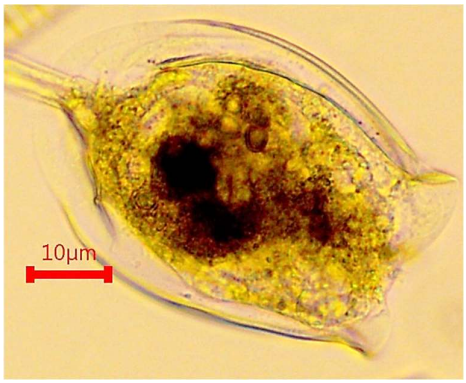


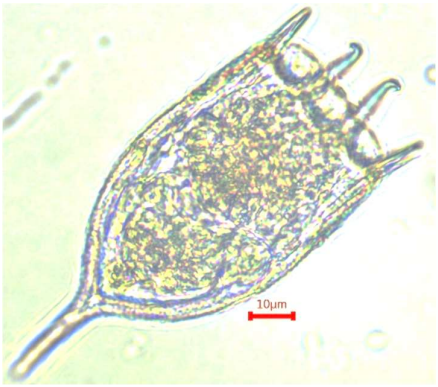
***Cosmarium* sp.**

Zooplankton of the sampling sites

***Nauplius* sp.**



***Monostyla* sp.**



***Keratella* sp.**

***Polyarthra* sp.**

Benthic community

Filopaludina bengalensis

Melanoides tuberculata

Radix rufescens

Taribia granifera

Lamallidens marginalis

Methods for habitat characterization, abiotic and biotic water and sediment quality and fisheries of rivers

Riverine Ecology and Fisheries Division

ICAR-Central Inland Fisheries Research Institute
Barrackpore, Kolkata- 700 120, West Bengal

1. CHARACTERIZATION OF DIFFERENT HABITAT TYPES BASED ON QUANTITATIVE AND QUALITATIVE ATTRIBUTES

Data to be collected

a) Stream width, in-stream depth and current speed

b) Collection and identification of major substrate materials (boulder, cobble, pebble, sand, silt and clay)

c) Observation of riparian vegetation (tree, shrubs, herbs and agricultural crops) and their % coverage

d) Identification of in stream barriers (both natural and manmade) along the river stretch

e) Collection of in-stream macro vegetation along selected stations

Classification of major habitat types

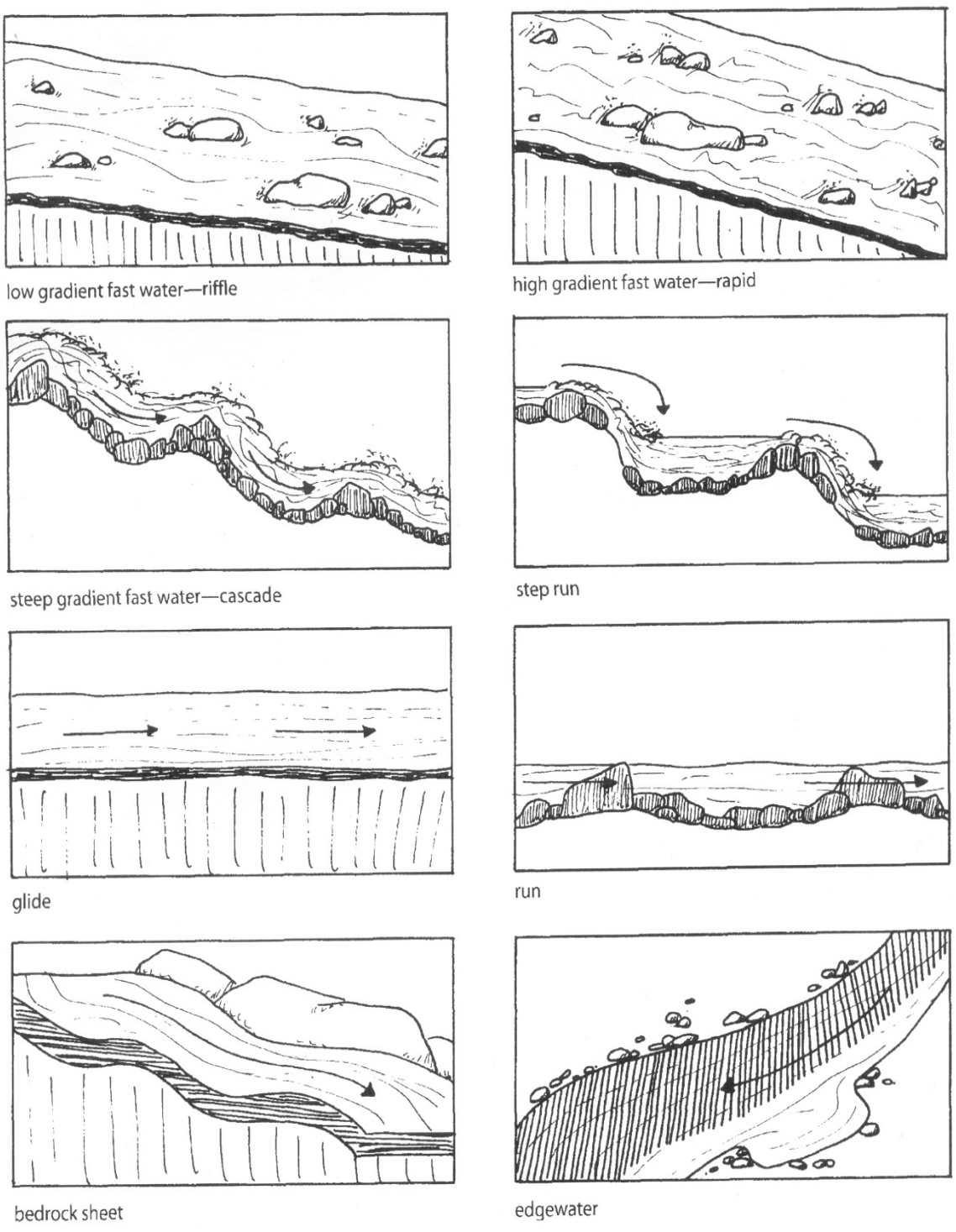


Fig. Classification of macrohabitats

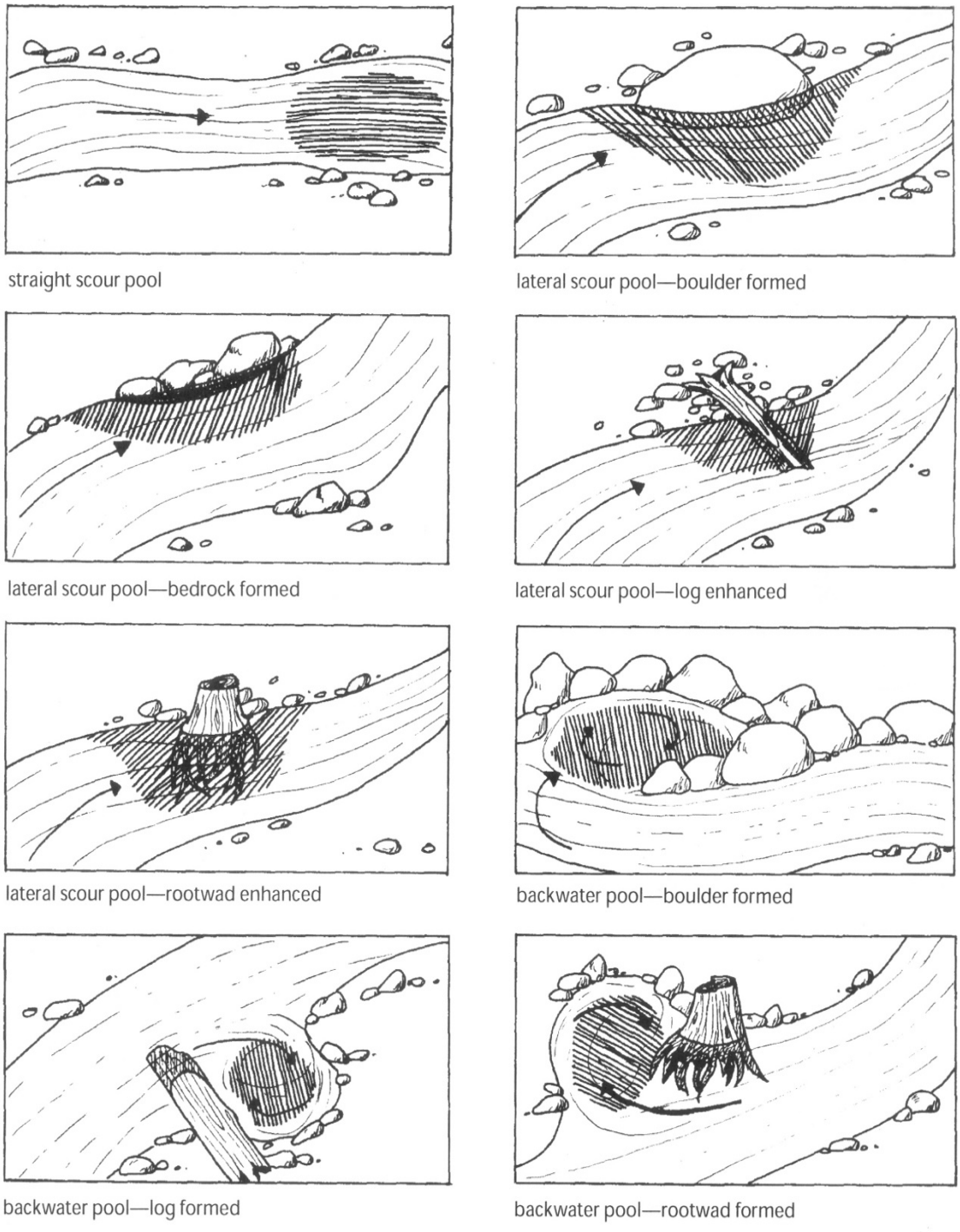


Fig. Classification of macrohabitats

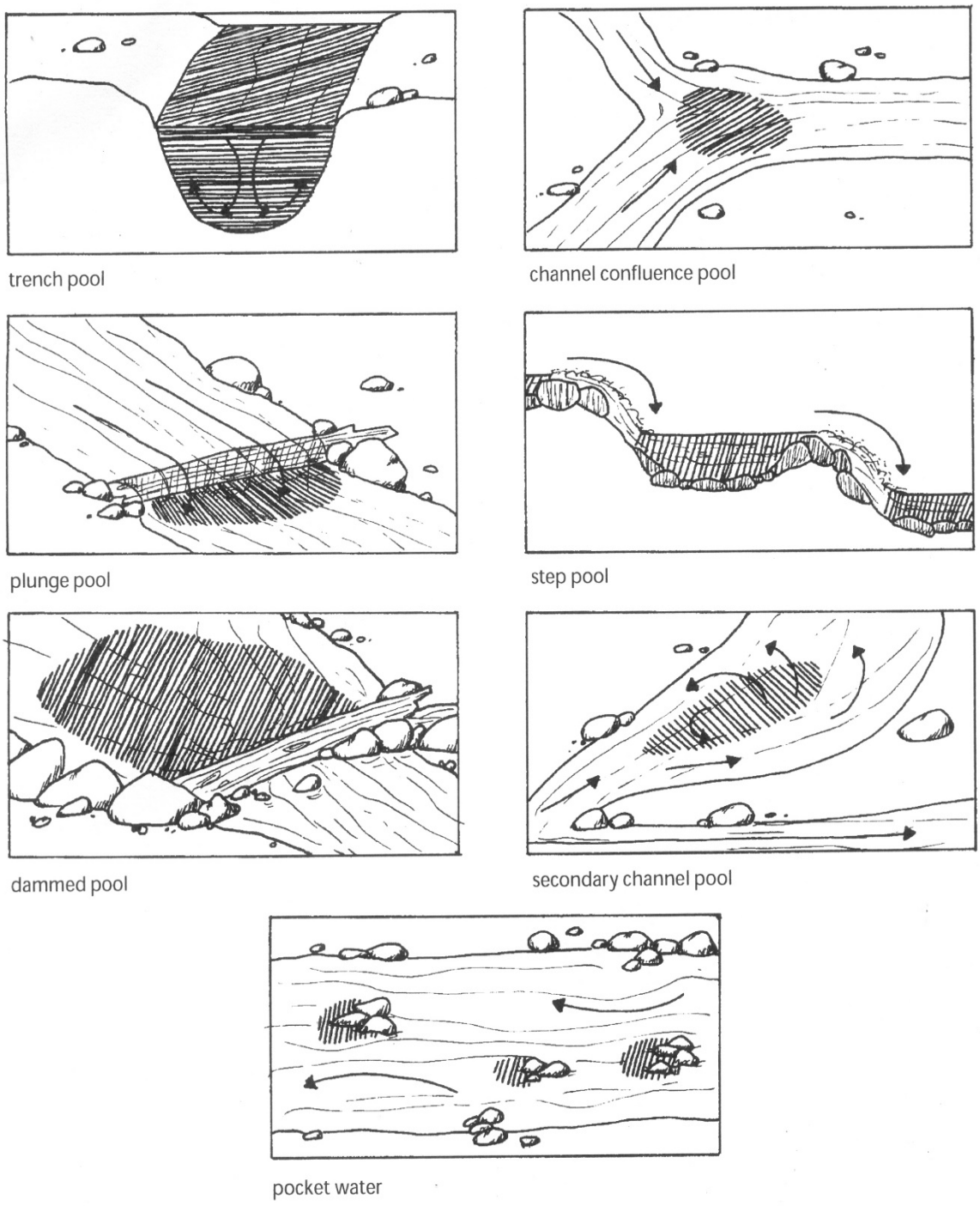


Fig. Classification of macrohabitats

Substrate

Substrate refers to the bottom material of a water body, and it is almost always documented in habitat surveys. Reasons for measuring substrate in any type of habitat assessment.

1. The composition of the substrate determines the roughness of stream channels, and roughness has a large influence on channel hydraulics (water depth, width, and current velocity) of stream habitat.

2. Substrate provides the micro-conditions needed by many fish species. For example, many species require specific substrates for spawning because eggs adhere to some surfaces. Also the interstitial water flow through the substrate maintains high oxygen levels around buried eggs.

3. Substrate provides clues to local and watershed influences on stream habitat quality. Land surface disturbances caused by forestry and agricultural practices alter surface water runoff and sedimentation rates, and these processes are reflected in the size composition of surface substrate.

It is necessary to categorize substrate types for making visual designations in the field. Substrate types have long been organized on a geometric size scale (the Wentworth scale, Wentworth 1922), in which each size category is twice as big as the preceding one. The Wentworth scale was grouped into familiar substrate types (e.g., sand, gravel, pebble) by Cummins (1962) and this modified Wentworth classification is frequently used in fish habitat studies because categories are easily distinguished for field surveys. Bain *et al*. (1985) described how the modified Wentworth classification can be used in a series of substrate observations to describe mean substrate size and substrate heterogeneity. This technique can also be used to directly measure the dominant substrate.

Table. Substrate categories based on modified Wentworth classification

Substrate type	**Particle size range (mm)**
Boulder	> 256
Cobble	64 – 256
Pebble	16 – 63
Gravel	2 – 15
Sand	0.06 – 1
Silt and clay	< 0.059

Stream flow

Stream flow or discharge is the quantity of water passing through a cross section of a stream channel per unit time. Stream velocity (recorded in m/s) and the cross-sectional area (m^2) produce volume per unit time (m^3/s). Water velocity or current speed is a component of discharge and is recorded as a rate (m/s) for a point in a stream. While discharge estimates depend on velocity measurements, fish and other stream organisms often respond to water velocity in their immediate vicinity or microhabitat (e.g., Growns and Davis, 1994; Hart, 1996). Techniques for measuring water velocity can be used for point estimates in stream microhabitats, or in a series of cross-sectional measurements for estimating discharge.

Changes in stream discharge affect water depths, substrate composition, suspended sediment loads, and nutrient and sediment transport. Stream flow directly affects habitat composition, and variability in stream flow largely determines habitat stability. Habitat composition and stability in turn affect the biotic components of a stream, especially fish community composition. Discharge can also affect riparian vegetation, which provides important fish cover and erosion control. Discharge determines the extent of stream channel inundation and the duration of inundation influences riparian soil moisture, soil oxygen concentration, and vegetation composition and distribution.

Flow meter: Mount the flow meter probe on a wading rod. Set the water depth on the wading rod; it will automatically set the flow meter to 0.6 of the water depth (mean velocity for a position). Hold the probe facing into the current. Stand downstream and far enough back to avoid interfering with the flow of water passing the meter. Depending on the flow meter, wait at least 30 s for the velocity reading to stabilize. Take either one or two meter readings at each location, depending on the water depth, as described below:

- For water depths (d) < 0.75 m, measure velocity once at 0.6 d from the water surface. A flow meter wading rod will automatically set the flow meter to the correct depth.

- For depths >0.75 m, measure velocity twice, at 0.2 d and 0.8 d. Average these two readings to determine the velocity for that cross section. If the water is too deep for a wading rod, lower the current meter to the proper depth on a graduated cable from a boat or bridge-mounted cable winder. If a wading rod is used, set the depth on the rod to 0.33 and 1.33 of the water depth, which will set the meter to 0.2 d and 0.8 d, respectively.

Assessment of Riparian habitat

A riparian zone is the area adjacent to a watercourse. Stream sides, river floodplain margins, and the edge habitat of lakes, ponds, and other bodies of water are all riparian zones

Procedures

(1) **Arrange transects and points:** Locate five or more transects extending outward from the stream bank or lakeshore bank (not the water edge) approximately 10 m or to the outer edge of the riparian zone (transition to uplands or vegetation unrelated to water body). Transects can be evenly spaced to cover the assessment site and should be perpendicular to the bank. For stream assessments place five or more transects on each side of the stream or river. Mark the transects as left or right bank on the data sheet. Identify 100 points at even intervals on all the transects. Select a length interval that results in about 20 points per transect or 100 for the

assessment site. Maintain the same spacing between points on all transects rather than forcing the same number of points on transects of different lengths.

(2) **Characterize vegetation composition:** For each transect, designate on a form the classes of vegetation that constitute a majority of the cover (primary vegetation component) and the classes of vegetation that constitute significant but secondary components of cover. The classes of vegetation are listed as (forbs, grasses, shrubs, etc.). Forbs are broadleaved herbaceous plants, grasses are narrow leaved, and both lack woody stems above ground. Shrubs are woody plants that are typically bushy and less than 6 m tall at maturity.

(3) **Measure vegetation cover by height:** For each transect point, extend a telescoping survey rod from the ground up to the maximum extension of herbaceous plant height (this may vary but should not be more than 1.5 m). Record whether or not the rod hits herbaceous vegetation by placing an H in the box for the sampling point. Record an H once per sample point even if herbaceous vegetation touches the rod at several points. Next, extend the rod upwards to the maximum extension of shrub height (usually about 6 m). Record whether or not the rod hits shrub vegetation by placing an S in the box for the sampling point. Next, extend the rod up to tree height and record whether or not the rod hits tree vegetation by placing a T in the box for the sampling point. When tree height exceeds rod length, an observer could use the survey rod to visually estimate if tree vegetation intersects the sampling point. Finally, place a dash in the boxes for sampling points that had no vegetation recorded so the number of sampling points are clearly shown on the data sheet. Calculate the percentage of sampling points with each type of vegetation by dividing the number of entries (H, S, T separately) by the total number of point measurements taken (at least 100). The results are percent cover for each vegetation height category. The following figure shows a sample data sheet for recording frequency and percent cover calculations.

Water Side Vegetation Assessment

This technique presented is most accurate for plants more than 10 m in height. The technique described was adapted from Swanson *et al*. (1988) to simplify their riparian community.

Procedures

(1)**Identify sampling points:** Data are to be recorded at each end of a habitat assessment site. For streams, at each end of the site set up a transect across the stream channel with endpoints on each bank. Three locations should be identified and marked along this transect line: one 30 cm out from the right bank, one in midstream, and one 30 cm out from the left bank. For lakes, mark an observation point 30 cm off the shoreline bank at each end of the site or periodically around the lake.

(2)**Classify riparian vegetation:**

- ✓ Looking into the riparian zone from each shoreline sampling location, identify and record which of the following three riparian types best describes the habitat
- ➢ Hydro-riparian wetlands have hydric soils or substrates that are rarely or only briefly dry. Vegetation is predominantly obligate and preferential wet riparian plants.
- ➢ Meso-riparian areas have non-hydric soils and substrates that are dry seasonally, vegetation is a mixture of obligate, preferential, and facultative riparian plants

- ➢ Xero-riparian habitats are mesic to xeric; the average moisture is higher than the surrounding uplands due to occasional (less than one month a year) surface wetting or increased groundwater from the associated water body. Here the vegetation is preferential, facultative, and non-riparian plants
- ✓ After identifying the riparian type, select the dominant class of trees, shrubs, and herbaceous plants (evergreen, deciduous, low, high, mixed) and record information on a data sheet.
- ✓ Finally, record the dominant plant taxa for trees, shrubs, and herbaceous vegetation layers. If multiple, similarly important taxa exist in a layer, then list them as codominant taxa using a hyphen to separate the species names.

2. ASSESSMENT OF HABITAT PARAMETERS (ENVIRONMENTAL VARIABLES)

Data to be collected:

a) **Physico-chemical parameters of water:** water temperature, transparency, turbidity, depth, water flow, pH, specific conductivity, TDS, salinity, pH, CO_2, Alkalinity, Total Hardness, Magnesium hardness, Calcium hardness, Chloride, Dissolved Oxygen, NO_2-N, NO_3-N, Total N, PO_4-P, Total-P, Available Silicate, Chlorophyll and phytoplankton primary production.

b) Physico-chemical parameters of soil: Texture**,** pH, sp. conductivity, organic C, available and total N, available and total P, $CaCO_3$

For habitat preference of fishes, following physico-chemical (water and soil quality) as well as biological parameters (Plankton, periphyton and benthos availability) has to be understood clearly. Collect subsurface water and soil sample from bottom of three different sampling points (Right bank, Left bank and Middle of the river) of each selected station for analysis of every individual parameter in two replicates. Parameter wise samples are to be preserved following the procedures as given in Table below.

For determination of different soil parameters, bottom sediment was collected using Peterson Grab, mixed thoroughly and dried at room temperature in shade. The dried sediment was ground, strained through different sieves separately and kept in plastic packets for analysis of different soil parameters.

2.1 Water Quality Parameters

Water Samples Collected should be preserved immediately as given in Table 8 for analysing certain water quality parameters at laboratory.

Table 8. Preservation of water samples for analysis of various parameters

Parameter	Preservation
pH, CO_2, Alkalinity, Hardness	These parameters are analyzed in the field. In case some samples required preservation for laboratory analysis, add 5 ml/1 of chloroform. Exclude light and air.
Dissolved Oxygen	Fix the Sample using two Winkler reagents, immediately. Exclude any bubble
NO_2-N, NO_3-N	Freeze or add 5ml/l of 2M H_2S0_4
PO_4-P, Total –P	Add 5 ml/1 of chloroform or 2M H_2S0_4

Chlorophyll	Collected in dark plastic bottle (500 ml) and stored in icebox while transferring to laboratory

2.1.a. Water temperature

Measure the water temperature using a Celsius thermometer by dipping the thermometer in water sample. Record the temperature in ºC. Alternatively, data is obtained by dipping temperature probe of multiprobe equipment in water.

2.1.b. Transparency

Water transparency is measured with the help of Secchi disc, which consists of a circular metallic disk of 20 cm diameter. The upper surface of the disk is divided into four equal quadrants; each of them is being painted black and white alternately, while the lower side is painted black to eliminate reflection of light. Lower the disk with the help of graduated wire into the water and note the depth (d_1) at which it disappears. Lift the disk slowly and again note the depth (d_2) at which the disc reappears. The reading $(d_1+d_2)/2$ in cm gives the measure of light penetration or Secchi disc transparency.

$$\text{Transparency (cm)} = \frac{d_1+d_2}{2}$$

2.1.c. Turbidity

Secchi disk has its limitation in bottom visible shallow water. Hence, a portable turbidity meter may be used to measure turbidity of a water body. Result is expressed as Nephelometric Turbidity Unit (NTU). Meter is to be calibrated with standard turbidity solutions.

2.1.d. Depth

Water depth (cm) of the water body can be measured using echo-sounder. However, in case of absence of such machine, a graduated nylon rope fitted with a weight at the end may also serve the purpose.

2.1.e. Water Flow

Flow of water can be measured through a flow meter, propeller-based or optical or magnetic.

2.1.f. Water pH

Measure the pH of water directly by dipping the handy electrode meter into the water sample. The pH meter should be standardized against two buffer solutions of known pH.

2.1.g. Specific conductivity

For specific conductivity take water sample in a 100 ml beaker, then dip the Specific conductivity meter in the water and take the reading in (µS/cm). Conductivity meter must be calibrated with 0.01N KCl solution before use.

2.1.h. Dissolved oxygen (DO)

DO can be measured by modified **Winkler's method**.

***Principle*:**

A divalent manganese solution, followed by strong alkali i.e. Winkler A and B respectively is added to the sample. Dissolved oxygen present in the water oxidizes an equivalent amount of

divalent manganese to basic hydroxides. When the solution is acidified in presence of iodide ions, the oxidized manganese ions again revert to divalent state and iodine, equivalent to the original dissolved oxygen content of the water, is liberated. This iodine is titrated with standardized thiosulphate solution.

***Reagents*:**

(a) Winkler A solution (Manganous sulphate): Dissolve 480 g $MnS0_4.4H_2O$ or 400 g of $MnS0_4.2H_20$ or 365 g of $MnSO_4.H_20$ in distilled water and make up the volume to 1 litre.

(b) Winkler B solution(alkaline iodide): Dissolve 500 g of sodium chloride and 300 g of potassium iodide in 900 ml of distilled water and make up the volume to 1litre.

(c) Standard thiosulphate solution (0.025N): To prepare 0.1N stock solution of sodium thiosulphate, dissolve 24.82 g of crystalline $Na_2S_20_3.5H_20$ and 4.0 g of borax as a preservative in 700 ml of distilled water and make up the volume to 1 litre. Standardize the strength of this solution to exactly 0.1N by titrating against 0.1N potassium dichromate. To make 0.025N thio solution, dilute 125ml of this standardized stock solution (0.1N) to 500ml

(d) Concentrated sulphuric acid

(e) 0.1N potassium dichromate: Dissolve 4.904 g of dried and crystalline $K_2Cr_2O_7$ in 1 litre of distilled water.

(f) Starch solution (0.2%): Add 2.0 g starch and 30 ml 20% NaOH solution in 350ml of distilled water. Stir until a thick, almost clear solution is obtained. Neutralise the alkali with HC1 and acidify with 1 ml of glacial acetic acid. Finally dilute the solution to 1 litre with distilled water.

***Procedure*:**

Collect water sample carefully in 300 ml BOD bottle. Add immediately 1 ml of manganous sulphate reagent with a pipette followed at once by 1 ml of alkaline iodide solution for fixing Oxygen. Restopping the bottle immediately and mix the contents thoroughly by shaking to develop a flocculent precipitate. After the precipitate had settled, repeat the mixing and settling. Finally add concentrated sulphuric acid (about 1 ml) to dissolve the precipitate and the precipitate is dissolved by inverting the BOD bottle. From this bottle, take 50 ml solution into a conical flask and titrate with 0.025N standard thiosulphate solution until a very pale straw colour remains. Add starch (about 5 ml) indicator which forms a blue colour and continue the titration until the solution turns clear. Solution should remain colourless for at least 20 seconds at the end point.

***Calculation*:**

$$\text{Dissolved oxygen (ppm)} = \frac{(8 \times 1000 \times N) \times v}{V}$$

Where,

v = volume of titrant

V = volume of sample

N = Normality of titrant (0.025 N)

2.1.i. Free CO_2

***Principle*:**

Free CO_2, an acidic oxide reacts with sodium hydroxide to form sodium carbonate. Completion of the reaction is indicated by the development of pink colour in presence of phenolphthalein indicator at the equivalence pH of 8.3.

***Reagents*:**

a) Phenolphthalein indicator

b) N/44 NaOH: Dissolve 0.909 g of NaOH pellets in 1 litre of distilled water

***Procedure*:**

Take about 50 ml of water sample in a conical flask and add 5-10 drops of phenolphthalein indicator to it. If there is no free carbon dioxide the colour turns pink. If the sample remains colourless, add N/44 sodium hydroxide solution drop by drop from a graduated pipette to restore the pink colour. Record ml of N/44 NaOH used during this titration.

***Calculation*:**

$$\text{Free } CO_2 \text{ (ppm)} = \frac{\text{No.of ml of N/44 NaOH required} \times 1000}{\text{ml sample taken for determination}}$$

2.1.j. Total alkalinity

Alkalinity of water is due to the carbonates and bicarbonates of alkaline and alkaline earth metals present in solution. The alkalinity of water is its capacity to neutralise acid. The amount of a strong acid needed to neutralize the alkalinity is called the total alkalinity

***Principle*:**

Alkalinity is determined by titrating the sample with a standard solution of strong acid. Alkalinity due to hydroxide and carbonate is determined to the first end point (pH 8.3) using phenolphthalein indicator and bicarbonate alkalinity is determined to second end point (pH 4.5) using Bromocresol green-Methyl red indicator.

Na_2CO_3/NaOH + H2SO4 → NaHCO3 / Na2SO4 (pH 8.3)

NaHCO3 + H2SO4 → H2CO3 + Na2SO4 (pH 4.5)

***Reagents*:**

a) 0.02(N) H_2SO_4: Add 30 27.2 ml of conc. H_2SO_4 (specific gravity 1.84 ~ 36.8N) carefully to 1 litre of distilled water to get approximately 1 N stock solution. To get 0.02N H_2SO_4 solution, take 20 ml of this stock solution and dilute to 1 litre. Standardize this solution using standard 0.02(N) Na_2CO_3.

b) Phenolphthalein indicator: Dissolve 80 mg of phenolphthalein indicator in 100 ml 95% ethyl alcohol.

c) Bromocresol green-Methyl red indicator: Dissolve 80 ml bromocesol green and 20 ml methyl red.

***Procedure*:**

Add 3-4 drops of phenolphthalein indicator (PHTH) solution in 100 ml water sample. If pink colour develops it indicates presence of hydroxide and/or carbonate alkalinity. Add 0.02N H_2SO_4 solution drop by drop from 1-2 ml graduated pipette and note the colourless endpoint. Add 4:8 drops of Bromocresol green-Methyl red mixed indicator (BCG mixed indicator) to the water sample. If the sample becomes red, then no bicarbonate present (Only hydroxide was initially present). If the sample turns blue-green then titrate with 0.02N H_2SO_4 solution with 10ml graduated pipette. The red coloration indicates the end point.

***Calculation*:**

$$\text{Phenolphthalein alkalinity (ppm)} = \frac{\text{ml of 0.02N H2SO4 used in PHTH indicator} \times 1000}{\text{ml of sample}}$$

$$\text{Total alkalinity (ppm)} = \frac{\text{ml of 0.02N H2SO4 used in PHTH and BCG mixed indicator} \times 1000}{\text{ml of sample}}$$

2.1.k. Total hardness

It is a measure of the quantity of divalent ions such as calcium, magnesium and/or iron in water. There are many different divalent salts; however, calcium and magnesium are the most common sources of water hardness.

***Principle*:**

Calcium and magnesium ions are titrated with the complexing agent ethylene diamine tetra acetic acid disodium salt (EDTA) to form the stable complexes. The end point of the titration is signalled with an indicator called Erichrome black-T.

***Reagents*:**

a) EDTA solution (0.01M): Dissolve 3.723 g disodium salt of EDTA in distilled water and make the volume up to 1 litre.

b) Eriochrome black T (solid) - Dissolve 4.5 g of hydroxyl amine hydrochloride and 0.5 g of Erichrome black-T in 100 ml of 70 % ethanol.

c) Ammonia buffer: Dissolve 67.5 g of ammonium chloride in 570 ml of concentrated ammonium hydroxide. Dilute to 1000 ml with distilled water.

***Procedure*:**

In 50 ml water sample, add 1 ml ammonia buffer solution to bring the pH of the solution between 10 ± 0.1, then titrate with standard 0.01M EDTA solution using Eriochrome black T indicator (pin ch) with colour change from magenta to blue.

***Calculation*:**

$$\text{Total Hardness as } CaCO_3 \text{ } mgl^{-1} = \frac{\text{ml EDTA titrate} \times 1 \times 1000}{\text{ml sample taken for titration}}$$

2.1.l. Calcium Hardness

***Reagents*:**

a) EDTA solution (0.01M): Dissolve 3.723 g disodium salt of EDTA in distilled water and make up the volume to 1 litre.

b) Indicator: Mix 0.2g murexide (ammonium purpurate) with 100 g NaCl. Ground the mixture with mortar-pestle and keep for further use.

c) NaOH solution (1N): Dissolve 4 g NaOH in 100 ml solution

***Procedure*:**

To 25 ml water sample, add 1ml 1N NaOH solution and add a pinch of indicator. Titrate the solution with 0.01M EDTA solution till the colour changes from pink to magenta.

***Calculation*:**

Calcium (mg/l) = titration reading x 16.032

2.1.m. Magnesium Hardness

Magnesium concentration can be obtained from total hardness and calcium reading using the following formula

Magnesium (mg/l) = **[**Total hardness (mg/l) - {calcium (mg/l) x 2.497}**]** x 0.243

2.1.n. Chloride

***Principle*:**

Potassium chromate can indicate the end point of the silver nitrate titration of chloride (argentometric method). Silver chloride is precipitated quantitatively before red silver chromate is formed.

***Reagents*:**

a) Silver nitrate solution (0.0141N): Dissolve 0.2395g $AgNO_3$ in 100 ml distilled water

b) Potassium chromate indicator: Dissolve 5 g K_2CrO_4 in distilled water. Add Silver nitrate solution till definite red precipitate is formed. Allow the solution to stand for 12 hrs. Then filter the solution and dilute to 100 ml.

***Procedure*:**

Take 25 ml water sample in a 50 ml conical flask, add 5 drops of potassium indicator and titrate with 0.0141N $AgNO_3$ solution.

***Calculation*:**

$$\text{Chloride (ppm)} = \frac{\text{ml of titrant used} \times N \times 35.46 \times 10^3}{\text{ml of sample}}$$

2.1.o. Nitrate nitrogen

***Principle*:**

Nitrate in water sample is reduced almost quantitatively to nitrite. The nitrite produced is determined by diazotising with sulfanilamide and coupling with N-(1-naphthyl) ethylenediamine (NED) to form a highly coloured azo dye which can be measured spectrophotometrically.

***Reagents*:**

a) Phenol solution: 23 g phenol in 500 ml of distilled water.

b) NaOH: 1.25 g in 500 ml of distilled water.

c) Buffer reagent: Mix equal volume of phenol solution and NaOH solution.

d) Copper sulphate solution: 0.1g in 1 litre distilled water.

e) Hydrazine sulphate: 3.625 g in 500 ml of distilled water.

f) Reducing agent: Mix 5 ml of copper sulphate solution to 5 ml of hydrazine sulphate.

g) Acetone

h) Sulfanilamide; Dissolve 5.0 g in 50 ml of conc. HC1 and make up the volume to 500 ml.

i) N-(1-naphthyl) ethylenediamine (NED): Dissolve 0.5 g of NED in 500 ml of distilled water.

j) Nitrate standard solutions: Dissolve 0.36119 g potassium nitrate, KNO_3 (AR dried at 105°C) in 250ml distilled water. Dilute 100 ml of this solution to 1 litre with distilled water. This final solution contains 2 ppm NO_3

***Procedure*:**

To 25 ml water sample in test tube, add 1 ml of alkaline buffer and 0.5 ml of reducing agent and keep in the dark for 20 hrs for complete reduction. Add 1 ml of acetone to the solution. After 8 minutes, add 0.5 ml sulphanilamide solution and 0.5 ml NED solution for development of pink azo dye. Measure the absorbance at 543 nm in UV spectrophotometer.

2.1.p. Nitrite nitrogen

***Principle*:**

The nitrite in water is allowed to react with sulfanilamide in an acid solution. The resulting diazo compound is reacted with NED and forms a highly coloured azo dye. The colour formed is measured spectrophotometrically. Nitrite-N concentration is calculated using standard calibration graph.

***Reagents*:**

a) Sulfanilamide solution: Dissolve 5.0 g of sulfanilamide in a mixture of 50 ml of cone. HC1 and about 300 ml of distilled water. Dilute to 500 ml with distilled water. The solution is stable for many months.

b) NED (N-(l-naphthyl)- ethylene diamine dihydrochloroide solution). Dissolve 0.5 g of the dihydrochloride in 500 ml of distilled water. Store the solution in a dark bottle. The solution should be renewed once a month or directly a strong brown colouration develops.

c) Standard nitrite: Dissolve 1.064 g anhydrous, analytical grade potassium nitrite, $KN0_2$, (dried at 105^0C for 1 hr) in distilled water. Add 1 ml 5N NaOH and dilute to 250 ml. This solution contains 700 mg/1 nitrite-N and should be stored in a dark bottle with 1ml of chloroform as a preservative in refrigerator. The solution is stable for several months.

***Procedure*:**

Add 1 ml of sulfanilamide solution from a pipette to each 50 ml sample, mix and allow the reagent to react for more than 2 minutes but less than 10 minutes to assure a complete reaction. Add 1ml of NED reagent and mix immediately. Leave for 10 minutes and then measure the absorbance of the samples and standards against a reagent blank at 540 nm. The colour is stable for 2 hrs. Calculate the nitrite concentration by using calibration curve.

2.1.q. Total N (NH_4, NO_2 and NO_3) in water

Procedure:

Take 200 ml distilled water in a Kjeldahl flux and warm. Add two pellets of Sodium hydroxide (NaOH), little dust of Devarda's Alloy and water sample (50 ml) in the flux. Attach the distillation assembly immediately and boil it for distilling approx 30 ml water to be collected at the receiver side. Make the volume to 50 ml. Add 10 drop Nessler Solution. The colour will appear as yellow. Measure the yellow color at 410 nm in spectrophotometer.

Standard:

3.8207 g NH_4Cl was taken in 1 litre solution of distilled water to have a 1000 ppm NH_4-N solution. 10 ml of this solution diluted to 1 litre makes 10 ppm stock solution. A series of standard solution of NH_4-N (0.1 to 5 ppm) was prepared from 10 ppm stock solution. Add 10 drop of Nessler Solution to 50 ml of each standard solutions to develop yellow colour. Standard curve was prepared from the absorbance values of standard solutions and the concentration of the unknown solution was determined from the standard curve. The results may be expressed in ppm or ppb.

2.1.r. Available phosphate P

***Principle*:**

Ammonium molybdate and Potassium antimony tartarate react in acid medium with orthophosphate to form a heteropoly acid - phosphomolybdic acid that is reduced to intensely coloured molybdenum blue by ascorbic acid.

***Reagents*:**

a) PAT solution: Dissolve 0.2743 g potassium antimony tartarate in 100 ml distilled water.

b) Ammonium molybdate (4%): 4 g ammonium molybdate was dissolved in 100 ml distilled water.

c) Sulphuric acid (5N): 70 ml of conc. H_2SO_4 dissolved in water to a final volume of 500 ml.

d) Ascorbic acid solution: Prepare a fresh ascorbic acid solution by dissolving 0.528 g ascorbic acid in 30 ml water.

e) Colour developing reagent: Prepare a solution with 50 ml 5(N) H_2SO_4, 5 ml PAT solution, 15 ml 4% ammonium molybdate solution and 30 ml freshly prepared ascorbic acid solution. The solution should be used within 4 hrs.

***Procedure*:**

To 25 ml water sample, add 4 ml of the colour developing reagent. After 10 minutes, measure the absorbance of the blue coloured solution at 880 nm using UV spectrophotometer.

***Calculation*:**

Calculate the concentration of Phosphate Phosphorous using calibration curve based on absorbance of the standard phosphate solution of 0.05-0.25 mg/l.

2.1.s. Total phosphorus in water

Evaporate 50 ml of river water, add 2 ml of perchloric acid, evaporate on a hot plate up to a volume of 5-10 ml (until the solution become colourless), cool at room temperature, add little water and then just neutralize with 1 N NaOH solution using phenolphthalein indicator (just pink end point). Then make up the volume up to 50 ml with distilled water. Determine phosphorous of the digested solution by the method of available phosphorous (Ascorbic acid method as mentioned above).

2.1.t. Available silicate-Si

***Principle*:**

Ammonium molybdate at pH ~1.2 reacts with silica to produce heteropoly acids. Oxalic acid is added to prevent interference due to phosphate.

***Reagents*:**

a) Ammonium molybdate (10%): Dissolve 10 g ammonium molybdate in water with stirring and gentle warming and dilute to 100 ml. Adjust the pH of the solution to 7-8 with NH_4OH. Store it in a polythene bottle to stabilize.

b) Oxalic acid solution: 5 g oxalic acid dissolved in 50 ml solution.

c) HCl solution (6N): Conc. HCl (12N) diluted with equal amount of distilled water.

***Procedure*:**

To 25ml filtered water, add 1 ml 6N HCl solution and 1 ml 10% ammonium molybdate and mix thoroughly. After 5 minutes, mix with 0.5 ml oxalic acid solution and a yellow colour develops in the solution. Determine absorbance at 410 nm after 2 minutes with the help of UV spectrophotometer.

***Calculation*:**

Calculation is done based on absorbance of the standard silicate solution of 1-5 mg/l.

2.1.u. Chlorophyll

Water sample was collected in a dark plastic bottle (500 ml) and stored in icebox to transfer into laboratory. In laboratory, water sample was filtered through a glass membrane filter (coated by a layer of magnesium carbonate suspension) using a vacuum pump. The membrane filter was collected and dissolved within acetone solution (10 ml) inside a small glass container. Then the container was kept into refrigerator for overnight. The next day the solution within the container was collected and introduced into a grinder for grinding. Then the material was transferred into a centrifuge tube and final volume was made up to 14.5 ml. After that the centrifuge was done for 20 minutes at 4500 rpm. Then the OD measured at four individual wavelengths (750, 664, 647 and 630 nm) and finally the calculation was done from the standard equation given bellow.

Calculation

a) C_a = 11.85x(absorbance at 664 nm) –1.54x(absorbance at 647 nm) – 0.08x(absorbance at 630 nm)

b) C_b =21.03x(absorbance at 647 nm) – 5.43x(absorbance at 664 nm) – 2.66x(absorbance at 630 nm)

c) C_c =24.52x(absorbance at 630 nm) – 7.60x(absorbance at 647 nm) – 1.67x(absorbance at 664 nm)

Where, Ca, Cb and Cc = concentrations of chlorophyll a, b and c (mg/m^3) respectively.

Absorbance 664, 647 and 630 = corrected optical density (with a 1 cm light path) at the respective wavelength.

$$\text{Chlorophyll a } (mg/m^3) = \frac{\text{Ca x extract volume, L}}{\text{Volume of sample, } m^3}$$

2.2. SOIL QUALITY PARAMETERS

2.2.a. Soil texture

To be analysed with samples sieved through 40 No. seive.

***Reagents*:**

a) 0.5 N sodium oxalate solution

***Procedure*:**

Take 100 g dry soil in a 300 ml BOD bottle. Add 15 ml 0.5 N sodium oxalate and 200 ml dist. water to it and shake for 1 hr. Transfer the whole material to 1 litre measuring cylinder, make up the volume and wait for 5 mins. Dip Bouycos hydrometer slowly and note the reading for silt + clay (T_1). After 2 hrs, again the note the reading using hydrometer to get the only clay content (T_2). Silt content is obtained by the difference of T_1 and T_2. Sand content is obtained by subtracting the reading of silt + clay from the sample weight.

2.2.b. Soil pH

***Procedure*:**

Electrometric method: Take 10g soil in 50cc beaker and add 25 ml of distilled water. Shake for half an hour. Dip the electrode of pH meter in the suspension and take the pH reading. Optimum range: near neutral (7.0 - 7.5).

2.2.c. Soil organic carbon (OC)

Estimates of total organic carbon (OC expressed as C) are used to assess the amount of organic matter in soils.

***Principle*:**

Determination of soil organic carbon is based on Walkley-Black chromic acid wet oxidation method. Oxidizable matter in the soil is oxidized by 1 N $K_2Cr_2O_7$ solution in presence of Conc. H_2SO_4. Heat generated during mixing of two volumes of H_2SO_4 with one volume of the dichromate, assists in the oxidation. Remaining dichromate is titrated with ferrous sulphate. The titre is inversely related to the amount of C present in the soil sample.

***Reagents*:**

a) $K_2Cr_2O_7$ solution 1(N): 49.04 g $K_2Cr_2O_7$ in 1 litre solution.

b) N/4 Mohr's solution: 98.0325 g. Ferrous ammonium sulpahate in distilled water, add 3.75 ml conc. H_2SO_4 carefully and finally make the volume up to 1 litre.

c) Diphenylamine indicator: Dissolve 0.5 g diphenylamine in 10 ml conc. H_2SO_4 and 20 ml dist. water was added dropwise.

d) Conc. H_3PO_4: 85%

e) Conc. H_2SO_4: Sp. gr. 1.84 C.P. (36 N)

***Procedure*:**

Take 1 g of soil sample in a 500 ml conical flask, add 10 ml 1(N) $K_2Cr_2O_7$ solution to it. Then carefully add 20 ml conc. H_2SO_4 drop wise. Keep it for 1 hr, and then dilute with water to 200 ml. Add 10 ml conc. H_3PO_4 and 1 ml diphenylamine indicator and titrate with N/4 Mohr's solution till the colour changes from blue to green. Note the reading of Mohr's solution consumed. Titrate the blank (without soil) also using the same procedure. In case of higher percentage of organic carbon repeat the same procedure with higher amount of $K_2Cr_2O_7$ solution.

***Calculation*:**

$$\% \text{ organic carbon} = \frac{\text{(Blank - sample) reading x factor of Mohr's solution x 0.003 x 100}}{\text{Sample weight x 4}}$$

2.2.d. Available phosphorus

***Principle*:**

Available phosphorus (P) is extracted from the soil with 0.002 N sulfuric acid. The extracted P is reacted with a sulfuric-molybdate to form a blue phosphomolybdate compound in the presence of a reducing agent like Ascorbic acid.

***Reagents*:**

a) Sulfuric acid extracting solution: Dissolve 3 g of $(NH_4)_2SO_4$ in approximately 500 ml of deionized water. Add 20 ml of N/10 sulfuric acid and dilute to 1 litre with deionized water.

***Procedure*:**

Place 1 g air dried soil sample in a 250 ml bottle. Add 200 ml 0.002N H_2SO_4 (pH- 3), shake the mixture for 30 minutes in a mechanical shaker. Keep it for 10 minutes and filter through Whatman 42 or equivalent filter paper. Take 50 ml of filtrate in a Nessler tube and determine its phosphate concentration as for water.

***Calculation*:**

ppm of phosphate in solution x 20 = mg P/100 gm soil.

2.2.e. Calcium carbonate

***Principle*:**

$CaCO_3$ in soil react with hydrochloric acid to liberate CO_2. Amount of HCl consumed is proportional to amount of $CaCO_3$ present in soil.

***Reagents*:**

a) 1N HCl: Take 88.8 ml of concentrated HCl in a volumetric flask and make up the volume to 1000 ml with distilled water

b) Bromothymol blue indicator

***Procedure*:**

Take 5 g soil sample in a 250 ml bottle. Add 100 ml 1N HCl and shake for one hour. Allow to settle the suspension and pipette out 20 ml of the clear liquid in a conical flask. Titrate it with 1N NaOH using Bromothymol blue indicator till it just turns blue. Note the reading and carry out a blank taking 20 ml of 1N HCl in a flask and titrating it in the same way.

***Calculation*:**

$$\% \ CaCO_3 = \text{(Titre for blank - Titre for soil solution) x 5}$$

2.2.f. Available Nitrogen

***Principle*:**

Available nitrogen is determined by oxidising soil organic matter with a mild oxidising agent like 0.32% $KMnO_4$. Liberated NH_3 is absorbed in H_2SO_4 for estimating available nitrogen through back titration.

***Reagents*:**

a) 0.32% $KMnO_4$: Dissolve 3.2 g KMnO4 in 1 litre distilled water.

b) 2.5% NaOH: Dissolve 25 g NaOH in about 800 ml dist. water, cool and make the volume to 1 litre.

c) Methyl red indicator

***Procedure*:**

Place 10 g soil sample in a 500 ml Kjeldahl flask. Add 100 ml of 0.32% $KMnO_4$ solution, 100 ml of 2.5% NaOH, 2 ml of liquid paraffin and some glass beads. Distil the mixture and collect the distillate in a conical flask containing 20 ml of 0.02N H_2SO_4 and a few drops of methyl red indicator. Collect about 75-80 ml of distillate. Titrate the excess of 0.02N H_2SO_4 with 0.02N NaOH to a colourless end point.

***Calculation*:**

Available nitrogen (mg/100 g soil) = $\left[(20 - (\text{No of ml of 0.02 N NaOH}) \times 2.8\right]$

Water bodies with moderate to high production potential have available N 25-75 mg/100 g soil.

2.2.g. Total Nitrogen

***Principle*:**

Most of the nitrogen in soil can be converted to ammonium sulphate by digestion using a digestion mixture. Ammonium sulphate reacts with NaOH releases NH3. Liberated NH_3 is absorbed in 0.1N H_2SO_4 for estimating Nitrogen through back titration.

***Reagents*:**

a) 12N NaOH: Dissolve 480 g NaOH in 1 litre water (add slowly with cooling)

b) Concentrated sulphuric acid

c) Salicylic acid

d) Potassium sulphate

e) 0.1N NaOH

f) Methyl red indicator

***Procedure*:**

Take 10 g of soil sample (or less for high organic matter sample) in a Kjeldahl flask. Add 20 ml of conc. H_2SO_4 and 0.5 g salicylic acid and keep for half an hour. Then add 2 g of sodium thiosulphate and 1 g of copper sulphate and 5 g of potassium sulphate and digest the mixture

until a white to bluish colour liquid is formed. Cool and dilute with water. Make it alkaline with 80 ml of 12N NaOH, add a few beads of glass and distil. Collect the distillate in a conical flask containing 20 ml of 0.1N H_2SO_4 and a few drops of methyl red indicator. Collect about 120-150ml of distillate. Titrate the excess of 0.1N H_2SO_4 with 0.1N NaOH till the solution turns colourless.

***Calculation*:**

Total nitrogen (%) = (20- ml of NaOH required) x 0.014

3. COLLECTION, PRESERVATION, AND IDENTIFICATION OF PLANKTON AND PERIPHYTON

Data to be collected:

a) Samples of both phytoplankton and zooplankton has to collected.

3.1 Phytoplankton

The phytoplankton (both algae and bacteria) occurs in unicellular, colonial or filamentous forms and carry on photosynthesis **(Sarma and Saini, 2003).** The study of algae and other micro and macro organisms which inhibit in the waters is utmost important. Collection and preservation of plankton samples are the preliminary steps for identification and enumeration of plankton. Scrupulous care must be taken while collecting plankton samples from a water body in order to get representative sample. Collection of triplicate samples in each selected site is very much important to achieve the unbiased data from the study locations.

a. Sampling methodology

Plankton samples usually referred to as surface and subsurface samples. Surface film should not be included in a surface samples because plankton often trapped on top or at the surface film together with dust and other detritus. Therefore, for surface water samples, a mild disturbance of surface film (if any) is required while collecting the samples.

b. Plankton net method (Welch, 1948; Ruttner, 1975): Filtering 100 L surface water through 25 µm mesh size conical plankton net (silk bolting cloth). However, for subsurface sampling, Kemmerer's/ Meyer's water sampler is used for collection from a known depth and filtered through the plankton net. Photic zone sampling, Secchidisc is first used to determine the depth of visibility in water column; the photic zone is the depth to which ambient light penetrates and is defined as twice the Secchi depth **(Kreger and Karoly, 2016).**

c. Total plankton count method (Baykal et al. 2011): Sampling of 1 L water sample from sub-surface photic region by using water sampler for total plankton count and transferred in to a polypropylene water sample bottle.

d. Labeling: A suitable label is fixed (giving detailed information – place, date of collection etc. water filtered etc.) in each tube before storage.

e. Preservation: Samples can be preserved in 2% buffered formalin solution. A better preservative is Lugol's solution, added to samples to yield a 1% final concentration (1:100). A small amount of glycerol is commonly added to samples preserved in Lugol's solution to prevent drying of samples. For longer preservation, 2.0% formaldehyde and 2.5% Lugol's solution

combined were most promising compared to 2.0% formaldehyde or 2.5% Lugol's iodine **(Mukharjee et al., 2014).**

f. Algal sedimentation (Bellinger and Sigee, 2010): This is preferred technique for sample concentration since it is non selective in terms of size and non-destructive. Sedimentation is normally carried out in a measuring cylinder and allowing the cylinder to stand on a vibration free surface over 24-72 h period. Sedimentation should be carried out in the dark and away from source of heat. The algal free liquid can be carefully siphoned off using pipette with minimal disturbance. The concentrated sample stored in an opaque glass or polyethylene container in the dark at constant temperature (4^0C) until needed for analysis.

g. Identification: Species identification up to a lowest taxonomic level, standard keys were followed [Smith (1950); Davis (1955), Edmondson (1959); Prescott (1962); Needham and Needham (1962); Ramanathan (1964); Phillipose (1967); Cox (1996), Thomas (1997), Karlson et al. (2010), Bellinger and Sigee (2010)] by employing trinocular microscope with 40x, 60x and 100x magnification.

h. Sample analysis

Quantitative analysis of phytoplankton: The two method *viz.* **Lackey's drop** method and Haemocytometer method are very common in the numerical estimation of phytoplankton.

(i) Lackey's drop method: Steps followed -

For counting, the concentrated sample is agitated to obtain uniform suspension and drop is kept on the slide (Quick transfer the drop to slide is important, otherwise the organisms begin settling and may get concentrated in one side)

⇩

1 drop (0.1ml) of water sample containing plankton is taken on a glass slide and covered with glass cover slip (22 sq. mm).

⇩

Number of drops in 1 ml can be counted separately so that per drop could be converted to per ml

⇩

The width of the high power microscopic field is measured separately. Now focus the centre of the cover glass and count the no. of organisms in one microscopic field. Repeat the procedure and count another field well separated from the first one.

⇩

Repeat the procedure in 3-6 drops and record the average values.

Calculation:

$$\text{No/ ml} = \frac{C \times TA}{A \times S \times V}$$

where, TA = Area of the cover slip (mm^2)

A = area of one microscopic field (mm^2)

T = total no. of organisms counted

S = No. of microscopic field counted

V = volume of sample under cover slip (ml)

(ii) Haemocytometer method: Steps followed -

Shake the concentrated phytoplankton sample and transferred immediately to the counting chamber of Haemocytometer with a pipette.

⇩

Place cover glass over the counting chamber

⇩

Count the no. of organisms in central large squares. Thus 25 medium sized squares (0.2 x0.2 mm) in this large square are to be used.

⇩

Begin count from top row of medium sized squares and continue to the bottom row.

Calculation:

$$U/ml = \frac{\text{No. of cells counted in central square}}{\text{Concentration factor}} \times 10^4$$

Where, 10^4 = Liquid holding capacity in central large square

$$\text{Concentration factor} = \frac{\text{Total volume of water filtered}}{\text{Volume of water sample made after concentration}}$$

3.2 Zooplankton

Zooplanktonic samples can be collected by employing plankton net and water sampler **(Battish, 1992).** Triplicate samples were collected from each selected stations to get representative samples.

a. Plankton net method: Samples are collected by filtering 50 L subsurface water through 50 µm mesh size silk bolting cloth. However, zooplanktons from desired depth are collected by Kemmerer's/ Meyer's water sampler (1-2 L). The collected samples are transferred immediately in to the polypropylene water sample bottle.

b. Preservation: Preservation is done immediately after collection in 4 % buffered formalin **(Battish, 1992).**

c. Concentration of zooplankton: The plankton samples are further concentrated by sieving it through a fine mesh or even through a membrane. Application of vacuum technique hastens the filtration process. Centrifugation is also a suitable method for concentration of sample.

d. Transfer and isolation of zooplankters: Transfer and isolation of zooplankter from one slide to another is practiced with the help of brush and brush hairs mounted on a stick. This process is important while dissection of zooplankter. For identification in to species level, dissections are

mandatory by serving dissecting micro needles (entomological pin (no. zero) or fine serving needles.

e. Identification: Identification is done by employing trinocular microscope (40x and 60x magnification) using standard keys [(Davis (1955), Edmondson (1959), Kasturirangan (1963), Tonapi (1980), Adoni (1985), Battish (1992), Shiel (1995), Yamani et al. (2011), MRC Tech. Paper No. 45 (2015)].

f. Quantitative analysis of zooplankton (APHA, 2012)

Sedgwick Rafter cell method: Steps followed –

Enumeration of zooplankton can be practiced effectively by using a counting cell or chamber i. e. Sedgwick Rafter cell.

⇩

Place the counting cell on a level surface. Shake the concentrated sample gently.

⇩

Transfer 1 ml sample to counting cell. Place a clean cover glass over the cell without enclosing air bubbles.

⇩

Allow five minutes for the organisms to settle and examine. Count the organisms appropriately within the cell. Examine maximum numbers of squares of the cell and record.

⇩

Repeat the procedure in 3-6 times and record the average values of the identified zooplankton

⇩

The total number of zooplankton present was calculated per litre **(Santhanam et al. 1989)**

$U/L = n^* v/ V$

where, n= no. of cells counts in 1 ml;

v = Total sample volume and

V= Volume water filtered

3.3. Periphyton

Heterogeneous group microorganisms growing on stones, aquatic macrophytes and other submerged surfaces are known as periphyton. They may be microscopic or macroscopic.

a. Sampling methodology (APHA, 2012)

Since the periphyton grows on stones, rocks and other available surface, sample can be collected from natural substrates. Alternatively, artificial substrates are also used for collection of sample with the help of periphyton sampler. Collections of triplicate samples are followed from the study locations.

i. Natural substrates: Samples are collected by scrapping a known area (sq. cm) from the natural substrates with the help of razor blade, hand brush, scalpel etc. and immediately transferred to a vial containing distilled water.

ii. Artificial substrates: The most commonly used artificial substrates are standard glass slides 25 x 75 mm (Richard et al. 1977). The artificial substrates are generally exposed at desired depth for a period of 1-2 weeks.

b. Preservation: Sample preservation is done in 5 % neutralized buffered formalin **(APHA, 2012).**

c. Identification: Identification of periphyton up to lower taxonomic level, standard keys were referred [Smith (1950), Edmondson (1959); Prescott (1962); Needham and Needham (1962), Ramanathan (1964), Cox (1996), Biggs and Kilroy (2000), Abebe et al. (2006)] using trinocular microscope (40x, 60x and 100x magnification)

d. Quantitative analysis of zooplankton:

Sedgwick-Rafter Cell method:

Shake the concentrated sample and transfer 1 m of sample in to the Sedgwick –Rafter cell by pipette.

⇩

Count the periphyton by strip count method (same as zooplankton analysis)

⇩

If, transferred sample in the cell is too dense, dilution of sample is essential (1:5/ 1:10)

Calculation:

Expressed in individual/ cm^2.

Individual/cm^2 = n*v/ a

where, n= no. of cells count in 1 ml

v = Total sample volume of scrapping and

a = area of scraping in cm^2

Lackey's drop method

For quantitative analysis of periphyton, Lackey's drop method is also followed. The method is same as phytoplankton analysis. Express the result as periphyton per cm^2; calculated as -

$$\text{Individual/ cm2} = A \times \frac{B}{C} \times \frac{1}{S}$$

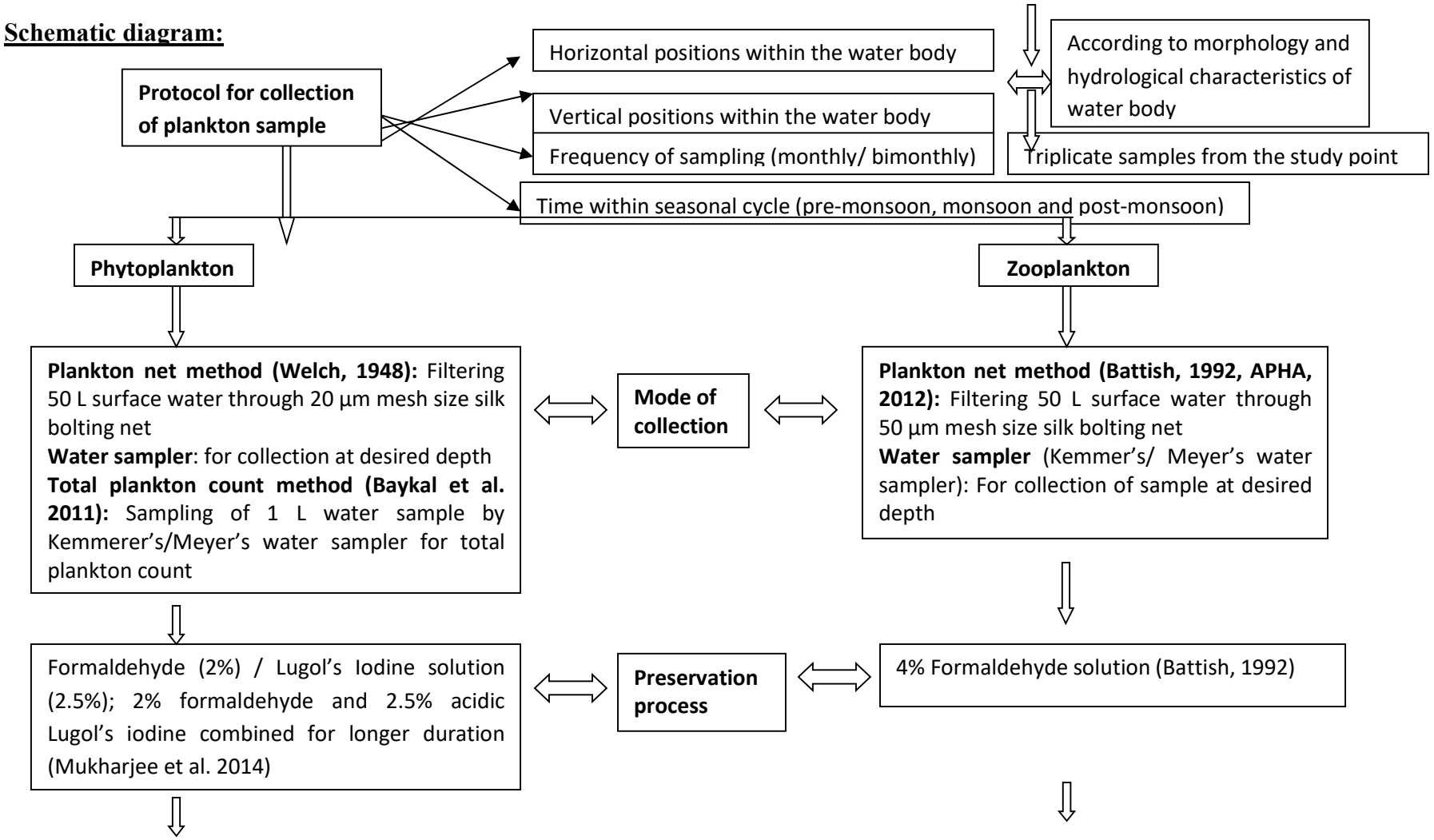
Where, A = Average no. of periphyton per drop

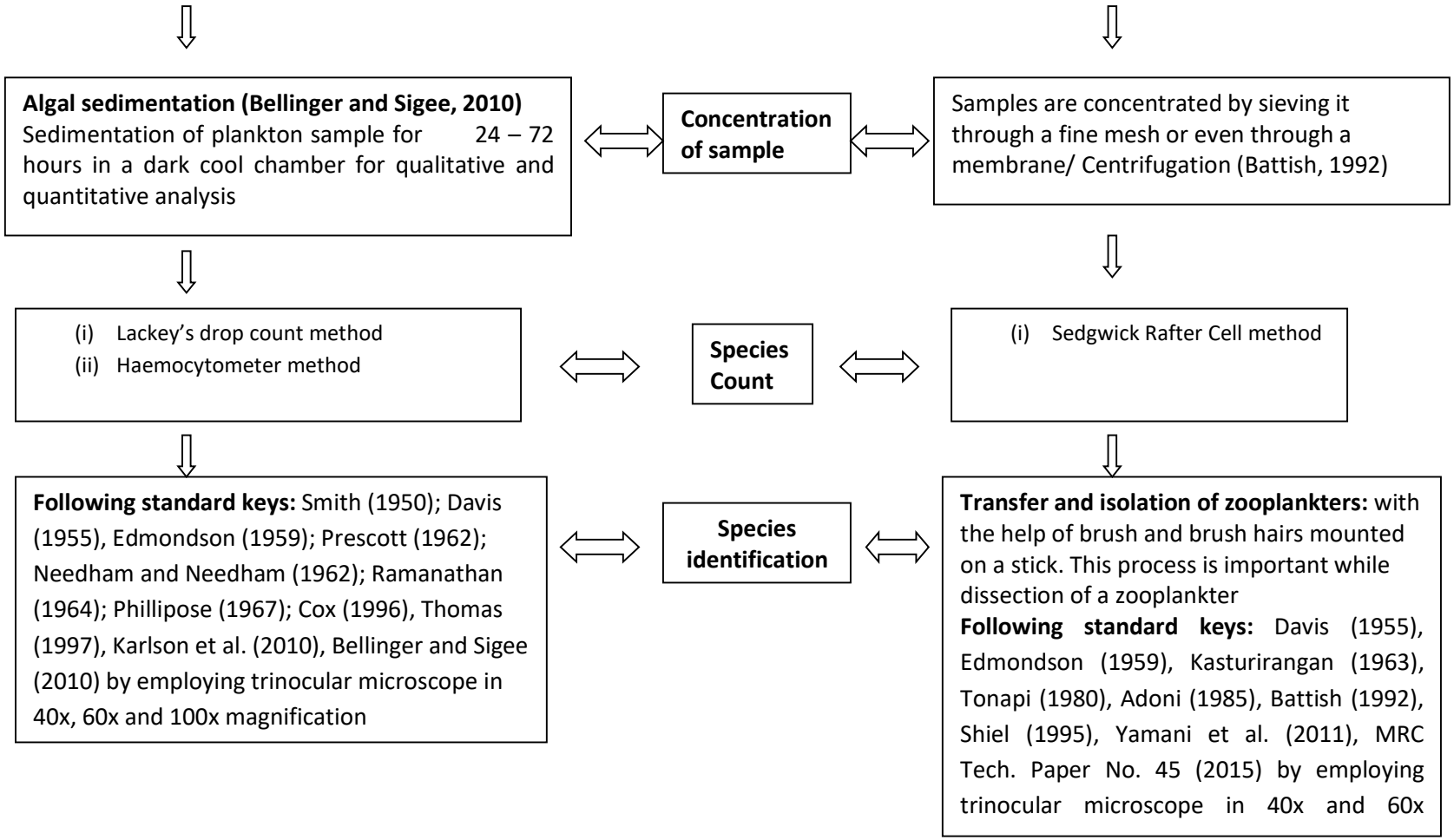
B = vol. of scraping (ml)

C = volume of one drop (ml) and

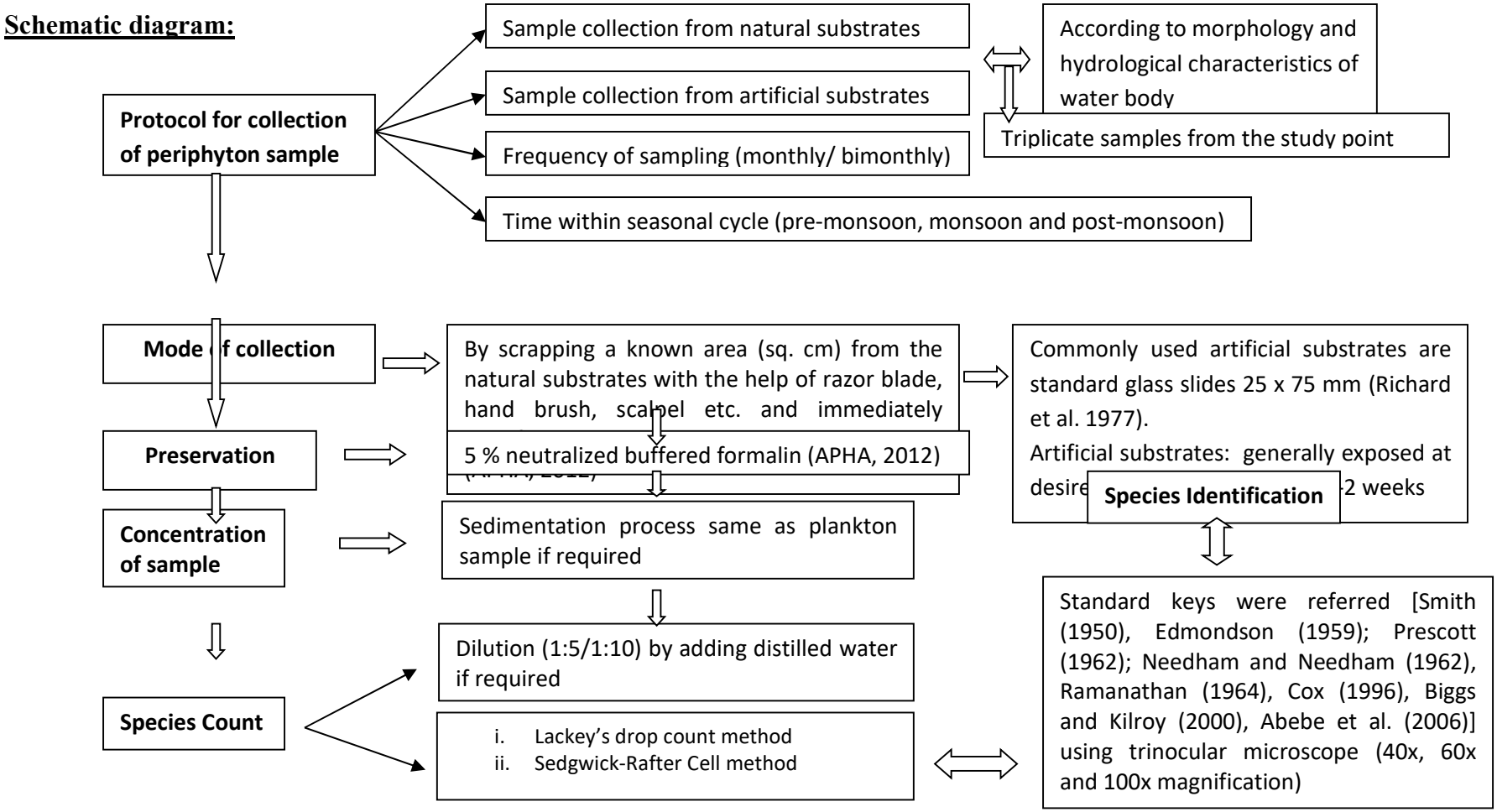
S = Area of scraping (sq. cm)

Schematic diagram:




Algal sedimentation (Bellinger and Sigee, 2010)
Sedimentation of plankton sample for 24 – 72 hours in a dark cool chamber for qualitative and quantitative analysis
Concentration of sample
Samples are concentrated by sieving it through a fine mesh or even through a membrane/ Centrifugation (Battish, 1992)
(i) Lackey's drop count method
(ii) Haemocytometer method
Species Count
(i) Sedgwick Rafter Cell method
Following standard keys: Smith (1950); Davis (1955), Edmondson (1959); Prescott (1962); Needham and Needham (1962); Ramanathan (1964); Phillipose (1967); Cox (1996), Thomas (1997), Karlson et al. (2010), Bellinger and Sigee (2010) by employing trinocular microscope in 40x, 60x and 100x magnification
Species identification
Transfer and isolation of zooplankters: with the help of brush and brush hairs mounted on a stick. This process is important while dissection of a zooplankter
Following standard keys: Davis (1955), Edmondson (1959), Kasturirangan (1963), Tonapi (1980), Adoni (1985), Battish (1992), Shiel (1995), Yamani et al. (2011), MRC Tech. Paper No. 45 (2015) by employing trinocular microscope in 40x and 60x

Schematic diagram:



4. Collection, identification of finfish/shellfish along selected stations and analysis of biological attributes (diversity, abundance, habitat preference)

Data to be collected:

a) Data on finfish and shellfish diversity, abundance and seasonality
b) Data on existing fishing crafts and gears (recording the types, specifications and numbers of gear and crafts operated for fishing) at different sampling stations
c) Collection of catch and effort data from the selected sampling stations

Collection of finfish/shellfish sample

Assessment of fish and shellfish diversity and composition has to be carried out through seasonal sampling at selected sampling stations in all selected four rivers. Fishing activities along the sampling sites employ a wide variety of gears with several local variations. For fish diversity studies, samples from the catches of all the fishing gears (both selective and non-selective) find operational during sampling survey (seine nets, gill nets, bag nets, lift nets, cast nets, hook and line, traps, set barriers, etc.) is to be collected (directly from the fishers' catch, unsorted) and analysed separately. Catch of non-selective gears are given more importance as it catches almost all the fishes present in the water column. Experimental fishing with non-selective gears has also been performed in case of less fishing activities in the area. The fishes caught are categorized species wise, counted, weighed and majority of the finfish/shellfish species were identified on the field itself. Length and weight of all the finfishes and carapace length and width along with weight of the shellfishes (crab/prawn) is to be recorded. Unidentified fish samples is to be preserved in 10% formalin (APHA, 2010) and taken to the laboratory for further analysis.

Identification

Identification of fishes up to species level with the help of standard taxonomic literature (Talwar and Kacker, 1984; Talwar and Jhingran, 1991; Talwar, 1991; Talwar *et al*., 1992; Jayaram, 1999; Chatterjee *et al*., 2000; Kamala Devi and Rao, 2007; Raje *et al*., 2007 and Vishwanath *et al*., 2007). For identification of crab up to species level, identification keys of Nandi & Pramanik, 1993, Keenan *et al*. (1998), Ng, 1998 and Marine Species Identification Portal (http://species-identification.org) are to be followed and for prawn standard literature of Jayachandran, 2001 is to be used. The fish species were listed according to the classification scheme by Nelson (2006). The scientific name of each fish species were ascertained as per updated and revised scheme provided in the Eschemeyer Catalog of Fishes.

Data analysis for fish diversity

For comparison of fish community structure between different sampling stations, c-dominance plot (PRIMER v6 PERMANOVA software package) where cumulative relative abundance/dominance of fish species (Y-axis) from a sampling zone is plotted against the increasing species rank on X-axis. The c-dominance curves for all stretches were compared to determine whether the fish community structure exhibit any signs of ecological stress. The abundance data of the fish samples were also subjected to cluster analysis (PRIMER v6 package of the Plymouth Marine Laboratory, U. K) to study the similarities in fish assemblage pattern among various sites.

Comparisons of the present data on fish catch structure with historic data (previously reported fish catch data) at those sampling locations were performed to understand time scale changes.

5. Collection, preservation and identification procedure of Zoo-Macrobenthos in Indian rivers

Data to be collected:

a) Collection of macro-benthos samples along selected stations for diversity, abundance, habitat preference

Purpose - This standard operating procedures includes sampling design, timing, methods, sample collection, preservation, identification and analysis. This is as per internationally recognized methodology for wadeable and non-wadeable areas. Since, the most of the Indian rivers are non-wadeable in head waters and wadeable in coastal and plain areas, it is prepared considering both the conditions with internationally recognized standards.

Definitions

a. Zoo-Macrobenthos - are of animal origin, living on or inside the bottom surface and visible to the unaided eye and retained on a U.S. standard No. 30 (0.6 mm). (APHA, 2012). Zoo-Macrobenthos of freshwater includes flat-worms, annelids, mollusks, crustaceans, and insects.

b. Pool – An area of a stream characterized by deep (usually > 0.5 m), slow velocity and a variety of substrate types. Because of slower velocities, sediment deposition can occur over pool substrate. Pools may have a higher diversity of permanent microhabitat types.

c. Riffle – An area of a stream with an observable decrease in gradient characterized by shallow (<0.5 m), fast velocity and stable, layered rock substrate. The surfaces of some substrate could be exposed above the waterline.

d. Run – An area of a stream characterized by deep (usually > 0.5 m), fast velocity and a variety of substrate types. Runs are commonly found below riffles. In low-gradient streams, runs (also called glides) are the dominant habitat where velocity is faster than the surrounding habitats.

Types of water bodies

Non-wadable water bodies should use a Ponar or Ekman dredge to collect sediment-dwelling benthic macro invertebrates. Multiple sediment grab samples will be composited and placed in an elutriator bucket or 500um mesh sieve bucket. Add water to the sample and hand-mix gently to break up lumps of sediment. Pour the sample slurry from the tub through the elutriator or sieve bucket which is placed over a second tub to catch the rinse water. Wash the sediment through the mesh with water at very low pressure. Excessive pressure will result in damage to organisms, in particular oligochaetes, and could compromise taxonomic analysis of the sample. Gently agitate the sieve bucket to aid in rinsing the fine sediment out of the sample. It may be necessary to sieve the slurry in small portions to prevent clogging of the mesh. Continue to rinse the composite with surface water until all sediments have been removed, leaving behind any sediment-dwelling invertebrates.

Wadable water bodies (eg: streams, rivers) can be sampled using a kick-net or dip net. Begin sampling at the downstream end of the reach and proceed upstream. A kick is a stationary sampling accomplished by positioning the net and disturbing the substrate for a distance of 0.5m upstream of the net.

Habitat Types

a. **Cobble (hard substrate) -** In many high-gradient streams, this habitat type will be dominant. Sample shallow areas with coarse (mixed gravel, cobble or larger) substrates by holding the bottom of the dip net against the substrate and dislodging organisms by kicking the substrate for 0.5 m upstream of the net.
b. **Snags -** Snags and other woody debris that have been submerged for a relatively long period (not recent deadfall) provide excellent colonization habitat. Sample submerged woody debris by jabbing in medium-sized snag material (sticks and branches). The snag habitat may be kicked first to help dislodge organisms, but only after placing the net downstream of the snag.
c. Accumulated woody material in pool areas are considered snag habitat. Large logs should be avoided because they are generally difficult to sample adequately.
d. **Vegetated banks -** When lower banks are submerged and have roots and emergent plants associated with them, they are sampled in a fashion similar to snags. Submerged areas of undercut banks are good habitats to sample. Sample banks with protruding roots and plants by jabbing into the habitat. Bank habitat can be kicked first to help dislodge organisms, but only after placing the net downstream.
e. **Submerged macrophytes** - Submerged macrophytes are seasonal in their occurrence and may not be a common feature of many streams, particularly those that are high-gradient. Sample aquatic plants that are rooted on the bottom of the stream in deep water by drawing the net through the vegetation from the bottom to the surface of the water (maximum of 0.5m each jab). In shallow water, sample by bumping or jabbing the net along the bottom in the rooted area, avoiding sediments where possible.
f. **Sand (and other fine sediment)** - Usually the least productive macro-invertebrate habitat in streams, this habitat may be the most prevalent in some streams. Sample banks of unvegetated or soft soil by bumping the net along the surface of the substrate rather than dragging the net through soft substrates; this reduces the amount of debris in the sample

Sampling devices -

a. Grab samplers - (Peterson grab - for sampling in hard bottoms, Ponar grabs - for medium to deep rivers, lakes, reservoirs, and estuaries, Vanveen grab - for sampling in open marine waters and in large lakes, Smith-McIntyre grab - to use in rough water, Ekman grab - for sampling in mud, silt, muck, and sludge in water with little current).

b. Riffle/run samplers - (Surber-type samplers - for sampling in shallow, flowing water (no more than 30 cm deep).

c. Core or cylindrical samplers - (box corer - to sample soft substrate in large rivers, lakes, and estuaries)

d. Drift samplers - to capture macro-invertebrates that have migrated or been disloged from the bottom substrates into the current.

Sample Processing

a. Sample pour in sieve bucket.

b. Washed screened materials preserved in 10% formalin or 70% alcohol.

c. Sample labels must be properly completed, including the sample identification code, date, stream name, sampling location, and collector's name and placed into the sample container. The outside of the container should be labelled with the same information. Chain-of-custody forms must include the same information as the sample container labels.

Sorting and Identification

a. Place sample directly in shallow white tray.

b. To facilitate sorting organisms from detritus, stined with rose Bengal (200 mg/L).

c. Identify organisms using stereo zoom and inverted microscope (whichever is need)

Data Analysis

Data recording in MS excel, analysis in PAST/ primer for biodiversity indices (Shannon's diversity index, Simpson's Diversity Index, species richness and evenness)

Equipment

Field supplies

1. Kick nets with 1000-micron mesh and weighted leading edge
2. Triangle frame sweep nets with 800-900 micron Nitex™ mesh
3. Sand sampler – rectangular frame net with 300 micron Nitex™ mesh
4. Fine-mesh sampler - 300 micron Nitex™ mesh placed between four inch PVC pipe fittings, and tall round plastic container into which the PVC device will fit
5. Sieve buckets with 600-micron mesh (US Standard No. 30)
6. Petite Ponar (only for boat sampling)
7. Wash tubs and picking trays
8. Forceps
9. 6-dram glass vials with polyseal screw caps
10. Plastic containers with tightly sealing lids large enough to hold several 6-dram vials (2/crewmember)
11. Ethyl alcohol for sample preservation
12. Labels and collection cards, pencils
13. Digital camera
14. GPS unit
15. Water quality meter (YSI Professional Plus)

Laboratory Supplies

1. Dissecting microscopes
2. Squeeze bottles

3. Compound microscopes
4. Dissecting needles
5. Microscope slides
6. Slide labels and holders
7. Forceps
8. Benthic macro-invertebrate lab sheets
9. Petri dishes
10. Cover slips
11. Glass vials
12. Polyvinyl lactophenol (CMC Mounting Media) or Hoyer's Solution

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Annexure-II

Format-1

Information regarding utilization of Fly Ash for (April 2022– March 2023)Name of the TPP : NTPC GADARWARA

Total generation capacity (MW) :

S.No.	Coal consumption during the year (MT)	Fly Ash* Generation during 2022-23		Fly ash utilization during 2022-2023		Total Fly Ash (including legacy fly ash) left unutilized as on 31/03/2023 (in MT)
		In MT	% of Ash generation of coal consumption during the year	In MT	% of Ash utilized during the year	
1.	**5851808**	**1834836**	**31.34%**	**1485907**	**80.98%**	**667000**
2.						
3.						

Note : * The term Fly Ash includes Fly Ash, Bottom Ash, Pond Ash etc.MT : Metric Tone
MW : Mega Watt

Manishjoshi
13.4.23
(Manish Joshi)
Sr Mgr (AUD)
NTPC Gadarwara

Format-2

Format for fly ash utilization in year 2022-23

Name of Thermal Power Plant	Capacity of Thermal Power Plant with No. of units	Coal consumption per day (MT)	Fly ash generation per day (MT)	Fly ash generated during year 2022-23 (MT)	Legacy fly ash/ Fly ash stored in dyke/pond (MT)	Details of work in which fly ash utilized along with quantity(MT)					Percentage utilization (%)
1	2	3	4	5	6	7					8
						Roads & Other construction work	Bricks	Low lying area	Cement industry	Others	
1.	**2X800 MW**	**16033**	**5027**	**1834836**	**667000**	**1335930**	**5010**	**4000**	**55972**	**Mines Filling - 27060**	**80.98%**
										Bottom Ash Dyke Lining - 58000	
Total	**2X800 MW**	**16033**	**5027**	**1834836**	**667000**	**1335930**	**5010**	**4000**	**55972**	**85060**	**80.98**

- **Legacy Fly Ash is taken as 0 as on 31.12.2021, as per Notification of the Ministry of Environment, Forest, and Climate Change dated 30.12.2022.**

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TEST REPORT

REPORT-SW-01502

Report No.:	ME-NG01502-230204- SA-NTPC-GADARWARA	Date: 04.02.2023
ULR No.:	TC748723000001376F	

Name and Address of Customer	**NTPC LIMITED GADARWARA STPP Tehsil- Gadarwara, Village- Dongargaon, P.O. Gangai, Dist.- Narsinghpur, Madhya Pradesh – 487770, India.**		PO No.: 4000266445-057-1019 (Version:0) PO Date: 30.10.2021
Sample Description / Type	Surface water	Sample Collected by	Laboratory
Sampling Location	DM Plant Raw water	Sample Quantity / Packing	5L X 2 No. PVC Can 500mL X 1 No. PVC Can 100mL X 1 No. PVC Can 1L X 1 No. Glass Bottle
Date of Sampling	24.01.2023	Date of Receipt of Sample	25.01.2023
Sampling Procedure	IS:3025(Part I):1987, RA 2019; APHA 23rd Ed. 2017, 1060-B, 1-40		
Date of Start of Analysis	25.01.2023	Date of Completion of Analysis	03.02.2023

Sr. No.	Parameter	Unit	Result	Method Reference
	Discipline: Chemical Testing; Product Group: Water (Surface Water)			
1.	Temperature	°C	21.9	APHA 23rd Ed. 2017, 2550-B, 2-74
2.	Colour	Hazen	BQL (LOQ:1)	APHA 23rd Ed. 2017, 2120-B, 2-6
3.	Odour	-	Agreeable	IS 3025 (Part 5):1984, Reaffirmed 2018
4.	pH	-	7.7	APHA 23rd Ed. 2017, 4500-H+-B, 4-95
5.	Electrical Conductivity	µS/cm	792	APHA 23rd Ed. 2017, 2510- B, 2-58
6.	Total Dissolved Solids	mg/L	454	IS 3025 (Part 16):1984 Reaffirmed 2017, Ed.2.1(1999-12)
7.	Total Suspended Solids	mg/L	5	APHA 23rd Ed. 2017, 2540-D, 2-70
8.	Chloride (as Cl)	mg/L	32.0	APHA 23rd Ed. 2017, 4500-Cl-B, 4-75
9.	Sulphate (as SO_4)	mg/L	18.6	APHA 23rd Ed. 2017, 4500- SO_4-E,4-199
10.	Biochemical Oxygen Demand (3 days 27°C)	mg/L	3.4	IS 3025 (Part 44): 2019, Reaffirmed 2019
11.	Chemical Oxygen Demand	mg/L	12	APHA 23rd Ed. 2017, 5220-B, 5-18
12.	Oil and Grease	mg/L	BQL (LOQ:1)	IS 3025 (Part 39): 1991, Reaffirmed 2021
13.	Fluoride (as F)	mg/L	0.53	APHA 23rd Ed. 2017, 4500-F- D, 4-90
14.	Dissolved Oxygen	mg/L	5.9	APHA 23rd Ed. 2017, 4500-O, B, 4-144 & C, 4-146
15.	Phosphate Dissolved (as PO_4)	mg/L	0.243	APHA 23rd Ed. 2017, 4500-P B, 4-160, E, 4-164

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TC-7487

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REPORT-SW-01502

TEST REPORT

Report No.:	ME-NG01502-230204- SA-NTPC-GADARWARA	Date: 04.02.2023
ULR No.:	TC748723000001376F	

Sr. No.	Parameter	Unit	Result	Method Reference
16.	Sodium Absorption Ratio	-	0.550	IS 11624:1986
17.	Phenolic Compounds (as C_6H_5OH)	mg/L	BQL (LOQ:0.001)	APHA 23rd Ed. 2017, 5530- B & C, 5-49, 5-50
	Residues in water (Trace metal Element)			
18.	Chromium Total (as Cr)	mg/L	BQL (LOQ:0.01)	IS 3025 (Part 2): 2019
19.	Chromium Hexa (as Cr^{6+})	mg/L	BQL(LOQ:0.02)	APHA 23rd Ed. 2017, 3500- Cr-B, 3-71
20.	Total Copper (as Cu)	mg/L	BQL (LOQ:0.01)	IS 3025 (Part 2): 2019
21.	Total Iron (as Fe)	mg/L	0.082	IS 3025 (Part 2): 2019
22.	Zinc (as Zn)	mg/L	0.051	IS 3025 (Part 2): 2019
23.	Cadmium (as Cd)	mg/L	BQL (LOQ:0.0027)	IS 3025 (Part 2): 2019
24.	Lead (as Pb)	mg/L	BQL (LOQ:0.008)	IS 3025 (Part 2): 2019
25.	Arsenic (as As)	mg/L	0.009	IS 3025 (Part 2): 2019
26.	Mercury (as Hg)	mg/L	BQL (LOQ:0.0005)	APHA 23rd Ed. 2017, 3112-B, 3-25

END OF REPORT

Note:
1. BQL: Below Quantification Limit.
2. LOQ: Limit of Quantification.
3. The result listed refers only to the tested sample(s) and applicable parameter(s).
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TEST REPORT

Report No.:	ME-NG01502N-230204- SA-NTPC-GADARWARA	Date: 04.02.2023
ULR No.:	-	

Name and Address of Customer	**NTPC LIMITED GADARWARA STPP Tehsil- Gadarwara, Village- Dongargaon, P.O. Gangai, Dist.- Narsinghpur, Madhya Pradesh – 487770, India.**		PO No.: 4000266445-057-1019 (Version:0) PO Date: 30.10.2021
Sample Description / Type	Surface water	Sample Collected by	Laboratory
Sampling Location	DM Plant Raw water	Sample Quantity / Packing	5L X 2 No. PVC Can
Date of Sampling	24.01.2023	Date of Receipt of Sample	25.01.2023
Sampling Procedure	IS:3025(Part I):1987, RA 2019; APHA 23rd Ed. 2017, 1060-B, 1-40		
Date of Start of Analysis	25.01.2023	Date of Completion of Analysis	03.02.2023

Sr. No.	Parameter	Unit	Result	Method Reference
	Discipline: Chemical Testing; Product Group: Water (Surface Water)			
1.	Residual Na_2CO_3	meq/L	(-)0.398	By calculations
2.	Bioassay test	-	Free from acute lethal toxicity	IS 6582:1971, Reaffirmed 2003

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TEST REPORT

Report No.:	ME-NG01656-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	TC748723000001530F	

Name and Address of Customer	**NTPC LIMITED GADARWARA STPP Tehsil- Gadarwara, Village- Dongargaon, P.O. Gangai, Dist.- Narsinghpur, Madhya Pradesh – 487770, India.**		PO No.: 4000266445-057-1019 (Version:0) PO Date: 30.10.2021
Sample Description / Type	Surface water	Sample Collected by	Laboratory
Sampling Location	Shakkar River	Sample Quantity / Packing	5L X 1 No. PVC Can 100mL X 1 No. PVC Can
Date of Sampling	27.01.2023	Date of Receipt of Sample	28.01.2023
Sampling Procedure	IS:3025(Part I):1987 RA 2019; APHA 23rd Ed. 2017, 1060-B, 1-40;		
Date of Start of Analysis	28.01.2023	Date of Completion of Analysis	05.02.2023

Sr. No.	Parameter	Unit	Result	Method Reference
	Discipline: Chemical Testing; Product Group: Water (Surface Water)			
1.	Colour	Hazen	BQL (LOQ:1)	APHA 23rd Ed. 2017, 2120-B, 2-6
2.	Odour	-	Agreeable	IS 3025 (Part 5):1984, Reaffirmed 2018
3.	Temperature	°C	21.7	APHA 23rd Ed. 2017, 2550-B, 2-74
4.	Turbidity	NTU	0.6	APHA 23rd Ed. 2017, 2130-B, 2-13
5.	pH	-	7.6	APHA 23rd Ed. 2017, 4500-H+-B, 4-95
6.	Electrical Conductivity	µS/cm	612	APHA 23rd Ed. 2017, 2510- B, 2-58
7.	Total Dissolved Solids	mg/L	356	IS 3025 (Part 16):1984 RA 2017, Ed.2.1(1999-12)
8.	Nitrate (as NO_3-N)	mg/L	0.53	APHA 23rd Ed. 2017, 4500-NO_3, B 4-127
9.	Ammonical Nitrogen (as NH_3-N)	mg/L	BQL (LOQ:0.1)	APHA 23rd Ed. 2017, 4500 NH3- F, 4-119
10.	Dissolved Oxygen	mg/L	6.0	APHA 23rd Ed. 2017, 4500-O, B, 4-144 & C, 4-146
11.	Biochemical Oxygen Demand (3 days 27°C)	mg/L	6.0	IS 3025 (Part 44): 2019, Reaffirmed 2019
12.	Chemical Oxygen Demand	mg/L	20	APHA 23rd Ed. 2017, 5220-B, 5-18
13.	Magnesium (as Mg)	mg/L	20.4	APHA 23rd Ed. 2017, 3500-Mg- B, 3-86
14.	Sodium (as Na)	mg/L	32.0	APHA 23rd Ed. 2017, 3500-Na-B, 3-99
15.	Phosphate Total (as P)	mg/L	0.046	APHA 23rd Ed. 2017, 4500-P-E, 4-164
16.	Carbonate (as CO_3)	mg/L	BQL (LOQ:0.48)	IS 3025 (Part 51):2001, Reaffirmed 2006
17.	Calcium (as Ca)	mg/L	60.9	APHA 23rd Ed. 2017, 3500-Ca-B, 3-69

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TEST REPORT

REPORT-SW-01656

Report No.:	ME-NG01656-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	TC748723000001530F	

Sr. No.	Parameter	Unit	Result	Method Reference
18.	Potassium (as K)	mg/L	0.84	APHA 23rd Ed. 2017, 3500-K- B, 3-89

END OF REPORT

Note:
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2. LOQ: Limit of Quantification.
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TEST REPORT

Report No.:	ME-NG01657-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	TC748723000001531F	

Name and Address of Customer	**NTPC LIMITED GADARWARA STPP Tehsil- Gadarwara, Village- Dongargaon, P.O. Gangai, Dist.- Narsinghpur, Madhya Pradesh – 487770, India.**		PO No.: 4000266445-057-1019 (Version:0) PO Date: 30.10.2021
Sample Description / Type	Surface water	Sample Collected by	Laboratory
Sampling Location	Sita Rewa River	Sample Quantity / Packing	5L X 1 No. PVC Can 100mL X 1 No. PVC Can
Date of Sampling	27.01.2023	Date of Receipt of Sample	28.01.2023
Sampling Procedure	IS:3025(Part I):1987 RA 2019; APHA 23rd Ed. 2017, 1060-B, 1-40;		
Date of Start of Analysis	28.01.2023	Date of Completion of Analysis	05.02.2023

Sr. No.	Parameter	Unit	Result	Method Reference
	Discipline: Chemical Testing; Product Group: Water (Surface Water)			
1.	Colour	Hazen	BQL (LOQ:1)	APHA 23rd Ed. 2017, 2120-B, 2-6
2.	Odour	-	Agreeable	IS 3025 (Part 5):1984, Reaffirmed 2018
3.	Temperature	°C	20.4	APHA 23rd Ed. 2017, 2550-B, 2-74
4.	Turbidity	NTU	0.5	APHA 23rd Ed. 2017, 2130-B, 2-13
5.	pH	-	7.5	APHA 23rd Ed. 2017, 4500-H+-B, 4-95
6.	Electrical Conductivity	µS/cm	495	APHA 23rd Ed. 2017, 2510- B, 2-58
7.	Total Dissolved Solids	mg/L	285	IS 3025 (Part 16):1984 RA 2017, Ed.2.1(1999-12)
8.	Nitrate (as NO_3-N)	mg/L	0.48	APHA 23rd Ed. 2017, 4500-NO_3, B 4-127
9.	Ammonical Nitrogen (as NH_3-N)	mg/L	BQL (LOQ:0.1)	APHA 23rd Ed. 2017, 4500 NH3- F, 4-119
10.	Dissolved Oxygen	mg/L	5.9	APHA 23rd Ed. 2017, 4500-O, B, 4-144 & C, 4-146
11.	Biochemical Oxygen Demand (3 days 27°C)	mg/L	4.7	IS 3025 (Part 44): 2019, Reaffirmed 2019
12.	Chemical Oxygen Demand	mg/L	16	APHA 23rd Ed. 2017, 5220-B, 5-18
13.	Magnesium (as Mg)	mg/L	15.1	APHA 23rd Ed. 2017, 3500-Mg- B, 3-86
14.	Sodium (as Na)	mg/L	20.2	APHA 23rd Ed. 2017, 3500-Na-B, 3-99
15.	Phosphate Total (as P)	mg/L	0.065	APHA 23rd Ed. 2017, 4500-P-E, 4-164
16.	Carbonate (as CO_3)	mg/L	BQL (LOQ:0.48)	IS 3025 (Part 51):2001, Reaffirmed 2006
17.	Calcium (as Ca)	mg/L	57.7	APHA 23rd Ed. 2017, 3500-Ca-B, 3-69

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TEST REPORT

Report No.:	ME-NG01657-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	TC748723000001531F	

Sr. No.	Parameter	Unit	Result	Method Reference
18.	Potassium (as K)	mg/L	0.42	APHA 23rd Ed. 2017, 3500-K- B, 3-89

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Note:
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REPORT-GW-01651

TEST REPORT

Report No.:	ME-NG01651-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	TC748723000001525F	

Name and Address of Customer	**NTPC LIMITED GADARWARA STPP Tehsil- Gadarwara, Village- Dongargaon, P.O. Gangai, Dist.- Narsinghpur, Madhya Pradesh – 487770, India.**		PO No.: 4000266445-057-1019 (Version:0) PO Date: 30.10.2021
Sample Description / Type	Ground water	Sample Collected by	Laboratory
Sampling Location	Meharkheda Village (Hand Pump)	Sample Quantity / Packing	5L X 2 No. PVC Can 500mL X 1 No. PVC Can 100mL X 1 No. PVC Can 500mLX1No.Sterile Glass Bottle
Date of Sampling	27.01.2023	Date of Receipt of Sample	28.01.2023
Sampling Procedure	IS:3025(Part I):1987 RA 2019; IS 1622:1981 RA 2019, APHA 23rd Ed. 2017, 1060-B, 1-40; 9060 A, 9-36		
Date of Start of Analysis	28.01.2023	Date of Completion of Analysis	05.02.2023

Sr. No.	Parameter	Unit	Result	Method Reference
	Discipline: Chemical Testing; Product Group: Water (Ground Water)			
1.	Colour	Hazen	BQL (LOQ:1)	APHA 23rd Ed. 2017, 2120-B, 2-6
2.	Odour	-	Agreeable	IS 3025 (Part 5):1984, Reaffirmed 2018
3.	Temperature	°C	21.2	APHA 23rd Ed. 2017, 2550-B, 2-74
4.	pH	-	7.2	APHA 23rd Ed. 2017, 4500-H+-B, 4-95
5.	Electrical Conductivity	µS/cm	801	APHA 23rd Ed. 2017, 2510- B, 2-58
6.	Total Dissolved Solids	mg/L	471	IS 3025 (Part 16):1984 Reaffirmed 2017, Ed.2.1(1999-12)
7.	Nitrate (as NO_3)	mg/L	34.6	APHA 23rd Ed. 2017, 4500-NO_3, B 4-127
8.	Nitrite (as N)	mg/L	BQL (LOQ:0.015)	APHA 23rd Ed. 2017, 4500-NO_2-B, 4-124
9.	Phosphate Ortho (as PO_4)	mg/L	0.089	APHA 23rd Ed. 2017, 4500-P-E, 4-164
10.	Chemical Oxygen Demand	mg/L	10	APHA 23rd Ed. 2017, 5220-B, 5-18
11.	Sodium (as Na)	mg/L	40.4	APHA 23rd Ed. 2017, 3500-Na-B, 3-99
12.	Potassium (as K)	mg/L	0.94	APHA 23rd Ed. 2017, 3500-K- B, 3-89
13.	Calcium (as Ca)	mg/L	98.6	APHA 23rd Ed. 2017, 3500-Ca-B, 3-69
14.	Magnesium (as Mg)	mg/L	18.0	APHA 23rd Ed. 2017, 3500-Mg- B, 3-86
15.	Carbonate (as CO_3)	mg/L	BQL (LOQ:0.48)	IS 3025 (Part 51):2001, Reaffirmed 2006

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Shital Lakhorkar
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TC-7487

Mahabal Enviro Engineers Pvt. Ltd.

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Phone: **0712-2612162/2612212** email: **nagpur@mahabal.com**

REPORT-GW-01651

TEST REPORT

Report No.:	ME-NG01651-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	TC748723000001525F	

Sr. No.	Parameter	Unit	Result	Method Reference
16.	Bicarbonate (as HCO_3)	mg/L	342	IS 3025 (Part 51):2001, Reaffirmed 2006, Ed.2.2 (2009)
17.	Chloride (as Cl)	mg/L	32.0	APHA 23rd Ed. 2017, 4500-Cl-B, 4-75
18.	Sulphate (as SO_4)	mg/L	48.0	APHA 23rd Ed. 2017, 4500- SO_4-E,4-199
19.	Sodium Absorption Ratio	-	0.982	IS 11624:1986
20.	Fluoride (as F)	mg/L	0.52	APHA 23rd Ed. 2017, 4500-F- D, 4-90
21.	Boron (as B)	mg/L	BQL (LOQ:0.1)	APHA 23rd Ed. 2017, 4500-B B, 4-27
	Residues in water (Trace metal Element)			
22.	Iron (as Fe)	mg/L	0.061	IS 3025 (Part 2): 2019
23.	Cadmium (as Cd)	mg/L	BQL (LOQ:0.0027)	IS 3025 (Part 2): 2019
24.	Arsenic (as As)	mg/L	BQL (LOQ:0.007)	IS 3025 (Part 2): 2019
25.	Chromium Total (as Cr)	mg/L	BQL (LOQ:0.01)	IS 3025 (Part 2): 2019
26.	Lead (as Pb)	mg/L	BQL (LOQ:0.008)	IS 3025 (Part 2): 2019
27.	Zinc (as Zn)	mg/L	BQL (LOQ:0.02)	IS 3025 (Part 2): 2019
28.	Mercury (as Hg)	mg/L	BQL (LOQ:0.0005)	APHA 23rd Ed. 2017, 3112-B, 3-25
29.	Nickel (as Ni)	mg/L	BQL (LOQ:0.01)	IS 3025 (Part 2): 2019
	Discipline: Biological Testing; Product Group: Water (Ground water)			
30.	Total Coliforms	MPN/ 100 mL	1.1	APHA 23rd Ed. 2017, 9221–B, 9-69
31.	*Escherichia coli*	MPN/ 100 mL	<1.1	APHA 23rd Ed. 2017, 9221–B, E & G, 9-69, 9-77 & 9-80
32.	*Detection of Salmonella Spp.*	/100mL	Absent	IS 15187:2016

END OF REPORT

Note:
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Harish Mendhi
Technical Manager
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Shital Lakhorkar
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TC-7487

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TEST REPORT

Report No.:	ME-NG01651N-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	-	

Name and Address of Customer	**NTPC LIMITED GADARWARA STPP Tehsil- Gadarwara, Village- Dongargaon, P.O. Gangai, Dist.- Narsinghpur, Madhya Pradesh – 487770, India.**		PO No.: 4000266445-057-1019 (Version:0) PO Date: 30.10.2021
Sample Description / Type	Ground water	Sample Collected by	Laboratory
Sampling Location	Meharkheda Village (Hand Pump)	Sample Quantity / Packing	5L X 2 No. PVC Can
Date of Sampling	27.01.2023	Date of Receipt of Sample	28.01.2023
Sampling Procedure	IS:3025(Part I):1987 RA 2019; APHA 23rd Ed. 2017, 1060-B, 1-40;		
Date of Start of Analysis	28.01.2023	Date of Completion of Analysis	05.02.2023

Sr. No.	Parameter	Unit	Result	Method Reference
	Discipline: Chemical Testing; Product Group: Water (Ground Water)			
1.	Sodium Percent (Exchangeable)	%	21.5	By calculation

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TEST REPORT

REPORT-GW-01652

Report No.:	ME-NG01652-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	TC748723000001526F	

Name and Address of Customer	**NTPC LIMITED GADARWARA STPP Tehsil- Gadarwara, Village- Dongargaon, P.O. Gangai, Dist.- Narsinghpur, Madhya Pradesh – 487770, India.**		PO No.: 4000266445-057-1019 (Version:0) PO Date: 30.10.2021
Sample Description / Type	Ground water	Sample Collected by	Laboratory
Sampling Location	Chorbarhetha Village (Hand Pump)	Sample Quantity / Packing	5L X 2 No. PVC Can 500mL X 1 No. PVC Can 100mL X 1 No. PVC Can 500mLX1No.Sterile Glass Bottle
Date of Sampling	27.01.2023	Date of Receipt of Sample	28.01.2023
Sampling Procedure	IS:3025(Part I):1987 RA 2019; IS 1622:1981 RA 2019, APHA 23rd Ed. 2017, 1060-B, 1-40; 9060 A, 9-36		
Date of Start of Analysis	28.01.2023	Date of Completion of Analysis	05.02.2023

Sr. No.	Parameter	Unit	Result	Method Reference
	Discipline: Chemical Testing; Product Group: Water (Ground Water)			
1.	Colour	Hazen	BQL (LOQ:1)	APHA 23rd Ed. 2017, 2120-B, 2-6
2.	Odour	-	Agreeable	IS 3025 (Part 5):1984, Reaffirmed 2018
3.	Temperature	°C	20.6	APHA 23rd Ed. 2017, 2550-B, 2-74
4.	pH	-	7.1	APHA 23rd Ed. 2017, 4500-H+-B, 4-95
5.	Electrical Conductivity	µS/cm	796	APHA 23rd Ed. 2017, 2510- B, 2-58
6.	Total Dissolved Solids	mg/L	466	IS 3025 (Part 16):1984 Reaffirmed 2017, Ed.2.1(1999-12)
7.	Nitrate (as NO_3)	mg/L	28.7	APHA 23rd Ed. 2017, 4500-NO_3, B 4-127
8.	Nitrite (as N)	mg/L	BQL (LOQ:0.015)	APHA 23rd Ed. 2017, 4500-NO_2-B, 4-124
9.	Phosphate Ortho (as PO_4)	mg/L	0.060	APHA 23rd Ed. 2017, 4500-P-E, 4-164
10.	Chemical Oxygen Demand	mg/L	8	APHA 23rd Ed. 2017, 5220-B, 5-18
11.	Sodium (as Na)	mg/L	48.0	APHA 23rd Ed. 2017, 3500-Na-B, 3-99
12.	Potassium (as K)	mg/L	1.1	APHA 23rd Ed. 2017, 3500-K- B, 3-89
13.	Calcium (as Ca)	mg/L	87.4	APHA 23rd Ed. 2017, 3500-Ca-B, 3-69
14.	Magnesium (as Mg)	mg/L	19.0	APHA 23rd Ed. 2017, 3500-Mg- B, 3-86
15.	Carbonate (as CO_3)	mg/L	BQL (LOQ:0.48)	IS 3025 (Part 51):2001, Reaffirmed 2006

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Mahabal Enviro Engineers Pvt. Ltd.

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TEST REPORT

REPORT-GW-01652

Report No.:	ME-NG01652-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	TC748723000001526F	

Sr. No.	Parameter	Unit	Result	Method Reference
16.	Bicarbonate (as HCO_3)	mg/L	325	IS 3025 (Part 51):2001, Reaffirmed 2006, Ed.2.2 (2009)
17.	Chloride (as Cl)	mg/L	33.0	APHA 23rd Ed. 2017, 4500-Cl-B, 4-75
18.	Sulphate (as SO_4)	mg/L	55.0	APHA 23rd Ed. 2017, 4500- SO_4-E,4-199
19.	Sodium Absorption Ratio	-	1.21	IS 11624:1986
20.	Fluoride (as F)	mg/L	0.53	APHA 23rd Ed. 2017, 4500-F- D, 4-90
21.	Boron (as B)	mg/L	BQL (LOQ:0.1)	APHA 23rd Ed. 2017, 4500-B B, 4-27
	Residues in water (Trace metal Element)			
22.	Iron (as Fe)	mg/L	0.180	IS 3025 (Part 2): 2019
23.	Cadmium (as Cd)	mg/L	BQL (LOQ:0.0027)	IS 3025 (Part 2): 2019
24.	Arsenic (as As)	mg/L	BQL (LOQ:0.007)	IS 3025 (Part 2): 2019
25.	Chromium Total (as Cr)	mg/L	BQL (LOQ:0.01)	IS 3025 (Part 2): 2019
26.	Lead (as Pb)	mg/L	BQL (LOQ:0.008)	IS 3025 (Part 2): 2019
27.	Zinc (as Zn)	mg/L	BQL (LOQ:0.02)	IS 3025 (Part 2): 2019
28.	Mercury (as Hg)	mg/L	BQL (LOQ:0.0005)	APHA 23rd Ed. 2017, 3112-B, 3-25
29.	Nickel (as Ni)	mg/L	BQL (LOQ:0.01)	IS 3025 (Part 2): 2019
	Discipline: Biological Testing; Product Group: Water (Ground water)			
30.	Total Coliforms	MPN/ 100 mL	5.1	APHA 23rd Ed. 2017, 9221–B, 9-69
31.	*Escherichia coli*	MPN/ 100 mL	2.2	APHA 23rd Ed. 2017, 9221–B, E & G, 9-69, 9-77 & 9-80
32.	*Detection of Salmonella Spp.*	/100mL	Absent	IS 15187:2016

END OF REPORT

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MAHABAL ENVIRO ENGINEERS PVT. LTD.

TC-7487

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TEST REPORT

REPORT-GW-01652

Report No.:	ME-NG01652N-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	-	

Name and Address of Customer	**NTPC LIMITED GADARWARA STPP Tehsil- Gadarwara, Village- Dongargaon, P.O. Gangai, Dist.- Narsinghpur, Madhya Pradesh – 487770, India.**		PO No.: 4000266445-057-1019 (Version:0) PO Date: 30.10.2021
Sample Description / Type	Ground water	Sample Collected by	Laboratory
Sampling Location	Chorbarhetha Village (Hand Pump)	Sample Quantity / Packing	5L X 2 No. PVC Can
Date of Sampling	27.01.2023	Date of Receipt of Sample	28.01.2023
Sampling Procedure	IS:3025(Part I):1987 RA 2019; APHA 23rd Ed. 2017, 1060-B, 1-40;		
Date of Start of Analysis	28.01.2023	Date of Completion of Analysis	05.02.2023

Sr. No.	Parameter	Unit	Result	Method Reference
	Discipline: Chemical Testing; Product Group: Water (Ground Water)			
1.	Sodium Percent (Exchangeable)	%	26.0	By calculation

END OF REPORT

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REPORT-GW-01653

TEST REPORT

Report No.:	ME-NG01653-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	TC748723000001527F	

Name and Address of Customer	**NTPC LIMITED GADARWARA STPP Tehsil- Gadarwara, Village- Dongargaon, P.O. Gangai, Dist.- Narsinghpur, Madhya Pradesh – 487770, India.**		PO No.: 4000266445-057-1019 (Version:0) PO Date: 30.10.2021
Sample Description / Type	Ground water	Sample Collected by	Laboratory
Sampling Location	Kudari Village (Hand Pump)	Sample Quantity / Packing	5L X 2 No. PVC Can 500mL X 1 No. PVC Can 100mL X 1 No. PVC Can 500mLX1No.Sterile Glass Bottle
Date of Sampling	27.01.2023	Date of Receipt of Sample	28.01.2023
Sampling Procedure	IS:3025(Part I):1987 RA 2019; IS 1622:1981 RA 2019, APHA 23rd Ed. 2017, 1060-B, 1-40; 9060 A, 9-36		
Date of Start of Analysis	28.01.2023	Date of Completion of Analysis	05.02.2023

Sr. No.	Parameter	Unit	Result	Method Reference
	Discipline: Chemical Testing; Product Group: Water (Ground Water)			
1.	Colour	Hazen	BQL (LOQ:1)	APHA 23rd Ed. 2017, 2120-B, 2-6
2.	Odour	-	Agreeable	IS 3025 (Part 5):1984, Reaffirmed 2018
3.	Temperature	°C	21.3	APHA 23rd Ed. 2017, 2550-B, 2-74
4.	pH	-	7.1	APHA 23rd Ed. 2017, 4500-H+-B, 4-95
5.	Electrical Conductivity	µS/cm	764	APHA 23rd Ed. 2017, 2510- B, 2-58
6.	Total Dissolved Solids	mg/L	444	IS 3025 (Part 16):1984 Reaffirmed 2017, Ed.2.1(1999-12)
7.	Nitrate (as NO_3)	mg/L	24.7	APHA 23rd Ed. 2017, 4500-NO_3, B 4-127
8.	Nitrite (as N)	mg/L	BQL (LOQ:0.015)	APHA 23rd Ed. 2017, 4500-NO_2-B, 4-124
9.	Phosphate Ortho (as PO_4)	mg/L	0.070	APHA 23rd Ed. 2017, 4500-P-E, 4-164
10.	Chemical Oxygen Demand	mg/L	12	APHA 23rd Ed. 2017, 5220-B, 5-18
11.	Sodium (as Na)	mg/L	42.0	APHA 23rd Ed. 2017, 3500-Na-B, 3-99
12.	Potassium (as K)	mg/L	0.8	APHA 23rd Ed. 2017, 3500-K- B, 3-89
13.	Calcium (as Ca)	mg/L	89.0	APHA 23rd Ed. 2017, 3500-Ca-B, 3-69
14.	Magnesium (as Mg)	mg/L	17.0	APHA 23rd Ed. 2017, 3500-Mg- B, 3-86
15.	Carbonate (as CO_3)	mg/L	BQL (LOQ:0.48)	IS 3025 (Part 51):2001, Reaffirmed 2006

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TC-7487

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TEST REPORT

Report No.:	ME-NG01653-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	TC748723000001527F	

Sr. No.	Parameter	Unit	Result	Method Reference
16.	Bicarbonate (as HCO_3)	mg/L	334	IS 3025 (Part 51):2001, Reaffirmed 2006, Ed.2.2 (2009)
17.	Chloride (as Cl)	mg/L	31.0	APHA 23rd Ed. 2017, 4500-Cl-B, 4-75
18.	Sulphate (as SO_4)	mg/L	44.0	APHA 23rd Ed. 2017, 4500- SO_4-E,4-199
19.	Sodium Absorption Ratio	-	1.07	IS 11624:1986
20.	Fluoride (as F)	mg/L	0.51	APHA 23rd Ed. 2017, 4500-F- D, 4-90
21.	Boron (as B)	mg/L	BQL (LOQ:0.1)	APHA 23rd Ed. 2017, 4500-B B, 4-27
	Residues in water (Trace metal Element)			
22.	Iron (as Fe)	mg/L	0.134	IS 3025 (Part 2): 2019
23.	Cadmium (as Cd)	mg/L	BQL (LOQ:0.0027)	IS 3025 (Part 2): 2019
24.	Arsenic (as As)	mg/L	BQL (LOQ:0.007)	IS 3025 (Part 2): 2019
25.	Chromium Total (as Cr)	mg/L	BQL (LOQ:0.01)	IS 3025 (Part 2): 2019
26.	Lead (as Pb)	mg/L	BQL (LOQ:0.008)	IS 3025 (Part 2): 2019
27.	Zinc (as Zn)	mg/L	BQL (LOQ:0.02)	IS 3025 (Part 2): 2019
28.	Mercury (as Hg)	mg/L	BQL (LOQ:0.0005)	APHA 23rd Ed. 2017, 3112-B, 3-25
29.	Nickel (as Ni)	mg/L	BQL (LOQ:0.01)	IS 3025 (Part 2): 2019
	Discipline: Biological Testing; Product Group: Water (Ground water)			
30.	Total Coliforms	MPN/ 100 mL	2.2	APHA 23rd Ed. 2017, 9221–B, 9-69
31.	*Escherichia coli*	MPN/ 100 mL	<1.1	APHA 23rd Ed. 2017, 9221–B, E & G, 9-69, 9-77 & 9-80
32.	*Detection of Salmonella Spp.*	/100mL	Absent	IS 15187:2016

END OF REPORT

Note:
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TC-7487

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REPORT-GW-01653

TEST REPORT

Report No.:	ME-NG01653N-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	-	

Name and Address of Customer	**NTPC LIMITED GADARWARA STPP Tehsil- Gadarwara, Village- Dongargaon, P.O. Gangai, Dist.- Narsinghpur, Madhya Pradesh – 487770, India.**		PO No.: 4000266445-057-1019 (Version:0) PO Date: 30.10.2021
Sample Description / Type	Ground water	Sample Collected by	Laboratory
Sampling Location	Kudari Village (Hand Pump)	Sample Quantity / Packing	5L X 2 No. PVC Can
Date of Sampling	27.01.2023	Date of Receipt of Sample	28.01.2023
Sampling Procedure	IS:3025(Part I):1987 RA 2019; APHA 23rd Ed. 2017, 1060-B, 1-40;		
Date of Start of Analysis	28.01.2023	Date of Completion of Analysis	05.02.2023

Sr. No.	Parameter	Unit	Result	Method Reference
	Discipline: Chemical Testing; Product Group: Water (Ground Water)			
1.	Sodium Percent (Exchangeable)	%	23.8	By calculation

END OF REPORT

Note:
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TEST REPORT

REPORT-GW-01654

Report No.:	ME-NG01654-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	TC748723000001528F	

Name and Address of Customer	**NTPC LIMITED GADARWARA STPP Tehsil- Gadarwara, Village- Dongargaon, P.O. Gangai, Dist.- Narsinghpur, Madhya Pradesh – 487770, India.**		PO No.: 4000266445-057-1019 (Version:0) PO Date: 30.10.2021
Sample Description / Type	Ground water	Sample Collected by	Laboratory
Sampling Location	Dongargaon Village (Borewell)	Sample Quantity / Packing	5L X 2 No. PVC Can 500mL X 1 No. PVC Can 100mL X 1 No. PVC Can 500mLX1No.Sterile Glass Bottle
Date of Sampling	27.01.2023	Date of Receipt of Sample	28.01.2023
Sampling Procedure	IS:3025(Part I):1987 RA 2019; IS 1622:1981 RA 2019, APHA 23rd Ed. 2017, 1060-B, 1-40; 9060 A, 9-36		
Date of Start of Analysis	28.01.2023	Date of Completion of Analysis	05.02.2023

Sr. No.	Parameter	Unit	Result	Method Reference
	Discipline: Chemical Testing; Product Group: Water (Ground Water)			
1.	Colour	Hazen	BQL (LOQ:1)	APHA 23rd Ed. 2017, 2120-B, 2-6
2.	Odour	-	Agreeable	IS 3025 (Part 5):1984, Reaffirmed 2018
3.	Temperature	°C	20.4	APHA 23rd Ed. 2017, 2550-B, 2-74
4.	pH	-	7.2	APHA 23rd Ed. 2017, 4500-H+-B, 4-95
5.	Electrical Conductivity	µS/cm	756	APHA 23rd Ed. 2017, 2510- B, 2-58
6.	Total Dissolved Solids	mg/L	440	IS 3025 (Part 16):1984 Reaffirmed 2017, Ed.2.1(1999-12)
7.	Nitrate (as NO_3)	mg/L	32.8	APHA 23rd Ed. 2017, 4500-NO_3, B 4-127
8.	Nitrite (as N)	mg/L	BQL (LOQ:0.015)	APHA 23rd Ed. 2017, 4500-NO_2-B, 4-124
9.	Phosphate Ortho (as PO_4)	mg/L	0.066	APHA 23rd Ed. 2017, 4500-P-E, 4-164
10.	Chemical Oxygen Demand	mg/L	10	APHA 23rd Ed. 2017, 5220-B, 5-18
11.	Sodium (as Na)	mg/L	22.0	APHA 23rd Ed. 2017, 3500-Na-B, 3-99
12.	Potassium (as K)	mg/L	0.6	APHA 23rd Ed. 2017, 3500-K- B, 3-89
13.	Calcium (as Ca)	mg/L	92.2	APHA 23rd Ed. 2017, 3500-Ca-B, 3-69
14.	Magnesium (as Mg)	mg/L	24.3	APHA 23rd Ed. 2017, 3500-Mg- B, 3-86
15.	Carbonate (as CO_3)	mg/L	BQL (LOQ:0.48)	IS 3025 (Part 51):2001, Reaffirmed 2006

Harish Mendhi
Technical Manager
Chemical Testing

Shital Lakhorkar
Group In-charge
Biological Testing

TC-7487

Mahabal Enviro Engineers Pvt. Ltd.

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TEST REPORT

REPORT-GW-01654

Report No.:	ME-NG01654-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	TC748723000001528F	

Sr. No.	Parameter	Unit	Result	Method Reference
16.	Bicarbonate (as HCO_3)	mg/L	315	IS 3025 (Part 51):2001, Reaffirmed 2006, Ed.2.2 (2009)
17.	Chloride (as Cl)	mg/L	31.0	APHA 23rd Ed. 2017, 4500-Cl-B, 4-75
18.	Sulphate (as SO_4)	mg/L	45.0	APHA 23rd Ed. 2017, 4500- SO_4-E,4-199
19.	Sodium Absorption Ratio	-	0.527	IS 11624:1986
20.	Fluoride (as F)	mg/L	0.52	APHA 23rd Ed. 2017, 4500-F- D, 4-90
21.	Boron (as B)	mg/L	BQL (LOQ:0.1)	APHA 23rd Ed. 2017, 4500-B B, 4-27
	Residues in water (Trace metal Element)			
22.	Iron (as Fe)	mg/L	0.092	IS 3025 (Part 2): 2019
23.	Cadmium (as Cd)	mg/L	BQL (LOQ:0.0027)	IS 3025 (Part 2): 2019
24.	Arsenic (as As)	mg/L	BQL (LOQ:0.007)	IS 3025 (Part 2): 2019
25.	Chromium Total (as Cr)	mg/L	BQL (LOQ:0.01)	IS 3025 (Part 2): 2019
26.	Lead (as Pb)	mg/L	BQL (LOQ:0.008)	IS 3025 (Part 2): 2019
27.	Zinc (as Zn)	mg/L	0.024	IS 3025 (Part 2): 2019
28.	Mercury (as Hg)	mg/L	BQL (LOQ:0.0005)	APHA 23rd Ed. 2017, 3112-B, 3-25
29.	Nickel (as Ni)	mg/L	BQL (LOQ:0.01)	IS 3025 (Part 2): 2019
	Discipline: Biological Testing; Product Group: Water (Ground water)			
30.	Total Coliforms	MPN/ 100 mL	3.6	APHA 23rd Ed. 2017, 9221–B, 9-69
31.	*Escherichia coli*	MPN/ 100 mL	<1.1	APHA 23rd Ed. 2017, 9221–B, E & G, 9-69, 9-77 & 9-80
32.	*Detection of Salmonella Spp.*	/100mL	Absent	IS 15187:2016

END OF REPORT

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2. LOQ: Limit of Quantification.
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REPORT-GW-01654

TEST REPORT

Report No.:	ME-NG01654N-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	-	

Name and Address of Customer	**NTPC LIMITED GADARWARA STPP Tehsil- Gadarwara, Village- Dongargaon, P.O. Gangai, Dist.- Narsinghpur, Madhya Pradesh – 487770, India.**		PO No.: 4000266445-057-1019 (Version:0) PO Date: 30.10.2021
Sample Description / Type	Ground water	Sample Collected by	Laboratory
Sampling Location	Dongargaon Village (Borewell)	Sample Quantity / Packing	5L X 2 No. PVC Can
Date of Sampling	27.01.2023	Date of Receipt of Sample	28.01.2023
Sampling Procedure	IS:3025(Part I):1987 RA 2019; APHA 23rd Ed. 2017, 1060-B, 1-40;		
Date of Start of Analysis	28.01.2023	Date of Completion of Analysis	05.02.2023

Sr. No.	Parameter	Unit	Result	Method Reference
	Discipline: Chemical Testing; Product Group: Water (Ground Water)			
1.	Sodium Percent (Exchangeable)	%	12.6	By calculation

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TEST REPORT

REPORT-GW-01655

Report No.:	ME-NG01655-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	TC748723000001529F	

Name and Address of Customer	**NTPC LIMITED GADARWARA STPP Tehsil- Gadarwara, Village- Dongargaon, P.O. Gangai, Dist.- Narsinghpur, Madhya Pradesh – 487770, India.**		PO No.: 4000266445-057-1019 (Version:0) PO Date: 30.10.2021
Sample Description / Type	Ground water	Sample Collected by	Laboratory
Sampling Location	Gangai Village (Borewell)	Sample Quantity / Packing	5L X 2 No. PVC Can 500mL X 1 No. PVC Can 100mL X 1 No. PVC Can 500mLX1No.Sterile Glass Bottle
Date of Sampling	27.01.2023	Date of Receipt of Sample	28.01.2023
Sampling Procedure	IS:3025(Part I):1987 RA 2019; IS 1622:1981 RA 2019, APHA 23rd Ed. 2017, 1060-B, 1-40; 9060 A, 9-36		
Date of Start of Analysis	28.01.2023	Date of Completion of Analysis	05.02.2023

Sr. No.	Parameter	Unit	Result	Method Reference
	Discipline: Chemical Testing; Product Group: Water (Ground Water)			
1.	Colour	Hazen	BQL (LOQ:1)	APHA 23rd Ed. 2017, 2120-B, 2-6
2.	Odour	-	Agreeable	IS 3025 (Part 5):1984, Reaffirmed 2018
3.	Temperature	°C	21.7	APHA 23rd Ed. 2017, 2550-B, 2-74
4.	pH	-	7.2	APHA 23rd Ed. 2017, 4500-H+-B, 4-95
5.	Electrical Conductivity	µS/cm	812	APHA 23rd Ed. 2017, 2510- B, 2-58
6.	Total Dissolved Solids	mg/L	473	IS 3025 (Part 16):1984 Reaffirmed 2017, Ed.2.1(1999-12)
7.	Nitrate (as NO_3)	mg/L	32.3	APHA 23rd Ed. 2017, 4500-NO_3, B 4-127
8.	Nitrite (as N)	mg/L	BQL (LOQ:0.015)	APHA 23rd Ed. 2017, 4500-NO_2-B, 4-124
9.	Phosphate Ortho (as PO_4)	mg/L	0.089	APHA 23rd Ed. 2017, 4500-P-E, 4-164
10.	Chemical Oxygen Demand	mg/L	8	APHA 23rd Ed. 2017, 5220-B, 5-18
11.	Sodium (as Na)	mg/L	30.0	APHA 23rd Ed. 2017, 3500-Na-B, 3-99
12.	Potassium (as K)	mg/L	1.2	APHA 23rd Ed. 2017, 3500-K- B, 3-89
13.	Calcium (as Ca)	mg/L	93.0	APHA 23rd Ed. 2017, 3500-Ca-B, 3-69
14.	Magnesium (as Mg)	mg/L	25.0	APHA 23rd Ed. 2017, 3500-Mg- B, 3-86
15.	Carbonate (as CO_3)	mg/L	BQL (LOQ:0.48)	IS 3025 (Part 51):2001, Reaffirmed 2006

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TC-7487

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TEST REPORT

REPORT-GW-01655

Report No.:	ME-NG01655-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	TC748723000001529F	

Sr. No.	Parameter	Unit	Result	Method Reference
16.	Bicarbonate (as HCO_3)	mg/L	332	IS 3025 (Part 51):2001, Reaffirmed 2006, Ed.2.2 (2009)
17.	Chloride (as Cl)	mg/L	32.0	APHA 23rd Ed. 2017, 4500-Cl-B, 4-75
18.	Sulphate (as SO_4)	mg/L	55.0	APHA 23rd Ed. 2017, 4500- SO_4-E,4-199
19.	Sodium Absorption Ratio	-	0.712	IS 11624:1986
20.	Fluoride (as F)	mg/L	0.52	APHA 23rd Ed. 2017, 4500-F- D, 4-90
21.	Boron (as B)	mg/L	BQL (LOQ:0.1)	APHA 23rd Ed. 2017, 4500-B B, 4-27
	Residues in water (Trace metal Element)			
22.	Iron (as Fe)	mg/L	0.071	IS 3025 (Part 2): 2019
23.	Cadmium (as Cd)	mg/L	BQL (LOQ:0.0027)	IS 3025 (Part 2): 2019
24.	Arsenic (as As)	mg/L	BQL (LOQ:0.007)	IS 3025 (Part 2): 2019
25.	Chromium Total (as Cr)	mg/L	BQL (LOQ:0.01)	IS 3025 (Part 2): 2019
26.	Lead (as Pb)	mg/L	BQL (LOQ:0.008)	IS 3025 (Part 2): 2019
27.	Zinc (as Zn)	mg/L	BQL (LOQ:0.02)	IS 3025 (Part 2): 2019
28.	Mercury (as Hg)	mg/L	BQL (LOQ:0.0005)	APHA 23rd Ed. 2017, 3112-B, 3-25
29.	Nickel (as Ni)	mg/L	BQL (LOQ:0.01)	IS 3025 (Part 2): 2019
	Discipline: Biological Testing; Product Group: Water (Ground water)			
30.	Total Coliforms	MPN/ 100 mL	2.2	APHA 23rd Ed. 2017, 9221–B, 9-69
31.	*Escherichia coli*	MPN/ 100 mL	<1.1	APHA 23rd Ed. 2017, 9221–B, E & G, 9-69, 9-77 & 9-80
32.	*Detection of Salmonella Spp.*	/100mL	Absent	IS 15187:2016

END OF REPORT

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TEST REPORT

Report No.:	ME-NG01655N-230206- SA-NTPC-GADARWARA	Date: 06.02.2023
ULR No.:	-	

Name and Address of Customer	**NTPC LIMITED GADARWARA STPP Tehsil- Gadarwara, Village- Dongargaon, P.O. Gangai, Dist.- Narsinghpur, Madhya Pradesh – 487770, India.**		PO No.: 4000266445-057-1019 (Version:0) PO Date: 30.10.2021
Sample Description / Type	Ground water	Sample Collected by	Laboratory
Sampling Location	Gangai Village (Borewell)	Sample Quantity / Packing	5L X 2 No. PVC Can
Date of Sampling	27.01.2023	Date of Receipt of Sample	28.01.2023
Sampling Procedure	IS:3025(Part I):1987 RA 2019; APHA 23rd Ed. 2017, 1060-B, 1-40;		
Date of Start of Analysis	28.01.2023	Date of Completion of Analysis	05.02.2023

Sr. No.	Parameter	Unit	Result	Method Reference
	Discipline: Chemical Testing; Product Group: Water (Ground Water)			
1.	Sodium Percent (Exchangeable)	%	16.2	By calculation

END OF REPORT

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TEST REPORT

Report No.:	ME-NG01573-230128-SA-NTPC-GADARWARA	Date: 28.01.2023
ULR No.:	TC7487230001447F	

Name and Address of Customer	**NTPC LIMITED GADARWARA STPP Tehsil- Gadarwara, Village- Dongargaon, P.O. Gangai, Dist.- Narsinghpur, Madhya Pradesh – 487770, India.**		PO No.: 4000266445-057-1019 (Version:0) PO Date: 30.10.2021
Sample Description / Type	Ambient Noise		
Date of Sampling	24.01.2023	Sampling Procedure	IS 9876:1981

Sr. No.	Location	Time in h	Sound Level 'L' equivalent dB (A)
	Discipline: Chemical Testing; Product Group: Atmospheric Pollution (Ambient Noise)		
1	Chourbaretha Vilage	11:15	51.2
		22:00	45.1
2	Gate No. 2	11:10	57.6
		22:10	49.8

As per The Noise Pollution (Regulation & Control) Rules, 2000 (Rules 3(1) and 4(1))			
Area Code	Area Type	Limits in dB (A) weighted scale	
		Day Time (6:00a.m. to 10:00 p.m.)	Night Time (10:00 p.m. to 6:00 a.m.)
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

END OF REPORT

Note:
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MAHABAL ENVIRO ENGINEERS P. LTD.

TC-7487

DISASTER MANAGEMENT PLAN

(On-Site Emergency Plan)

OF GADARWARA SUPER THERMAL

POWER STATION

Stage-I (2X800 MW)

NTPC Limited

Gadarwara Super Thermal Power Station

Pradipta Kumar Mishra
Digitally signed by Pradipta Kumar Mishra
Date: 2020.10.15 15:41:20 +05'30'

Revision 03
Sept 2020

RECORD OF REVIEW AND REVISIONS

Issue	Revision	Date of Issue	Prepared by	Reviewed by	Approved by	Pages Reviewed
01.	00	29.06.17	G. Srinivasa Rao, Sr.Manager (Safety)	A.K. Goswami GM(O&M) & Factory Manager	A. K. Pandey CGM & Occupier	All
02	01	23.11.18	Anup Mahashabde, Sr.Manager (Safety)	A.K. Goswami GM(O&M) & Factory Manager	A. K. Pandey CGM & Occupier	All
03	02	12.11.19	Anup Mahashabde, Sr.Manager (Safety)	Pradipta Kumar Mishra GM(O&M) Factory Manager	A. K. Pandey ED & Occupier	All
04	03	28.09.2020	Anup Mahashabde, Sr.Manager (Safety)	Balagi Bhagwatrao Narare GM(O&M) Factory Manager	Pradipta Kumar Mishra CGM & Occupier	All

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TABLE OF CONTENTS

Pradipta Kumar Mishra
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Gadarwara

FOREWORD

NTPC gives utmost emphasis for the safety of man, machinery and environment right from the design stage of a power plant to the operational stage. In spite of safe design of plants and machinery, major accidents can take place and may lead to on- site emergency situations due to un-expected human errors or malfunctioning of system or sabotage or natural calamities. Since thermal power plants are listed under Major Accident Hazard (MAH) Industries, it is obligatory on part of the occupier of a factory to prepare on-site emergency plan under Sec.41-B (4) Chapter IV-A of "Factories Act, 1948". In order to comply with the requirement and at the same time to build up the capabilities of plant personnel in tackling on-site emergency situations, the "Disaster Management Plan" has been prepared for NTPC Gadarwara. This plan shall be implemented right from its 1st unit commissioning. All workers of the plant shall be educated on various possible emergencies, their role and responsibilities in mitigating the situation and people in the vicinity shall also be informed and educated appropriately.

It is relevant to mention that this document is not a static one nor it claims that it has considered all the possibilities of emergencies but as experience is gained and the site becomes more and more matured this plan shall be modified and make it current all the time.

I take this opportunity to thank the Department of Industrial Health & Safety, Govt. of MP, Indore (MP) and National Safety Council of India, Mumbai for providing valuable inputs in preparation of this plan.

Pradipta Kumar Mishra

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(Pradipta Kumar Mishra)
CGM

Dated – 28th Sept 2020

CHAPTER: A

INTRODUCTION

Pradipta Kumar Mishra
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I. INTRODUCTION

Emergencies in Power Plant may occur due to many reasons. It may occur due to natural causes like earth quake, cyclone, flood etc. It may occur due to malfunction of standard working systems / practices or it may be due to the terrorist activity.

Large scale emergencies like major release of flammable or toxic material and events which have significant environmental impact are possible in a thermal power plant due to handling of chemicals like Chlorine gas, Hydrogen gas, LDO, HCl, NaOH, $FeCl_3$, H_2SO_4 etc.

This Disaster Management Plan (DMP) is aimed to ensure safety of life, protection of environment, protection of installation, restoration of production and salvage operations in this same order of priorities. For effective implementation of the plan, this DMP will be widely circulated and plant personnel trained through rehearsals/drills. The public living in the vicinity of the power plant shall also be educated appropriately to mitigate the panic and adhere to proper precautions in the event of an emergency.

The suggestions of the statutory authorities, employees and stake holders shall be considered in adding value to this document on periodic review and revisions.

We are thankful to Department of Industrial Health and Safety, Govt. of MP, National Safety Council of India, Mumbai, Disaster Management Institute, Bhopal who have provided us guidance and inputs in preparation of this Disaster Management Plan.

- Safety Department -

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For any clarification / suggestions, please contact:

Mr. Anup Mahashabde, Sr.Manager(Safety), Mobile: 9425816793

II. IMPORTANT DEFINITIONS AND GLOSSARY OF TERMS

1. **Accident:** Unplanned event giving rise to death, ill health, injury, damage or other losses to personnel or property (IS-18001).
2. **Assembly point:** A notified common place in the plant where all the workers shall assemble in case of any emergency.
3. **Chief Incident Controller (CIC):** The person who has the overall responsibility of directing operations from the Emergency Control Centre.
4. **Disaster:** Disaster means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area.
5. **Disaster Management:** Disaster Management means a continuous and integrated process of planning, organizing, co-ordinating and implementing measures which are necessary or expedient for –
    i. Preventing of danger or threat of any disaster;
    ii. Mitigation or reduction of risk of any disaster or its severity or consequences;
    iii. Capacity-building;
    iv. Preparedness to deal with any disaster;
    v. Prompt response to any threatening disaster situation or disaster;
    vi. Assessing the severity or magnitude of effects of any disaster;
    vii. Evacuation, rescue and relief; and
    viii. Rehabilitation and reconstruction.
6. **Emergency:** It is one which has the potential to cause serious injury or loss life and/or property and which tends to cause disruption inside and /or outside the works.

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7. **Emergency Control Centre:** It is a place from which the operations to handle the emergency are directed and coordinated.
8. **Emergency Plan:** A formal written documented plan which, on the basis of identified potential accidents together with their consequences, describes how such accidents and their consequences should be handled, either on-site or off-site.
9. **Emergency preparedness:** Preparedness means the state of readiness to deal with a threatening disaster situation or disaster and the effects thereof.
10. **Emergency Response:** The efforts to minimize the severity of an accident by protecting the people, the environment or the property and bring back the scene to normal pre-emergency conditions.
11. **Evacuation:** Removal of persons from the accident site / neighboring place and diverting them to assembly point.
12. **Hazard:** A source or a situation with a potential to cause harm in terms of human injury or ill health, damage to property, damage to the environment or a combination of these.
13. **Hazard Analysis:** Identification of undesired events that may lead to the materialization of the hazard. The analysis of the mechanism by which those undesired events could occur and usually the estimation of the nature, characteristics and magnitude of the possible loss/damage to life and property. The loss/damage, severity would be analyzed and assessed for each hazard identified.
14. **Hazardous Chemical:** Hazardous chemicals means any chemical which satisfies any of the criteria laid down in part I of Schedule I or listed in column 2 of part 2, any chemical listed in Column 2 of Schedules 2 and 3 of the Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989.
15. **IDLH Value:** Immediately Dangerous to Life or Health (IDLH) is a condition “that possesses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate are delayed permanent adverse health effects or prevent escape from such an environment”.
16. **Mock-drill**: Simulated accident setup to test emergency response methods and for use as a training tool.

17. **On-Site Emergency:** An accident, which takes place within the boundaries and its effects are felt within the premises involving the people working within the specified boundaries of the plant.
18. **Off-site Emergency:** An accident, which takes place within the boundaries but its effects are also felt outside the premises involving the general public in the vicinity.
19. **Works Incident Controller (WIC):** The person who will take control of handling the emergency at the incident site.
20. **Vulnerable Zone:** It is an area, which may be affected or exposed by the release of hazardous chemicals.

Source of References for definitions of the above given terms:

1. Loss Prevention in the Process Industries – Hazard Identification, Assessment and Control (Second Edition) by Frank P Lees
2. IS-18001: 2000 – Occupational Health and Safety Management Systems –Specification with Guidance for use
3. Major Hazard Control – A Practical Manual, an ILO Publication
4. Technical Guidance for Hazard Analysis by US EPA
5. National Institute of Occupational Safety and Health, US Department of Health and Human Services – Pocket Guide to Chemical Hazards (June 1994 Edition)
6. Guiding Principles: Chemical Accident Prevention Manual, OECD, 2003
7. Disaster Management Act, 2005

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III. Incident Information Summery Format

The first information about an incident becomes a very vital input for effective handling of any emergency situation. It is important to gather as much as information as possible very quickly so as to facilitate various decisions and to initiate appropriate actions. In order to obtain maximum information from the person giving the first information about the incident, the suggested format for "Incident Information Summery" is given below. The questions given in the format are to be asked to the caller who is giving the first information. Answers for some of the questions may be unknown to the caller but it is important to gather more information as possible.

INCIDENT INFORMATION SUMMERY	
Date & Time ……	*Name of the caller : ……..*
Location of the incident……	*Caller's contact No. ……..*
Near by location:……	*Nearby population……..….*
Nature of incident (ex. Leak, explosion, spill, fire, derailment, accident)……..……	*Time of release……..…..*
Possible effects ……	*No. of dead or injured……..…..*
Where dead or injured are taken? ……	*Rescue accomplished?..... or Rescue needed?.....*
Name of the material released ……	*If unknown, container type …….……..……*
MSDS available..... , CAS No……	*Railcar/truck ID nos, if any …….……..*
Placard/label information……..	*Characteristics of material (ex. Color, smell etc)……..*
Present physical state of material……	*Total amount of material that may be released……*
Other hazardous material in area……..…	*Amount of material released so far/ duration of release……..…*
Whether significant amount of material appear to be entering the atmosphere, water, storm drains, or soil? ……	*Whether the release was in a confined space? ……..*
Direction, height, color & odor of any vapor clouds or plumes ……	*Weather conditions (wind direction, speed, inversion)…… ……*
Local terrain conditions significant to dispersion of personnel at the scene……	*Any other relevant information? .....*

CHAPTER – A1

OBJECTIVES OF DISASTER MANAGEMENT PLAN

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A.1. OBJECTIVES OF DISASTER MANAGEMENT PLAN

The objectives of the Disaster Management Plan are to develop, implement and maintain an integrated emergency management system for protection of people, property and the environment in the event of an on-site emergency caused by hazardous material or a major accident.

The ultimate goal is to reduce the vulnerability of the plant due to any emergency, to save lives and protect property by developing capabilities that mitigate the effects of, prepare for, respond to and recover from any emergency that could affect the area.

- ¤ It would help to accomplish the aforesaid objectives by assigning actions at Planed times & places in an emergency that exceeds the capability or routine responsibility of any one agency.
- ¤ It sets forth lines of authority and inter-group relationships, and shows how all actions will be coordinated. It describes how people and property will be protected in emergencies.
- ¤ The plan identifies resources viz. personnel, equipment, facilities, and supplies available within or by agreement with others for use during response.
- ¤ This is a positive effort towards Emergency Management making use of the combined resources of the plant and the outside services to achieve the following:
  - Effective Rescue and Medical treatment of casualties.
  - Safe guard other people in the premises.
  - Minimize damage to property and the environment.
  - Initially contain and ultimately bring the incident under control.
  - Identify the dead and injured, if any.
  - Provide for the needs of relatives, who come for any inquiry.
  - Provide authoritative information to the news media.
  - Secure the safe rehabilitation of affected area.
  - Preserve relevant records and equipment for the subsequent enquiry, (If conducted), into the cause and circumstances of the Emergency.

CHAPTER – A2

PLANT SITE DETAILS

A.2.1. GENERAL INFORMATION

Name of the Factory	NTPC Limited, Gadarwara Super Thermal Power Station, Village & Thana: Dongargoan, PO: Gangai, Taluk: Gadarwara, Distt. Narsinghpur(MP)
Location	Plant is located near village Dongargoan, Tehsil Gadarwara, District Narsinghpur (MP). Plant is spread over in an area of 1844 acres land. **Distances:** i) 16 KMs.(approx) from Gadarwara town on north side ii) 135 Kms. from Jabalpur and iii) 225 KMs. from Bhopal.
Nature of Industry	Coal based 'Thermal Power Plant' having generation capacity of 1600 MW (2 units of 800 MW each of Stage-I).
Principal Raw Material	***Raw Coal*** – 21900 Metric Tonnes per day. Transported thro' Indian railways. **Water** – 4680 cum/hr, drawn from Narmada river at Kakraghat (24 KM)
Name & Address of Occupier & Chief Incident Controller	Sh.Pradipta Kumar Mishra, Chief General Manager, *Mobile No : +91 9650995253* *BSNL Landline No : +91 7790220010*

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Name & Address of Factory Manager & Works Incident Controller	Sh. Balaji Narera, General Manager(O&M) Mobile No : +91 9416212442 BSNL Landline No. : +91 7790220037

Employment Details (as on 29.08.2020)	NTPC Employees	Contractors' employees
	340	**1800**

Wind direction	South-West to North-East
Access to the Plant and Escape Route	There are two gates for access to the Power Plant which are manned by CISF Security wing. There is one railway gate for entry of coal carrying wagons. All the plant locations are connected with well laid plant roads for access/escape.
Vicinity Details	Vicinity Map (5 KM radius) & details of population (1.5 KM radius) are given at Chapter A4 under sub heading A4.1 and A4.2.

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A.2.2. BRIEF DESCRIPTION ABOUT THE PLANT

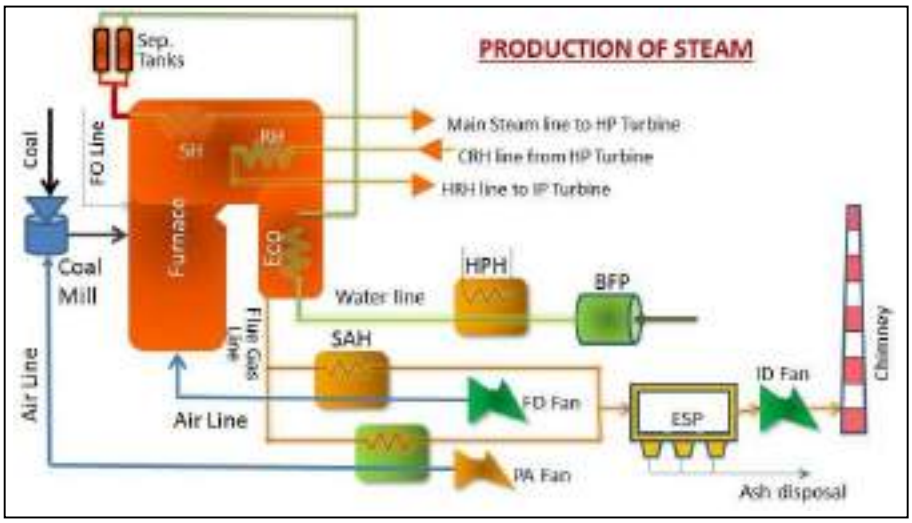
About Gadarwara Plant

With the total installed capacity of the plant is 1600 MW (2 x 800 MW Stage-I), Gadarwara Super Thermal Power Station is one of the fully owned Power Plants of NTPC Limited. Gadarwara is a coal based power plant and situated in a sparingly populated area near village Dongargoan in Gadarwara tehsil, Narasinghpur District of Madhya Pradesh state.

PROCESSES INVOLVED IN POWER GENERATION AT GADARWARA :

a. Production of Steam:

Coal is unloaded at Wagon Tipplers and crushed in Crusher House in the coal handling plant. The crushed coal is transported up to the raw coal bunkers with the help of belt conveyors and fed to Coal mills where it is pulverized in to a powder form. The pulverized fuel is fed to the furnace through coal pipes with the help of hot and cold air mixture from Primary Air Fan (PA Fan). Atmospheric air from Forced Daft Fan (FD Fan) is heated in the air heaters and sent to the furnace as combustion air.



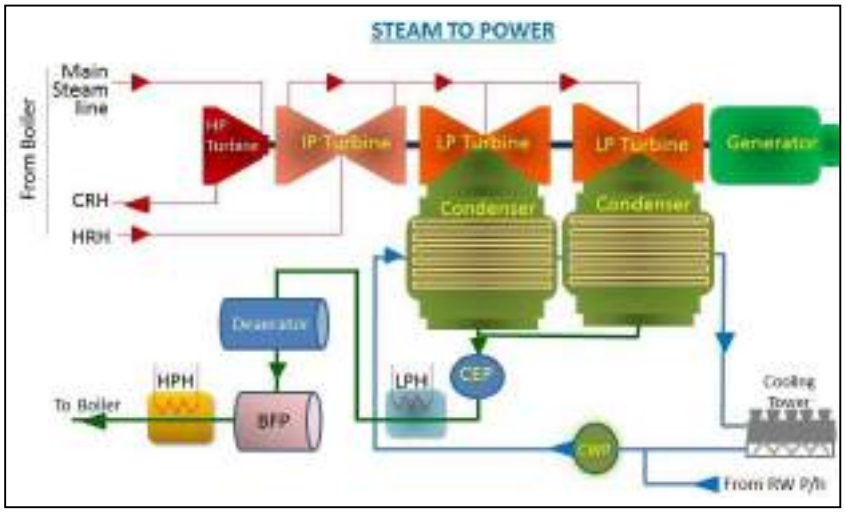
De-mineralized Water from the Boiler Feed Pump (BFP) passes through Economizer and reaches the separator tank from where it goes to water walls on all the four sides of the furnace. Water is partly converted in to steam as it rises up in the furnace and get separated in the separator tank and passes through super heaters(SH) which are located inside the furnace where it becomes super saturated steam that finally goes to HP Turbine. The exhaust steam from HP Turbine (CRH line) comes back to the boiler where it is reheated and goes back (HRH line) to IP Turbine.

Flue gases from the furnace are extracted by Induced Draft Fan (ID Fan) which maintains balance draft in the furnace with FD Fan. These flue gases emit their heat energy to various super heaters in the pent house and finally pass through air pre-heaters (PAH/ SAH) and goes to Electro Static Precipitator (ESP) where the ash particles are extracted, so that they do not pass through the Chimney to pollute the atmosphere. The dry ash is collected through vacuum system and is supplied to ash brick plant and cement plants.

Water requirement for boilers and other plant equipment as well as drinking water is being met from Narmada river at Kakraghat, which is about 24 km from the main plant. Makeup Water Pump House near Kakraghat village pumps fresh water to the Reservoir at the plant having 7,50,000 M^3 storage capacity. The approximate fresh water requirement is 4680 cubic metre per hour. Water used in the boiler is de-mineralized at DM Plant with anion / cation exchange process.

b. **Steam to Power** :

The Main Steam line conveys steam to HP Turbine through a stop valve and through control valves that automatically regulate the supply of steam to the turbine. The steam passes through each stage in turn until it reaches the end of the high pressure cylinder and in its passage some of its heat energy is changed into mechanical energy.



The steam leaving the high pressure cylinder (i.e., CRH) goes back to the boiler for reheating and returns (i.e., HRH) by a further pipe to the intermediate pressure cylinder. Here it passes through another series of stationary and moving blades. Finally, the steam is taken to the low pressure cylinders, each of which it enters at the centre flowing outwards in opposite directions through the rows of turbine

blades (an arrangement known as double flow) to the extremities of the cylinder. As the steam gives up its heat energy to drive the turbine, its temperature and pressure fall and it expands. Because of this expansion the blades are much large and longer towards the low pressure ends of the turbine.

When as much energy as possible has been extracted from the steam, it is exhausted directly to the Condenser which is located beneath the LP Turbines. The condenser consists of the large vessel containing tubes and cold water is circulated through these tubes and as the steam from the turbine passes around them it is rapidly condensed into water (condensate).

From the condensers, the condensate is pumped through low pressure heaters and Deaerator by the extraction pump (CEP), after which its pressure is raised to boiler pressure by the Boiler Feed Pump (BFP). It is passed through further feed heaters (HRH) to the economizer and the boiler for re-conversion in to steam. Circulating Water Pump (CWP) pumps the cold water which passes through condenser gains the temperature from steam. This water is cooled in cooling tower (where its heat is removed by evaporation) and re-circulated.

c. Switching and Transmission of Power:

The electricity produced in the stator winding of generator at about 27 KV and is fed through terminal connections to one side of a generator transformer that step up the voltage to 765KV. From here, over head conductors carry electricity to 765KV Switchyard where it is fed into a common set of bus bars. Power is evacuated from the station through 765 KV double circuit lines of PGCL to Jabalpur and Warora.

Important Associated Processes / Material having bearing on Plant Emergencies:

1. **Chlorine** is used in pre-treatment of DM Water and Circulating water system. Liquid Chlorine filled containers (1 Ton containers) are brought to the DM Plant by the suppliers through their own transport. The tonner containers are connected to the manifold and evaporation system for use.

   Seven Chlorine gas leak sensors are provided, to cover the leakage from the connected ton containers, unconnected ton containers & chlorination rooms. The

sensors are located within the trenches of chlorination plant and chlorinator rooms and are connected to the detectors/ analog switch mounted inside the local control panel. Sensors which are installed in connected tonners are connected to the absorption system through DDCMIS (digitally distributed control management information system) & LCP (local control panel), while the balance sensors are used to provide audio visual alarm on OWS (operator's working station) and LCP in case of chlorine leak being sensed by either of them.

THE CHLORINE LEAK ABSORPTION SYSTEM: This system consists of 2 Nos. Caustic re-circulation pumps, 2 Nos. Chlorine Air Mix Blowers and a Caustic Storage Tank with tower. The Absorption System starts automatically, if any of the sensors installed in the connected tonner area senses the gas leak. Initial stabilization time of approximately 60 seconds is to be provided for each sensor to start sensing.

2. **Hydrogen** gas is used in Generators for stator cooling which is generated through electrolysis process in the Hydrogen Generation Plant. The Hydrogen plant of Gadarwara has a capacity of 20 Nm^3/hr having two streams of 10 Nm^3/hr along with H_2 gas compressors each of capacity 12.5 Nm^3/hr & pressure of 160 kg/cm^2, with all accessories instrumentation, control panel, piping, manifold, ventilation system etc.

   Two gas generating systems are supplied, each capable of producing up to 10.0 normal cubic meters per hour of hydrogen gas and 5 normal cubic meters per hour of oxygen gas. Each gas generating system consists of an air-cooled silicon rectifier and transformer, six (6) electrolytic cells connected electrically in series, a liquid seal, mist eliminator, all interconnecting piping, various Indicating devices and controls. In the rectifier the voltage is reduced by the rectifier transformer and converted to direct current. When DC current flows through the cells, the water in the cells is converted into hydrogen and oxygen gases. The rate of evolution of gas is directly proportional to the DC current. Hydrogen generation plant is provided with standard protections and shall be tripped automatically in case H_2 leakage in cell room reaches 40% LEL.

   Some amount of H_2 gas goes to O_2% gas analyzer, gas purity is checked, and purity up to 99% is sent to Gas Holder by auto change over valve duly interlocked.

A Manual Gas Analyzer is also considered for manually measuring the purity of the hydrogen gas at Cell skid and it will be mounted on wall of cell room near cell skid. On-line percent oxygen in hydrogen, analyzer is also considered, to continuously measure hydrogen gas purity at the electrolytic cells. A signal from this analyzer is sent to solenoid valve, through PLC, which controls the pneumatic valve, to divert hydrogen gas to the gasholder if the purity is greater than 99% hydrogen, or to vent if the gas purity is less than 99%. Vent header with flame arrestor is located above 5 meter from the roof of the building.

3. The following chemical are used in water treatment process;

HCL and **NaOH** are used in DM Plant for the purpose of regenerating the resins in the mixed bed. Mixed Bed Contains cation resin & Anion resin. Cation resin used to be regenerated by HCl (Hydrochloric acid) & Anion Resin by Sodium Hydroxide NaOH (Caustic/Alkali). Caustic Measuring Tank is provided for measuring the Caustic quantity required for regeneration of Anion Resin. As contingency measure, Caustic Measuring Tank for RO can be used for Mixed Bed (MB) Caustic regeneration. Ejector system is provided for injecting both, Acid & Caustic during MB regeneration.

Bulk Chemical Unloading /Storage: HCl (Hydrochloric Acid) and NaOH (Caustic Lye) will be unloaded from Mobile Tankers with respective unloading/transfer pumps. HCl will be Stored in Bulk HCl Storage Tanks ($20M^3$ x 2 nos.) & NaOH will be Stored in Bulk Caustic Storage Tanks ($10M^3$ x 2 nos.).

Ferric Chloride ($FeCl_3$) is used in pre-treatment by dosing in clarifuculator for the purpose of turbidity removal from raw water. $FeCl_3$ will be Stored in Bulk $FeCl_3$ Storage Tanks ($10M^3$ x 2 nos.).

H_2SO_4 is used in circulating water system to remove harness in the water to prevent scaling in condenser tubes. H_2SO_4 will be Stored in Bulk H_2SO_4 Storage Tanks ($70M^3$ x 3 nos.).

Dosing tanks are provided with level transmitter having high level alarm and low interlocks in DDCMIS. Low level set point of Level transmitter is provided for trip the pump if tank level is low. Dosing Pump is provided with manually operated stroke controller to dose acid/alkali as per required dosing rate. If there is any

electrical fault with working pump, standby pump will come into operation automatically. NaOH Dosing System: NaOH Dosing Tank are provided with agitator.

4. **LDO** : There will be light diesel oil (LDO) firing at least in one burner elevation having a minimum capacity of 7.5% BMCR(Boiler Maximum Continuous Rating) to facilitate cold start-up of the unit when no auxiliary steam is available. LDO system shall be sized for 7.5% BMCR capacity of two (2) boilers. LDO will be stored in Bulk LDO Storage Tanks (2500 Kilo Liters x 2 nos.). LDO is unloaded in to the tanks at Fuel Oil Unloading Pump house.

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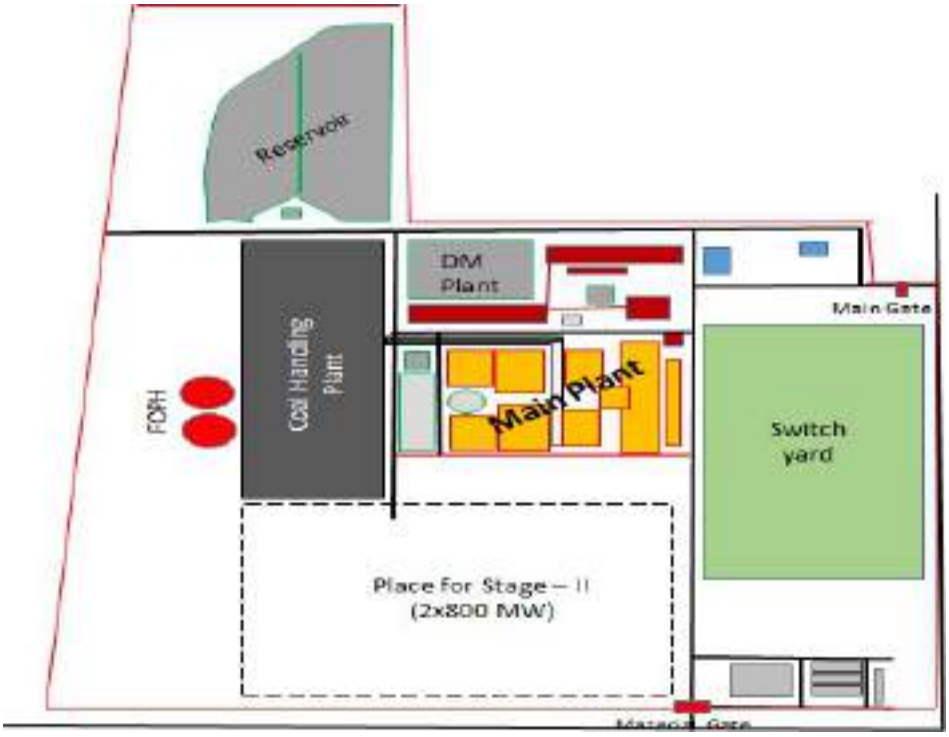
GENERAL LAYOUT OF NTPC GADARWARA:



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CHAPTER – A3

PRELIMINARY HAZARD ANALYSIS

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A.3.1. HAZARDOUS SUBSTANCES ON-SITE

I. FLAMMABLE, EXPLOSIVE AND HAZARDOUS MATERIALS

Sl. No.	Material	Type of container	Location & No of containers	Max. storage capacity	Normal Inventory
1.	Hydrogen	H2 Gas Holder H2 Gas Cylinders	H2 Plant - 2 Nos. H2 Plant & TG Bldg.	20 CuM (2 KG) 100 Cylinders (200 KG)	0.2 MT
2.	L.D.O.	18 M Dia x 11.5 M high Cylindrical surface tank (LDO tanks -2 nos.) 6 M Dia x 5 M Height Cylindrical surface tank (Day Oil Tank-1 no.)	FO Pump House – 2 Nos. Aux. Boiler Area- 1 no.	2500 kL each 6025 MT 100 kL 241 MT	12291 MT
3.	Coal	Open Yard for stacking & reclaiming	Coal Handling Plant – 4 Bays	6.6 lac MT	6.6 lac MT*

**** 8.03 Million MT /annum coal is fed to the boilers on receipt directly thro' conveyors daily. However, 6.6 lac MT is kept in open yard as reserve stock.***

II. TOXIC & CORROSIVE CHEMICALS / MATERIALS

(Material Safety Data Sheets of each Material are at Annexure-2)

Sl. No.	Material	Type of container	Location & No of containers	Max. storage capacity	Normal Inventory
1.	Chlorine gas	Chlorine Tonners	DM Plant & CW Chlorination plant 10 Nos.	38 Tons	20 Tons
2.	Hydro Chloric Acid (HCL 30-33%)	Horizontal tank with dish ends & 4.5 mm rubber lined	DM Plant 2 Nos.	150 CuM 361.5 MT	180.75 MT
3.	Sodium Hydroxide (NaOH 48%)	Horizontal tank with dish ends & 4.5 mm rubber lined	DM Plant 2 Nos.	100 CuM 241 MT	72.88 MT

4.	Ammonia Solution 25%	HDPE Jerry cans (25 Lts.)	DM Plant & Central Stores 200 cans	15,000 lts. 12.35 MT	4.12 MT
5.	Hydrazine Hydrate 80%	HDPE Containers (200 Ltrs)	DM Plant & Central Stores 4 Containers	2,000 Ltrs. 15.89 MT	0.64 MT
6.	Sulphuric Acid (H_2SO_4 98%)	Horizontal tank with dish ends made of SS	CW Chemical Treatment plant 3 containers	2,000 Ltrs. 3.68 MT	1.47 MT
7.	Ferric Chloride $FeCl_3$	*Horizontal tank with dish ends & 4.5 mm rubber lined*	DM Plant 2 Nos.	20 CuM 30 MT	15 MT
8.	Alum cakes	Compartment with acid proof tails	Chemical house in DM Plant 25 Sq.Mtr.	10,000 Kgs	10 MT

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A.3.2. SUMMERY OF RISK ANALYSIS

Risk analysis of the following major hazard potential areas of NTPC Gadarwara Super Thermal Power Station has been carried out.

a. Chlorination Plants

b. Hydrogen Generation Plant

c. Fuel Oil Pump House.

The summery of the risk analysis is given below.

I. Effects of Chlorine Gas Leakage in Chlorination Plants:

1. In case of Chlorine gas leakage in the 6 mm Cu Tube between Tonner valve and Header;
   a. Max. effect would be of 600 PPM up to 150 M radius.
   b. Max. effect of 10 PPM up to 1500 M.
   c. If scrubber works or the leak is arrested in time, the maximum effect would be 600 PPM up to 20 M and 10 PPM up to 250 M.
2. In case of Chlorine gas leakage due to rupture of flange Joint of 25 mm Pipe line in Evaporator section of the plant, the effect would be;
   a. Max. effect is 600 PPM up to 500 M radius and effect of 10 PPM up to 5 KM
   b. Max. effect is 600 PPM up to 18 M and 10 PPM up to 600 M, in case of instantaneous leak or the leak is arrested in time.

II. Effects of Hydrogen gas leakage in Hydrogen Generation Plant:

1. In case of leakage of Hydrogen in the 3 mm rubber pipe at Electrolytic section;
   a. Rupture probability is 7.8×10^{-6} / year
   b. Risk of burning or explosion is negligible.
2. In case of H_2 Gas leakage in the ¾ in dia pipe at Oxygen removal section;
   a. Rupture probability is 1.7×10^{-5} / year
   b. Risk of explosion is negligible. However, there is minor risk of burning.

3. In case of H_2 Gas leakage in the ½ in dia pipe at Pipeline connected to H_2 cylinder;
   a. Rupture probability is 1.7×10^{-5} / year
   b. There is a risk of Jet Fire (2^{nd} degree risk).
   c. Burn injuries & structural damage may be possible.

III. Risk analysis summery in Fuel Oil Pump House:

1. In case of LDO leakage in the 6 mm hole from the outlet pipeline of LDO tank, the liquid fuel comes out and can for oil pool within the bund area. In case there is pool fire, the effect would be within acceptable level.
2. In case of rupture of the LDO tank, can result liquid to come out and fill the pool area of the bund. In case, there is pool fire, likely risk of damage to the objects from thermal radiations.
3. In case of Tank fire of LDO, there is likely risk of injury/damage to people & objects from thermal radiations.

IV. Risk analysis summery of Acid/Alkali Storage area:

1. Hydrochloric acid can leak from the tank outlet pipe line flange joint or from flange joint near measuring tank. HCl comes out and can form acid pool within the acid proof lined dyke area. In this case, the leaking acid will be either diverted to neutralization pit or will be pumped to other tank. The effect would be within acceptable level. The same shall be the case with H2 SO4, NaOH and FeCl3 tanks.
2. In case of rupture of the acid/alkali tank, can result the acid/alkali to come out and fill the pool area of the dyke (acid proof tiled). In this case too, the acid/alkali in the dyke will either be diverted to neutralization pit or be pumped to the other storage tank of same material. The effect would be within acceptable level.

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A.3.4. SYSTEM ELEMENTS OR EVENTS THAT CAN LEAD TO A MAJOR ACCIDENT

Considering the process and the material being used at Gadarwara Super Thermal Power Station, the major hazard potential has been assessed and enumerated below.

Major Plant Sections	Major Hazard Potential						
	Slow Isolated Fire	Fast Spreading Fire	Explosion	Bursting of Pipes/ vessels	Release of Hazardous liquid	Release of Hazardous Gases	Floods
Coal Handling Plant	Coal yard	Conveyors	Coal dust explosion				
Boiler House	Mills / Burners		Furnace	Steam Lines, Air receivers		Flue gas from ducts	
Turbine House		Oil Tanks Con. room	H2 in Generator	Steam Lines	Control fluid		
DM Plant					HCl, NaOH	Chlorine	
H2 Plant	H2 pipes		H2 Holder / cylinders				
GT & 765 KV S/yard	Transformers		CT / PT / CBs				
Fuel Oil Pump Hs.		HFO / LDO tanks		FO lines	HFO/LDO		
Cable Galleries		Cables in the trays					
Chemical Godown					Chemicals		
Reservoir							Breach of dyke
Ash Dyke							Breach of bund
Makeup Water P/Hs.							Flood

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A.3.5. EMERGENCY SCENARIOS

From the major hazard potential assessment (A.3.4. above) and summery of Risk Analysis (A.3.2), probable emergency scenarios have been identified in the order of their seriousness. Except in the case of A.3.5.1, in all other cases, the emergency scenario would be confined to On-site Emergency nature only. Significant On-site / Off-site emergency scenarios are as given below.

A.3.5.1. Major On-site Emergency Scenario-1:

At DM Plant, Chlorine tonner containers are connected to the Chlorination system through manifold and then to the evaporation line for use. Uncontrolled release of Chlorine (up to 600 PPM – 20 M radius) from Chlorine tonners or Chlorination system of Chlorination Plants may occur due to total system failure or an illicit act/sabotage. The situation, if not controlled in time, may lead to **On-site Emergency** in case the Chlorine content in the atmosphere, for ex. 600 PPM up to a distance ranging from 150 M to 500 M radius (a worst case scenario).

A.3.5.2. Major On-site Emergency Scenario-2:

Hydrogen gas is used in the Generator for stator cooling. Gadarwara has a Hydrogen plant to generate 10 M^3/Hr, where the hydrogen is produced by means of water electrolysis in the Electrolyser using KOH solution. The hydrogen generated is stored in the holder after purity checks and oxygen thus generated is vented out to the atmosphere. Fire and explosion in H_2 Plant and H_2 gas cylinder storage room is possible in case of total failure of entire protection systems or due an illicit act/sabotage.

A.3.5.3. Major On-site Emergency Scenario-3:

Major fire and explosion in LDO tanks or major pool fire may take place at FOPH due to total system failure or an illicit act/sabotage.

A.3.5.4. Other Emergency Scenarios:

(a) Major Fire in Coal handling plant :

There have been occasions of major fire in conveyor galleries in various power plants. Fires may occur due to over friction in the belt conveyors, spontaneous fire in the coal lumps/oil soaked waste in the surroundings of conveyor belt, hot works without

precautions, poor housekeeping practices in the wagon tippler, conveyor galleries, crusher house and Transfer Points. Initially the fire may be a slow and isolated but over a period of time, if a running conveyor catches this fire it spreads rapidly and engulf the whole conveyor gallery.

(b) Major Fire in Cable Galleries/ Plant Control Room

Major fire in Cable Galleries/Plant Control Room at TG Building can be turned in an emergency situation in case the protection systems fail. The fire may originate from over heating of cables, short circuits, etc.

(c) Major Fire in Oil Tanks in TG Building and Transformers

Major Fire in Main Oil Tanks / Control Oil Tanks in main power house may occur due to hot works without precautions, poor housekeeping practices and intentional acts.

Similarly, the fire and explosion in Transformers may occur due to;

i. Failure of terminal bushings and flash-over.

ii. Sudden gas pressure formation due to transformer internal faults and subsequent failure of explosion vents and pressure release devices may cause explosion of transformer and fires.

iii. Accumulated leakage of oil from different parts of transformers and spurious sparking nearby.

(d) Release of Liquid Chemicals:

There are chances of spill-over/leakage of HCl, H_2SO_4, $FeCl_3$ & NaOH from storage tanks and also due to bursting of acid/alkali lines in DM Plant. There are chances of chemical burns due to contact with acid/alkali. However all storage and handling areas are provided with eye washers and drench showers, neutralization pit, transfer pumps, PPEs etc.

(e) Boiler Explosion:

Whenever Boiler is pressurized due to non-evacuation of steam, there are chances of Boiler explosion. However, various interlocks and protections are available for Boiler to taken care off to avoid any chance for Boiler explosion.

(f) Turbo-Generator Explosion:

H_2 gas explosion is a possible hazard in Generator. Various interlocks and protections are available to taken care off to avoid generator explosion. Oil sealing of generator rotor prevents the escape of hydrogen from generator.

A.3.5.5. Off-site Emergency Scenario:

In the case of water release / ash slurry release due to bund failure from the reservoir / ash pond, which are located away from the plant boundaries, would lead to emergency situations in the villages and fields in the vicinity of the reservoir / ash pond.

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CHAPTER – A 4

AREA RISK EVALUATION

A.4. AREA RISK EVALUATION

A. 4.1 : MAH installations in the radius of 3 Kms: There is no any MAH installation located within 3 KM radius from the plant. The following map depicts the villages in the near surrounding of the power plant.

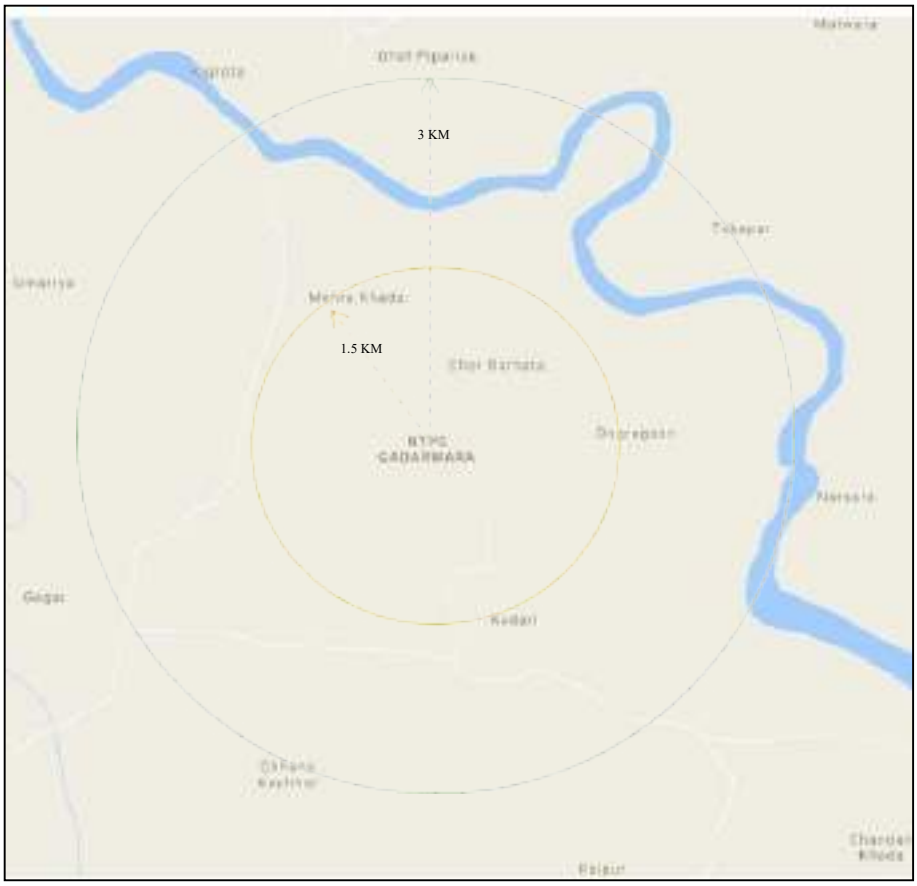

Fig. A.4-1 Vicinity Map

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A.4.2. NEARBY RESIDENCE AND POPULATION CENTRES

Details of population of villages in the 1.5 km vicinity of NTPC-Gadarwara are as below (Also Ref. Vicinity Map at Fig. A.4-1).

Sl. No.	Village	Distance from Plant	Population*
01	Chorebhareta	0.8 km	967
02	Dongargoan	1 km	1342
03	Kurari	1.4 km	949
04	Mehrakhera	1.5 km	342

**As per Primary Census Abstract, 2011*

Sensitive Population Centers within 1.5 KM radius: There are no sensitive population centers like Cinema halls, major Schools/Colleges, Hospitals, Fire brigade located within 1.5 KM radius of the plant.

Details of population of villages in the 1.6 to 3.5 km vicinity of NTPC-Gadarwara

Sl. No.	Village	Distance from Plant	Population*
01	Narsara	3.25 KM	1028
02	Tekapar	3.20 KM	1563
03	Ghatpipariya	3.30 KM	1403
04	Umariya	3.30 KM	3754
05	Gangai	3.25 KM	1524
06	Chhenakachhar	3.00 KM	1940
07	Raipur	3.50 KM	2200

A.4.3. Procedures for notification of Chemical Release at other factories:

At present, there are no any factories located in the close vicinity of Gadarwara Super Thermal Power Station.

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CHAPTER – A 5

EMERGENCY CONTROL CENTRE (ECC)

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A.5. EMERGENCY CONTROL CENTRE (ECC)

The Emergency Control Centre is the place from where the operations to handle the emergency are directed and co-ordinated. In the event of any emergency the ECC will be manned by CIC, his support team and the senior officers of District Administration.

A.5.1. Location of ECC:

CGM's chambers in Administration building has been identified as Emergency Control Centre (ECC) with adequate means of communication to areas inside and outside the plant together with relevant data, personnel protective equipments and equipments to assist those manning the centre and to enable them to plan accordingly.

Alternate Emergency Control Centre would be the Construction Office. Depends up on the anticipated risk during an emergency, one of the above two ECCs shall be decided by CIC for use. However, on construction of Disaster Management Room, the same shall be the alternate ECC.

A.5.2 : Facilities and Items in each ECC :-

a. Safety data pertaining to all hazardous materials, which are likely to cause emergency.
b. Procedure of major and special fire fighting, rescue operations, First Aid etc.
c. Emergency call out list.
d. Nominal Roll of Employees (General and shift wise).
e. Following facilities are available in Emergency Control Centre.
    1. 2 Nos. of intercom phones
    2. 2 Nos. of P&T phones
    3. Fax machine
    4. Emergency manuals
    5. Blown up area maps
    6. District phone directory

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A.5.3 : Manning of Emergency Control Centre:-

During normal working days, ECC will be under the control of Executive Secretaries (2 nos) to GGM(CIC) in the day time. During an emergency, the ECC will be manned by the following personnel. However, no other personnel shall have access to the Control Centre.

1. Chief Incident Controller (CIC), i.e., Chief General Manager or his Alternate
2. Executive Secretary to CGM
3. Members of Support team to CIC
4. Telephone Attendant
5. Three Messengers
6. Sr. Officers of outside services called in for assistance.

CHAPTER – B

ACTION PLAN

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B. ACTION PLAN

The primary purpose of the Disaster Management Plan is to control and contain the incident so as to prevent it from spreading to nearby population centers. It is not possible to cover every eventuality in the plan. However, the successful handling of emergency will depend on appropriate action and decisions being taken on the spot. For effective control and management of On-site emergency arising out of potential emergency situations in a power plant, an action process flow is drawn out, as illustrated in Fig-B-1 below.

Fig B-1: Process of Disaster Management Plan

B.1. Plant Emergency Organization: Various teams have been identified and their roles & responsibilities are explained in the action plan. The organization chart (Fig.B-1.1) illustrates the reporting system in case of emergency.

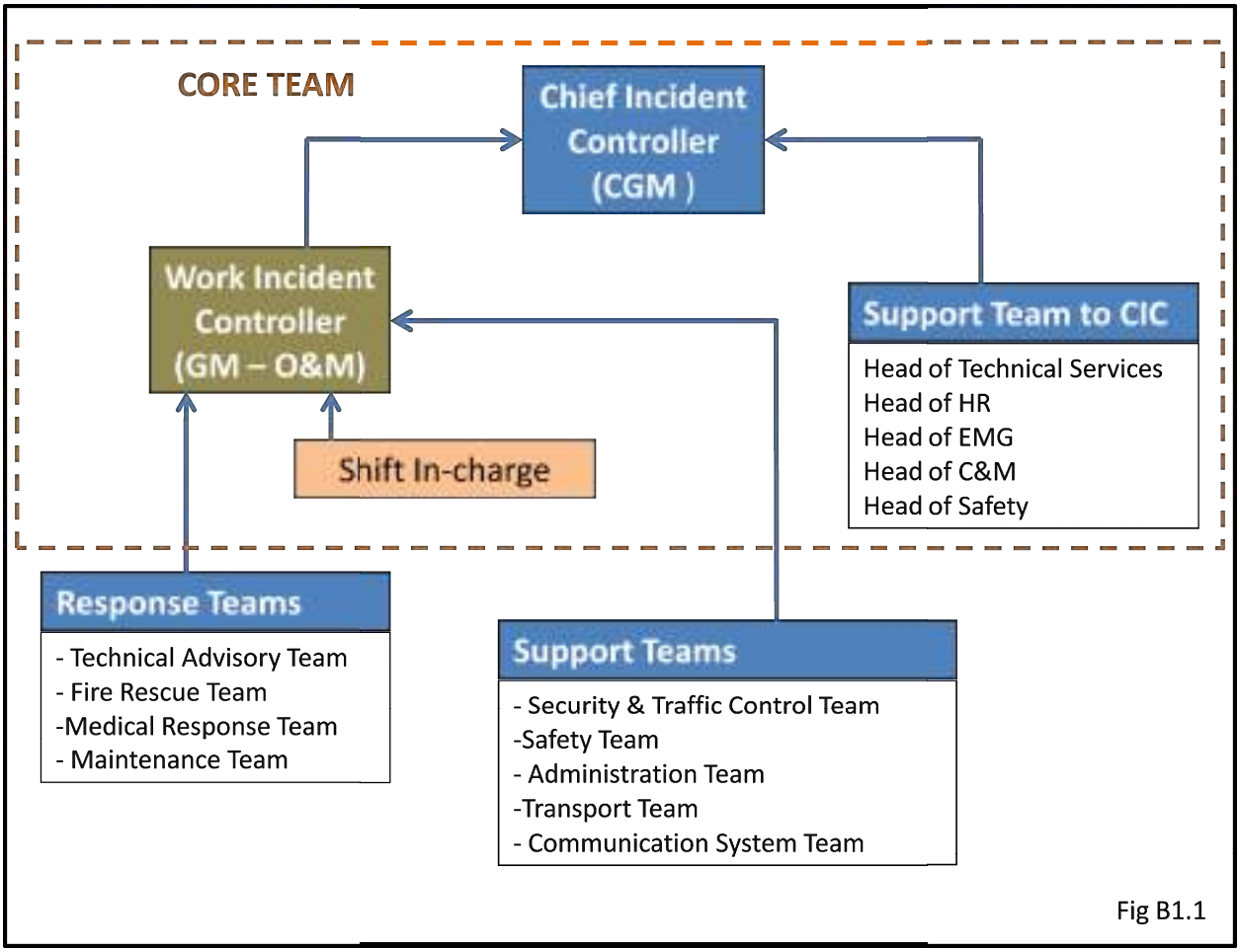

Fig B1.1

B.1.2. CORE TEAM: The Core Team consisting of Chief Incident Controller, Works Incident Controller and the Support Team to CIC as shown in Fig.B1.1.

B.1.2.2. RESPONSIBILITIES OF CORE TEAM:

(i) Responsibilities of Chief Incident Controller (CIC):

The Chief Incident Controller (CIC) has an overall responsibility for directing operations and calling outside help. The head of the Station assumes the role of CIC. In absence of Station head, the in-charge station head shall act as CIC *(for example, if charge is given to GM(P), he shall be CIC)*.

Depending on the location of the emergency site and the prevailing wind direction, the CIC will decide and use one of the two Emergency Control Centres, for directing operations and controlling the emergency. He will then proceed to that Emergency

Control Centre and take overall control of the emergency. Specific responsibilities/duties and requirements to be ensured by CIC are as under:

a. After assuming the position as CIC, he would get the information from the Works Incident Controller (WIC) and take overall control of the emergency.
b. Decide to declare emergency.
c. Decide and declare the location Assembly point after consulting with WIC.
d. Continually review and assess existing and possible developments to determine the most probable course of events and effective methods to deal with them.
e. In consultation with the WIC and Support Team to CIC, directs a safe shut down and evacuation of plant, if required.
f. Ensure that casualties are receiving adequate attention.
g. Provide directions to CMO in organising hospitalisation of victims and any additional help, if required.
h. Ensure that families / relatives of affected persons are informed.
i. If feel necessary, direct for information and liaison with Fire Services, Police Services, District Emergency Authorities and Officials of Directorate of Industrial Health and Safety, Govt. of M.P.
j. Ensure accounting of personnel and collate the actual attendance with the master list of persons including contractors and visitors.
k. Ensure the rescue of missing ones.
l. Ensure control of traffic movement within the Plant.
m. Instruct for the safe removal of vehicles loaded with flammable or dangerous substances from the incident site.
n. Arrange to maintain the chronological record of events.
o. Decide whether off-site emergency exists or is likely to take place. If off site emergency exists-
    i. Arrange to alert / evacuate the public living in the vicinity of the Plant.
    ii. Call out outside emergency services.
    iii. Inform district emergency authorities.

iv. Coordinate with district emergency authorities to mitigate the consequences outside the factory.

v. Coordinate with district emergency authorities for evacuation, shelter, rescue and rehabilitation of people & livestock in the vicinity of affected area.

p. Issue authorised statements to the press or the media in consultation with media contact person.

q. Inform company senior officials.

r. Declare cessation / termination of emergency after having full control on emergency event.

s. Control rehabilitation of affected area after the emergency exits.

(ii) Responsibilities of Support Team to CIC :

On knowing about the emergency, members of 'Support Team to CIC' shall proceed to Emergency control centre to assist the Chief Incident Controller. *List of the members is at Annexure-1(Table-a).*

They will:-

a. Report to Chief Incident Controller and follow the instructions of CIC.

b. Maintain a log of incidents.

c. Arrange for urgently required materials through cash purchase or whatever means.

d. Arrange funds for various relief measures as well as emergency purchase of materials and sending his representative for emergency purchase.

e. Identify suitable staff to act as runners or messengers, between CIC and WIC, if the telephone and other system of communication fail due to any reason.

(iii) Responsibilities of Works Incident Controller (WIC):

The WIC operates from the nearest accident site. As per the response level matrix as indicated above assumes the role of WIC. For silent hours, i.e. B and C shifts or on

holidays, the Shift In-charge would work as WIC until the arrival of the WIC. The responsibilities of the WIC are as under:

a. Take charge of the scene of emergency as WIC and assess the scale of emergency.
b. Discuss and decide with the Shift In-charge for continuation of plant operations or to take shutdown.
c. In consultation with CIC, activate the on-site emergency plan.
d. Provide advice to the heads of DMP Teams reporting to him.
e. Search for trapped persons or casualties, if any.
f. Initiate rescue operations until the rescue team arrives through available staff and evacuate the non-essential persons and direct them to report at the Assembly Point.
g. Set up communication network with the Emergency Control Centre (ECC-1 or ECC-2, as the case may be), using Intercom / walkie-talkie / Mobile phones.
h. Ensure that the outside emergency services have been called in, if required.
i. Direct all operations within the affected area with following priorities –
    i. Secure safety of personnel, giving priority to saving life and preventing further injury.
    ii. Advice and inform as required by the emergency responders, i.e. Fire and Security personnel or emergency services.
j. Keep CIC informed of developments from time to time.
k. Preserve evidences, which would be necessary for subsequent investigation to find out the immediate and underlying causes of the emergency and for concluding preventive measures.

B.1.3. *RESPONSIBILITIES OF SHIFT CHARGE ENGINEER(SHIFT IN-CHARGE):*

On knowing about the emergency, the Shift Charge Engineer(shift in-charge), will rush to the Incident site, make an overall assessment of the situation either individually or with the help of Fire Station In-charge. Later, report to the Works incident Controller and Chief Incident Controller about the emergency situation and follow the process given in the information flow chart. His responsibilities shall be:

a) Take decision to stop, continue or isolate operations within the affected area taking into consideration safety of personnel, damage to plant/property/ environment and minimize loss of material.

b) Appraise the gravity of emergency to Works Incident Controller and Chief Incident Controller and on instructions from CIC, activate Major Emergency Control Procedures.

c) Shall act as Works Incident Controller (WIC) till his arrival. He will have to:

   i. Direct for search of causalities.

   ii. Arrange for evacuation of people likely to be effected.

   iii. Ensure key persons are informed.

   iv. Inform to Works Incident Controller/Chief Incident Controller about the type of outside help required.

   v. Render advice/information to fire fighting and other emergency services.

ESSENTIAL STAFF:

In case the plant is immediately affected or likely to be affected as decided by the Chief Incident Controller/Works Incident Controller, efforts will be needed to make shut down and make process units safe. This work will be carried out by plant engineers and essential operators available in the shift. They can do it without exposing themselves to undue risk. Essential staff also includes personnel for emergency works as identified by Head of Maintenance Department, such as for providing extra lighting or replacement of lighting, providing temporary bypass of the works.

B.1.4. RESPONSIBILITIES OF RESPONSE TEAMS AND SUPPORT TEAMS:

(i) Technical Advisory Team:

The team will immediately report to WIC at incident spot. Their responsibilities are;

a. To identify source of hazard and try to neutralize/contain it with the co-ordination of Maintenance Team.

b. To isolate remaining plant and keep that in safe condition

c. To organize safe shutdown of plant, if necessary.

d. To organize all support service like operation of fire pumps, sprinkler system etc.

e. To measure gas concentrations in case of gas leakage at various places.

List of team members is given in Annexure-1(Table-b).

(ii) Fire and Rescue Team

This is the most important function and hence all care is taken to ensure that the team members have sufficient knowledge and skill in fire fighting and also to ensure that they have been trained and tested periodically.

Head of CISF Fire wing is the in-charge for the operation and handles this function in consultation with the WIC.

The fire and rescue team would typically consists of personnel from NTPC and CISF-Fire wing. This team would be assisted by security personnel for handling the injured one and also for rescue operation.

List of team members is given in Annexure-1(Table-c).

A) Functions of Tam Leader

1. Rush to the spot of emergency on receipt of message.
2. Assess the situation and co-ordinate rescue operation such as evacuation of affected personnel and isolation of affected area.
3. Decide beforehand proper use of fire fighting equipment.
4. Ensure availability of PPE and their safe use by the team members.
5. Check the wind direction and advise the fire fighting operation accordingly.
6. Ensure that sufficient numbers of trained fire fighting persons are always available on site.
7. If required arrange to contact and call other trained fire persons from nearby industries with an information to CIC & WIC.
8. Keep / arrange liaison with members of Mutual Aid and establishments such as Industries as well as with MP Fire services for additional help.
9. Take part in the fire fighting, if situation so demands.

B. Functions of Team members

1. Be available at their work stations.
2. Note down the fire call details in the prescribed format.
3. Quickly respond and rush to the scene of emergency.
4. Report their team leader / senior person at site.
5. Know, understand and follow safe use of fire fighting equipment.
6. Use fire-fighting equipment properly.
7. Use appropriate PPE.
8. First priority would be given to save lives by rescuing people.

(iii) Medical Team

Leader of the team is Asst. Chief Medical Officer (ACMO). The following medical arrangements should be made by the ACMO and his team. The assistance of trained first-aiders would be taken in handling the victims.

List of team members is given in Annexure-1(Table-d).

Functions of Team members

1. Rush to the site with stretchers, Ambulance, first aid equipments and trained first aid persons.
2. Depute the trained first aid persons in dispensary.
3. Keep the required medicines in readiness and ensure that they would be available at any time dispensary.
4. Tie-up with nearby hospitals and maintain a list containing 24-hour telephone numbers.
5. Arrange ambulance for victims / injured/ affected person to the hospitals.
6. Administer first-aid and if required send the victims to the nearby hospital for further treatment.
7. Get in touch with WIC/ CIC for any type of medical aid required.
8. Ensure proper medical help is given to the victim.
9. Make necessary arrangement with nearby hospital(s) to treat victims if their number is large.

10. Maintain records of affected persons, treatment given to them, etc.

(iv) Maintenance Team

This team will assist WIC in management of the incident. The team would include personnel from Mechanical Maintenance, Electrical Maintenance, Control & Instrumentation and Civil Maintenance.

List of team members is given in Annexure-1(Table-e).

A) Functions of Team Leader

1. Assess the emergency situation and guide the team members accordingly.
2. Keep liaison with other tem leaders and coordinators for requirement of their services if any.
3. Consult WIC and inform him the latest development and information of the situation.
4. Direct action to restore facilities, repairs, demolition as required under the circumstances
5. Ensure shutting off supply of electricity to the affected areas if so required.
6. Get necessary equipment's like cranes, dozers, trucks, welding and cutting set etc as needed for tackling the emergency and make available required personnel to operate above facilities.
7. Make sufficient number of contractor workers available to do civil jobs, like filling sand bags, making bunds, closing drains, excavation & required for the emergency.
8. Keep workshops / facilities open with necessary personnel throughout emergency to cater any need for repairs of additional equipment.
9. Make arrangements of temporary lighting / emergency lighting for affected areas, shelters and other places of assembly.
10. Know and understand Operating Procedures for controlling or shutting down various operations through regular training programs.
11. Ensure that the team members also know and understand the Operating Procedures.
12. Guide the team in efficiently controlling/shutting down the operations in consultation with WIC.

13. Keep the contact details of all the team members handy, especially for any specific operation vis-a-vis persons, so that they can be contacted when not on duty.
14. Ensure that sufficient number of different categories of skilled personnel is available and used for the purpose.
15. Ensure own safety and the safety of team members.

B) Functions of Team Members

1. Know, understand and follow the direction of the leader.
2. Contact the other team members for any assistance/ help.
3. Arrange to restore facilities, repairs, demolition as required under the circumstances
4. Arrange shutting off supply of electricity to the affected areas if so required.
5. Use necessary equipment's like cranes, dozers, trucks, welding and cutting set etc as needed for tackling the emergency and make available required personnel to operate above facilities
6. Arrange civil jobs, like filling sand bags, making bunds, closing drains, excavation & required for the emergency.
7. Keep workshops / facilities open with necessary personnel throughout emergency to cater any need for repairs of additional equipment.
8. Make arrangements of temporary lighting / emergency lighting for affected areas, shelters and other places of assembly.
9. Preserve record and other evidence, which may be required for inquiry.

(v) Security & Traffic Control Team

It is very important that during the emergency, the movement of persons within the factory is controlled effectively, non-essential persons and vehicles are guided to pre-determined locations and only essential persons and vehicles are allowed to tackle the emergency. To prevent access by the public into an area used by the fire service and other services for support activities is another responsibility of this team. Security personnel would be the members of this team. The Leader of the team is Head of CISF at site. *List of team members is given in Annexure-1(Table-f).*

A. Functions of the Leader

1. After getting information, arrange for cordoning of affected area and deploy manpower for this purpose.
2. Consult WIC / CIC and decide the locations for assembly of persons.
3. Guide the team members in adopting a particular procedure-like cordon, traffic control, entry of key and other required persons.
4. Consult WIC/CIC and decide the traffic movement in the plant.
5. Arrange Police help in consultation with WIC/CIC for control of traffic and public outside.
6. Allocate and brief the team how to control the traffic and vulnerable locations.
7. Ensure availability of PPE for the Team members and self.

B. Functions of Team Members

1. The security person stationed near the affected area will reach at site and take charge for security.
2. Stop unauthorised entry at site and inside the plant.
3. Allow entry of only emergency vehicles- fire brigades, ambulance etc.
4. Receive the help under mutual aid members and direct such persons to the affected site.
5. Barricade the incident site and control the traffic movement
6. Know and understand traffic signs and rules to be followed during an emergency.
7. Understand and follow procedure for wearing PPE.
8. Guide the traffic as instructed by the team leader, using proper signs.
9. Curb the panic among people.

(vi) Administration Team

The role of Administration team is to provide the necessary common facilities during any disaster / emergency in the plant. *List of team members is given in Annexure-1(Table-g).*

Functions of Team Members

1. Organise the transportation of personnel & equipment and relief materials.
2. Arrange for canteen services for personnel on duty as well as affected one's like Food & refreshments etc.
3. Assess and maintain law and order situation inside the plant.
4. Arrange for temporary shelters for rehabilitation of those evacuated.
5. Arrange for help of security personnel for cordoning off the affected area, for fire fighting / rescue help and evacuation of casualties.
6. Arrange for head counts of employees, contractors, transporters and visitors.
7. Inform and assist the relatives of persons affected in emergency.
8. Keep the employees informed in township and seek their help if necessary.

(vii) Safety Team:

This team will assist WIC in management of the incident. The team would include personnel from Safety Department and Participative Safety Forums. AGM(C&M) will head the team. *List of team members is given in Annexure-1(Table-h).*

A) Functions of Team Leader

1. Rush to the site of incident and assess the emergency situation and guide the team members accordingly.
2. Keep liaison with other tem leaders for requirement of services if any.
3. Ensure all facilities & requirements at ECC available.
4. In consultation with Chemistry and EMG departments, co-ordinate for monitoring of gas concentration at affected / likely affected areas.
5. Arrange required safety equipment and ensure safety of all members of emergency teams at incident site.
6. Guide authorities (Factories Deptt, Mutual aid organization etc.) on all safety related issues.
7. Collect and preserve evidences for subsequent inquires.

B. Functions of Team Members

1. Keep ready all the apparatus required for monitoring of gas concentrations.

2. Mobilise the additional PPEs and other Safety Equipment (like Gas monitors, fall arrestors, safety nets etc.) required for Emergency Operations.

(viii) Communication System Team:

The role of Communication team is to provide and ensure working of all types of communication systems and facilities in ECC and at the site of emergency. The Head of the team will be the head of IT Department. He will be assisted by his department personnel. *List of team members is given in Annexure-1(Table-i).*

On knowing the emergency, the head of the communication team will immediately report to WIC at incident spot and take the guidance.

Functions of Team Members

1. Maintaining the communication network in working condition during the period of emergency.
2. Attending urgent repairs in the communication system, if required.
3. Keeping ready the additional communication facilities like Walkie Talkies / Radios, etc for use in case of other communication systems fail.

(ix) Transportation Team:

The role of Transportation team is to pool up the resources for transportation of emergency equipment and shifting of people from affected areas. *List of team members is given in Annexure-1(Table-j).*

On knowing the emergency, the head of the Transportation team will immediately report to WIC at incident spot and take the guidance.

Functions of Team Members

1. Taking in to possession all the plant vehicles, earth moving equipment under their control.
2. Arranging vehicles for evacuation of people from affected areas to assembly points.
3. Arranging vehicles for the officials comes to take part in emergency management activities.

4. Arranging mobile lifting equipment, earth moving equipment for emergency operations.
5. Keeping contact with travel agencies for additional vehicle requirement, if any.

DMP Teams Response Chart for Various Emergencies in the Plant

TEAMS TO RESPOND IN CASE OF ON-SITE EMERGENCY	MAJOR EMERGENCIES																										
	Slow Isolated Fire					Fast Spreading Fire					Explosion					Bursting of Pipes/ vessels					Release of Hazardous liquid				Release of Hazardous Gases			Floods	
	Coal yard	Coal Mills	Boiler Burners	H_2 piping	Transformers	Coal Conveyors	Fuel Oil Tanks	Plant Contr. Room	MCC/COTs in TG	Cable Gallery	H_2 Holder/ cylinders	Boiler Furnace	Turbo-generator	CT/PT/CBs in Swy'rd	Coal dust in CHP	Steam Lines	Air receivers	Fuel Oil lines	H_2 Pipe Lines	Comp. air lines	Control fluid in TG	HCl	NaOH	LDO	Heavy Chlorine Leak	Chlorine leak (Slow)	Flue Gas From Ducts	Breach of Reservoir	Breach of Ash dyke
Technical Advisory Team					√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√		
Fire & Rescue Team	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√		√	√	√		√	√	√	√	√	√			
Medical Response Team						√	√	√	√	√	√	√	√	√	√							√	√		√	√			
Maintenance Team	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Sec. & Traffic Cont. Team					√	√	√				√	√	√					√	√			√	√	√	√	√		√	√
Safety Team	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Administration Team						√	√	√			√	√	√		√										√	√		√	√
Transportation Team						√	√	√			√	√	√	√	√										√			√	√
Communication System Team						√		√			√	√	√		√										√				

B.1.5. Designated Person for Media Contacts:

Any incident will attract the interest of the media, and a major accident is likely to involve wide spread radio and television coverage. Unless appropriate arrangements are made, this can divert personnel from the task of handling emergency. It is essential to make arrangements for the authoritative release of information during any emergency of significant length, and a senior management member should be appointed as the sole source of information. Inquiries made to other employees should be directed to this appointed person.

Head of HR shall be the authorized person for media contacts during On-site Emergency situations. However, he shall take complete information about the emergency and rescue operations from Chief Incident Controller before issuing the press releases/ media contacts.

B.1.6. RESPONSIBILITY OF CORPORATE CENTRE

Responsibilities of Chairman & Managing Director (CMD):

Upon receipt of information regarding occurrence, CMD shall constitute the Corporate Crisis Management Group with Director (Operations) as the Co-ordinator and Director (HR) and Executive Director (CP) as permanent members another two members can be co-opted by Director (Operations) depending on the type of emergency. The Crisis Management Group will immediately initiate action on request of services required by the CIC.

As per terms of "Constitution of a Committee and Conduct of inquiry", Chairman & Managing Director(CMD) shall constitute inquiry committee.

Taskforce:

A Task Force consisting of the following shall immediately proceed to the Disaster site to study the circumstances relating to the mishap.

1. General Manager (OS) or AGM (OS) in case GM (OS) is not available - Coordinator.
2. General Manager (PE) or AGM (PE) in case GM (PE) is not available.
3. Sr. Medical Specialist.
4. Head of Safety.

If the Task Force Co-ordinator feels necessary, it may co-opt any other official to help the Task Force.

OS Control Room:

CIC shall provide the OS Control Room with the first information of the occurrence when CMD is informed, Shift-in-Charge OS Control Room will in turn inform Directors and Delhi based Executive Directors regarding the occurrence. Information from site shall be collected at regular intervals by OS Control Room till the crisis Control Room under Addl. General Manager (IR) starts functioning.

Crisis Control Room:

A Crisis Control Room shall be set up at Corporate Centre, which shall be controlled by Addl. General Manager (IR). Information shall be collected regularly and given to the Chairman & Managing Director(CMD), Directors, Executive Director (HR) and other concerned officials to deal with the situation.

Services of NTPC Helicopter:

Chief General Manager may requisites the services of the Helicopter for shifting of critically injured personnel to hospitals with advanced medical facilities. Request for same can be made along with the requirement of essential external services. Executive Director (CP) shall organize the deployment of the helicopter to the Plant. Thereafter helicopter movement shall be directed by Chief General Manager till the crisis is over.

B 1.7. OUTSIDE ORGANISATIONS TO ASSIT DURING EMERGENCY AND PROTOCOLS FOR LIAISONING

To handle effectively the large scale emergency situations, pooling & utilizing the services of external resources plays an important role. In view of importance, NTPC Gadarwara has become the member of District Crisis Management Group (DCMG) formed under NDMA guidelines, whose Chairman is the District Collector, Narsinghpur (MP). Technical resources assistance can be obtained from the DCMG in case of any emergency situation.

B 1.8. Mutual Aid :

Being a remote location and no large scale factories / industries available in the near vicinity of the power station, mutual aid agreement is not existing.

For Medical assistance, the company has agreements with the following Hospitals at Gadarwara, Narsinghpur, Jabalpur & Bhopal.

1. Govt. Civil Hospital, Gadarwara
2. Govt. District Hospital, Narsinghpur
3. Jabalpur Hospital and Research Centre, Jabalpur
4. Bansal Hospital, Bhopal
5. Chirayu Hospital, Bhopal
6. Dayal patho services, Gadarwara

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B 1.9. COMMUNICATION AND SEQUENCE OF ACTIONS DURING AN EMERGENCY

The Action Plan for effective communication and sequence of actions during and after an emergency consists of:

a. First Information & Assessment of emergency.

b. Responsibilities for Declaration of Emergency.

c. Handling of Emergency *(refer B 1.1 to B 1.8 and B 3)*

d. Responsibility for All Clear Signal.

First Information:

The first person who observes/identifies the hazardous incident shall inform by telephone or by any other means, communicates to the Shift Charge Engineer about the incident. In case, the information is received by Fire Station, In-charge of Fire Station Control room shall inform to Shift Charge Engineer about the incident before the fire team proceeds to the site of emergency. *See Information Flow Chart at Fig. B 1.2 at next page.*

Responsibility for Declaration of Major Emergency:

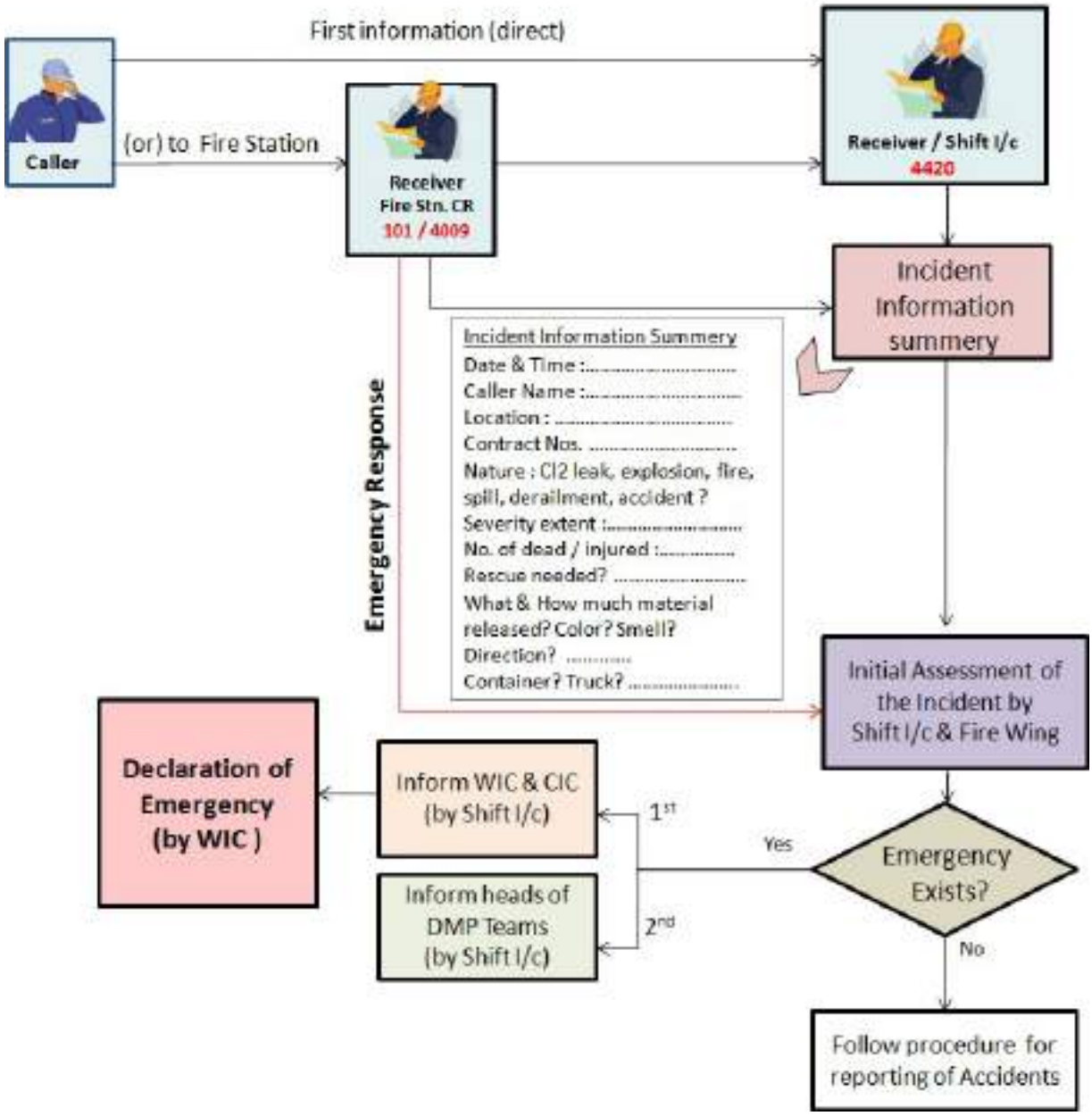
The Works Incident Controller or the Shift Incharge (incase WIC is not in the plant premises) on hearing the hazardous incident shall go to the scene of the incident, make an informal assessment of the situation and decide whether a major emergency exists or is likely to develop and inform the same to CIC. Based on the advice of WIC or Shift Incharge, the Chief Incident Controller (CIC) declares a Major Emergency and instructs to blow the emergency siren.

Once the Emergency siren is sounded, Emergency procedures will be activated.

Responsibility for 'All Clear Signal':

After cessation of emergency, Works Incident Controller will communicate to Chief Incident Controller about it. After verification of status, CIC will communicate to announce the "All clear" by instruction to sound the **"ALL CLEAR SIGNAL".**

FIRST INFORMATION FLOW CHART & INCIDENT INFORMATION SUMMARY



In case the receiver of the incident information is Fire Station Control Room, the person in-charge should take the information in the Incident Summery Form and report the summery to the Shift Charge Engineer immediately. In turn the SCE should conduct an initial assessment and proceed further as per the above chart.

CHAPTER – B2

NOTIFICATION PROCEDURES AND COMMUNICATION SYSTEMS

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B 2.1. ALARM SYSTEMS

The emergency siren will be sounded by the Shift Incharge from the Plant Control Room which is manned round the clock with responsible executives of Operation Department.

The emergency siren audible to a distance of 3 Kms range will be installed at the roof top of Service Building in the Main Plant area.

The emergency alarm shall consist of repeated long and short blast for continuous period of 2 minutes. The purpose is to communicate all persons inside the plant about major emergency occurred in the plant.

The siren is sounded such that the nature of emergency can be distinguished as a Chlorine release or a major fire. The Siren is tested once in every three months for its effective functioning during emergencies.

EMERGENCY SIREN

SI. NO.	T Y P E	DURATION
1.	FIRE	15 SECONDS ON, 5 SECONDS OFF **(3 TIMES)**
2.	HEAVY CHLORINE LEAK	20 SECONDS ON, 10 SECONDS OFF **(5 TIMES)**
3.	ALL CLEAR SIGNAL	CONTINUOUS SIREN FOR THREE MINUTES (**ONLY ONCE**)

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B 2.2. COMMUNICATION

B 2.2.1. Procedure of Communication about Emergency to CIC, WIC, Heads and members of DMP Teams:

Communication to	Responsibility	Message of Communication / what is to be communicated	Communication channel
CIC, WIC	Shift In-charge	Details as per Incident Information Summery Form & findings of initial assessment of the emergency by him.	Mobile Phone
Heads of DMP Teams	WIC	As mentioned above.	Mobile Phone
Members of DMP Teams	Head of DMP Team concern	Briefing the emergency and asking to rush to the site with requisite PPEs and facilities to accomplish defined tasks in the action plan.	Mobile Phone / SMS thro' 'Sparsh'

B 2.2.2. Procedure of Communication to All employees in the Plant:

Communication to	Responsibility	Message (Sample message for Chlorine leakage)	Communication channel
All employees inside the Plant	Shift In-charge or his deputy after deciding the Assembly Point by CIC.	Chlorine Leak has taken place in the Plant and as a result of which chlorine content in the atmosphere may become high. Steps to control the situation are in progress. In the mean time all employees are advised to; a.Not to get panicked / worried. b.Leave you work locations and report at Assembly Point (Name the location). (Announcement to be made in Local Language)	PA System provided in the Control Room
Essential Staff on Plant Control Desks (Rooms)	Shift In-charge or his deputy	"Chlorine Leak has taken place in Plant and as a result of which chlorine content in the atmosphere may become high. Steps to control the	Mobile / Landline/ Intercom Phone

		situation are in progress. In the mean time Essential staff on Control Desks is advised to: a. Direct all non-essential workers to go to assembly point. b. Remain in control rooms keeping all the doors, windows tightly closed. c. If found necessary, we may evacuate you. d. Don't try to come out of the rooms as the chlorine concentration outside may be very high. (Announcement to be made in local language)	Or PA System

B 2.2.3. Procedure of Communication to Corp. Centre, External Services, District Administration and likely affected Villages:

Communication to	Responsibility	Message	Communication channel
CC, mutual aid organizations, external / local authorities, etc.	Head of HR	The message should be as advised by CIC.	Mobile / landline phones
Empanelled Hospitals	CMO	The message depends upon the type & nature of injuries.	Mobile / Landline phone
People in the likely affected villages in the vicinity of Plant	Head of HR	"Chlorine Leak has taken place in Gadarwara Power Plant and as a result of which chlorine content in the atmosphere may become high. Steps to control the situation are in progress. In the mean time you are advised to; a. Not to get panicked. b. Keep the doors and windows tightly	Mobile PA System with driver & announcer wearing Chlorine gas masks.

		closed. c. Don't try to come out from closed doors, if you find irritating smell, out side concentration of chlorine may be much more. d. If found necessary, we may evacuate you to the nearest evacuation centre. Be prepared for it. (Announcement shall be made in local language) Safety precautions to be followed by the affected villagers as communicated.	

B 2.3. Procedure for notifying families of injured employees:

Responsibility	Wording	Communication channel
AGM (HR) after identifying the injured employees and the severity of injuries.	Wording to be decided according to the situation.	1. Responsible officer of HR in case of Serious/fatality. 2. By phone in case of minor injuries.

COMMUNICATION SYSTEMS AVAILABLE :

Public address system has been provided in the plants. Intercom telephones are available at all required desks and mobile phones with CUG connection are provided to all employees.

P&T (STD) telephones and Fax provisions are provided in all departments. The facility is also used to contact district authorities for information and help.

Cable TV facility is available in Township for internal communication door to door.

CHAPTER – B3

Emergency Response Systems and Procedures

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B 3.0. EMERGENCY RESPONSE SYSTEMS AND PROCEDURES

B 3.1. CHLORINE LEAK:

Chlorine is used in pre-treatment of DM Water and Circulating water systems. Chlorine tonners are brought to the Chlorination Plants by the suppliers through their own transport. The tonners are connected to the manifold and evaporation system in the Chlorination Plants for the purpose of chlorination of water used in the Boilers and the cooling water. Leakage of Chlorine gas / liquid from the tonners or the manifold or the evaporator system may occur in case of total failure of safety systems. The emergency response systems and procedures for various types of probable chlorine leak scenarios are given hereunder.

a) Release of Chlorine from Tonners / Chlorination System:

System Safety: A well designed scrubber system (Chlorine neutralization system) is provided in the Chlorination Plant to extract the leaking chlorine and to neutralize it before letting out to the atmosphere. This system comes in to operation automatically in case of leakage of Chlorine exceeds more than 1 PPM. Chlorine Sensors are provided in the Tonners area and the evaporation area to detect the leakage of chlorine. These sensors actuate alarm in the control rooms as well as the scrubber system immediately.

To reduce the storage, handling and use of Chlorine gas to lowest possible extent, alternate substitute system, called Chorine Dioxide (ClO_2) dosing is being done. For this purpose, portable ClO_2 generation plants are being installed where in ClO_2 is produced by electrolysis process using Hydrochloric acid.

Additionally, to control and arrest manually any leakage of chlorine from the tonner valve, regulator or from the body of the container, emergency ‘leak sealing kits’ are provided in the operator’s room.

The operators have been fully trained to seal any such leakage with the help of emergency leak sealing kit in shortest possible time. Self Contained Breathing Apparatuses are also provided in the operator’s room to use in such operation.

Response Procedures:

Response Procedure in case of leakage from header i.e. after tonner and before evaporator:

a. Wear breathing apparatus suitably.
b. Ensure the Scrubber system ON.
c. Isolate chlorine tonner valve.
d. Check point of leakage with ammonia torch, and mark it suitably. Run the chlorination system till header pressure shows zero.
e. When pressure of the system evaporator pr. gauge becomes zero, close evaporator gas outlet valve (for CW Chlorinator).
f. If after some time positive pressure is observed, open the gas outlet valve and repeat the above two steps (d & e).
g. Attend the point of leakage. Test it with Nitrogen gas pressure and put back the system in service.

Response Procedure in case of leakage of chlorine from flow meter or system after evaporator for CW Chlorinator:

a. Operator has to use breathing apparatus kept in ready condition.
b. Shut the evaporator gas outlet valve.
c. Close the liquid chlorine valve at the supply container.
d. Reopen the evaporator gas outlet valve.
e. Operate the gas control unit to remove chlorine from the whole system.
f. When the evaporator mounted gas pr. gauge indicator indicates zero, close the evaporator gas outlet valve.
g. Observe the pressure gauge pointer. If a positive pressure is indicated after approx.10 minutes, open gas outlet valve and repeat step e & f.
h. When the pressure gauge remains at zero, shut down the gas control unit and set the main isolator to 'OFF' position.
i. Inform maintenance section for necessary repairs with emergency sealing kit or other suitable resource.

Response Procedure in case of leakage of chlorine tonner valve:

a. If the leakage is from the liquid side of the tonner, the tonner should be rotated with a lifting tackle already provided, in such a way that the leakage would now be from the gas side.

b. Attempt should be made to stop the leakage with an emergency sealing kit.

c. The tonner should then be taken for quick dozing with an intention of emptying it as early as possible.

d. Mark the defective empty tonner for return to the supplier for suitable action of repairs.

General precautions in case of chlorine leakage:

i. Evacuate and cordon off the affected area. Entry to the authorized personnel only should be permitted.

ii. Suitable breathing apparatus must be used wherever necessary.

iii. Safety data-sheet of chlorine should be followed.

iv. The authorized persons attending the chlorine leakage should wear proper personal protective equipments. There should always be one person watching so that in case there is any undesired incident, rescue operation could be put in action immediately.

v. Only the specially trained and well equipped persons should be allowed to work as authorized persons. The authorized persons are expected to be fully aware of the hazards associated with chlorine.

vi. Non essential staff should move away from the affected zone in a direction perpendicular to the wind direction. (Wind-sock may be observed to know the direction of wind.)

vii. Use wet handkerchief to cover the nose and mouth to reduce the effect of chlorine.

b) Massive release of Chlorine due to Terrorist / Sabotage Activities:

In case of any terrorist activity / sabotage and blasting of manifold system or Chlorine tonners with the use of explosives, heavy quantum of Chlorine may leak, which in no case can be sealed.

System Safety: Such probabilities in Gadarwara are reduced to almost zero, by providing fool proof security measures and restricting entry into chlorine handling / storage area.

Response Procedure:

In such case, only action is evacuation of victims and personnel from the affected area. The actions envisaged in the "Chapter B - Action Plan" to be followed.

In all the above scenarios, CISF-Fire Wing personnel will assist the Maintenance team and Rescue team by providing services of leak detection, leak arresting, providing water curtains at appropriate positions and rescue of affected persons if any. They shall follow the instructions given in the Fire Orders of NTPC Gadarwara Unit.

c) Explosion of Chlorine due to Fire:

Such an explosion may occur due to major fire in the chlorination plant. However there is no possibility of major fire in any of the Chlorination Plants at Gadarwara.

System Safety: To prevent fire incidents, no flammable material is allowed to be kept in the vicinity of Chlorine. Even uncontrolled growth of grass is not allowed there.

Response Procedure:

In case of major fire in Chlorination Plant, the emergency action is to evacuate personnel the plant and the likely affected areas. Control and extinguish the fire using fire hydrants, fire tenders from distance.

B 3.2. MAJOR FIRES:

(a) Fire in Coal handling plant :

System Safety: A well designed fire detection and fire fighting systems have been provided all over the conveyor galleries, viz., Linear heat sensing cables, Infra-red cameras, Medium velocity water spray system with quartzite bulbs/deluge valves, dust suppression system, hydrant water system, portable fire extinguishers etc.

Additionally, hot work permit system is in vogue and good housekeeping practices are in place. Scheduled preventive maintenance and protocol inspections of detection & protection systems are conducted to ensure healthiness of the systems.

Response Procedure:

a. Evacuate all non-essential workers from the area and keep all passages, doors etc., clear for fire fighting operations.
b. Start rescue and fire fighting operation immediately as deemed fit for the extent of fire.
c. Attempt should be made to manually start the MVW Spray system, if it is not operated automatically.
d. Ensure manning of Fire Water Pump house to start the hydrant pumps / maintaining the water pressure and to start additional pumps, if needed.
e. Ensure isolation of all electrical power supplies in the affected area.
f. Depending upon the extent of fire, additional fire crew / accessories turnouts to be called in.
g. Arrange to call all 'Off-duty' fire staff to report for fire fighting operations.
h. Establish co-ordination with external fire brigades called in.
i. The instructions given in the Fire Orders of NTPC Gadarwara Unit shall be followed.

General precautions:

i. Evacuate and cordon off the affected area. Entry to the authorized personnel only should be permitted.
ii. Suitable breathing apparatus must be used wherever necessary.
iii. Fire proximity suits, water gel blankets must be used wherever required.
iv. While carrying out fire fighting operations, safety of the persons / plant buildings/ equipments should be borne in mind.

(b) Fire in Hydrogen generation plant:

The Hydrogen plant of Gadarwara has a capacity to generate 7.5 M^3/Hr, where the hydrogen is produced by means of water electrolysis in the Electrolyser using KOH

solution. The hydrogen generated is stored in the holder after purity checks, however, oxygen thus generated is vented out to the atmosphere. There is a possibility of jet fire in the hydrogen lines wherever there is gas leak and a source of ignition. Since the hydrogen fire is invisible, severe heat radiation and subsequent fire in the plant may take place if the leak is not noticed and arrested in time.

System Safety: The plant is well designed to prevent any leakages from the system. However to prevent any untoward incidents, the following precautions are taken.

i. All electrical equipment and lighting fixtures are explosion poof in the entire plant.
ii. Hydrogen gas sensors are provided in the plant and cylinder storage area which are interlocked to the plant tripping system.
iii. Strict use of non sparking tools.
iv. Availability of Fire Hydrant water system & portable fire extinguishers in the plant.
v. Prohibition of use of mobiles, radios, etc. in side the plant.
vi. Prohibition of storing flammable material in and around H_2 plant area.
vii. Prohibition of entry of unauthorized persons in the plant and posting of security guard.

Response Procedure:

a. Evacuate all non-essential workers from the area and keep all passages, doors etc., clear for fire fighting operations.
b. Start rescue and fire fighting operation immediately as deemed fit for the extent of fire.
c. Ensure manning of Fire Water Pump house to start the hydrant pumps / maintaining the water pressure and to start additional pumps, if needed.
d. Depending upon the extent of fire, decide whether to shutdown the plant or part of the plant.
e. Ensure isolation of all electrical power supplies in the affected area.
f. Seek for additional fire crew / 'Off-duty' fire staff turnouts, if found necessary.
g. Establish co-ordination with external fire brigades, if called in.
h. The instructions given in the Fire Orders of NTPC Gadarwara Unit shall be followed.

General precautions:

i. Evacuate and cordon off the affected area. Entry to the authorized personnel only should be permitted.

ii. Fire proximity suits, water gel blankets must be used wherever required.

iii. While carrying out fire fighting operations, safety of the persons / plant buildings/ equipments should be borne in mind.

(c) Fire in Fuel Oil Pump House:

There is chance of major fire in the FOPH and the HSD and LDO tanks due to system malfunction or illicit acts.

System Safety: To prevent and control the fire, following fire safety arrangements have been made here.

i. Foam Flooding system on all oil storage tanks.
ii. MVW spray system on all tanks and in the Pump house.
iii. Fire Detection system.
iv. Fire Hydrants, Landing valves.
v. Foam Hydrant system.
vi. Round the clock security.

Response Procedure:

a. Evacuate all non-essential workers from the area and keep all passages, doors etc., clear for fire fighting operations.

b. Start rescue and fire fighting operation immediately as deemed fit for the extent of fire.

c. Start all fixed fire fighting systems manually if they are not operated automatically.

d. Ensure manning of Fire Water Pump house to start the hydrant pumps / maintaining the water pressure and to start additional pumps, if needed.

e. Depending upon the extent of fire, decide whether to shutdown the plant or part of the plant.

f. Ensure isolation of all electrical power supplies in the affected area.

g. Seek for additional fire crew / 'Off-duty' fire staff turnouts, if found necessary.

h. Establish co-ordination with external fire brigades, if called in.

i. The instructions given in the Fire Orders of NTPC Gadarwara Unit shall be followed.

General precautions:

i. Evacuate and cordon off the affected area. Entry to the authorized personnel only should be permitted.

ii. Fire proximity suits, water gel blankets must be used wherever required.

iii. While carrying out fire fighting operations, safety of the persons / plant buildings/ equipments should be borne in mind.

(d) Fire in Cable Galleries

The main hazard in cable galleries is fire due to over heating of cables, short circuits, etc. To prevent chance of fire origination in the cables, all the cables used in the Gadarwara are of Fire Retardant & Low Smoke (FRLS) type.

System Safety: To prevent further chances of fire in the cable galleries the following systems have been adopted in Gadarwara.

i. Zoning of cable gallery and fire proof sealing between zones, cable entries/intersections and intermittent places on cable trays, cable raisers and cable entry points.

ii. Providing Smoke detectors, flame sensors (linear heat sensing cables, quartzite bulbs).

iii. Automatic MV Water spray system.

Response Procedure:

a. Close ventilation system, if any in the cable gallery room.

b. Exhaust the smoke using Smoke exhausters.

c. Identify the affected portion of the gallery/tray and isolate electrically.

d. In case identification is difficult, then isolate all possible connected supplies.

e. Check if the water spray system is not operated automatically, operate manually if required.

f. Extinguish fire preferably with CO_2 or DCP extinguishers. (Water can be used externally, if the cables are fully dead).

g. In case of major fire, use breathing apparatus and fire suit.

(e) Fire in Plant Control Room

There has been a chance of fire in the Plant Control Room.

System Safety: To prevent chances of fire in the Plant Control Room the following precautions have been taken.

i. Smoke detectors.

ii. Automatic Inergen Gas Flooding system.

iii. Portable Fire extinguishers

Response Procedure:

a. Close ventilation system.

b. Exhaust the smoke using Smoke exhausters.

c. Check the Inergen Flooding system, if it is not operated automatically, operate manually if required.

d. Extinguish fire preferably using CO_2 extinguishers.

e. In case of major fire, use breathing apparatus and fire suit.

(f) Burner Floor:

There is a chance of fire in the oil piping at Burner Floor of the Boilers.

System Safety: To prevent chances of fire in the Plant Control Room the following precautions have been taken.

i. Fire detectors.

ii. Automatic Water spray system.

iii. Portable Fire extinguishers.

Response Procedure:

a. Evacuate all non-essential workers from the area and keep all passages, doors etc., clear for fire fighting operations.

b. Start rescue and fire fighting operation immediately as deemed fit for the extent of fire.

c. Start manually the MVW Spray system if not operated automatically.

(g) Storage godowns:

Chances of major fire are only possible in gas cylinder storage / chemical storage areas in the stores.

System Safety: such chances are reduced by proper layout and by providing adequate fire safety measures.

Response Procedure in case of *Fire on DA/LPG Cylinder:*

a) Try to shutoff the valve of the cylinder immediately.

b) Separate the hot cylinder from other cylinders and cool it with copious flow of water.

(h) Flashover & Fire in Switchgears:

Following reasons convert in to Fires or Flashovers in indoor / Outdoor Switch gears:-

i. Short circuit either at bus-bars, breaker high voltage parts or cable termination chambers may occur due to reptiles or falling of internal accessories on to live parts.

ii. Failure of supporting insulators of bus-bars, breakers, termination and subsequent earthing of supply may cause flash-over.

iii. Failure of measurement equipments like CTs & PTs may cause flashover in the concerned chambers.

System Safety: All switchgears are well designed to prevent chances of flash-over or fire. In addition, to take care of the above problems, the following precautions are taken.

i. Plugging of cable gland plates and breaker inspection plates against reptile entry.

ii. Periodical inspection/testing of switch gear equipment.

iii. Providing proper nomenclature of switchgear equipment with regards to voltage level, feeder description and panel numbering to avoid wrong identification.

iv. Standard Operating procedures are prepared and followed in Operation and Maintenance of the switchgears.

Response Procedure:

a. Evacuate all non-essential workers from the area and keep all passages, doors etc., clear for fire fighting operations.

b. Start rescue and fire fighting operation immediately as deemed fit for the extent of fire.

B 3.3. EXPLOSION:

(a) Explosion in Hydrogen Generation Plant:

Explosion in H_2 Plant and Cylinder storage room is only possible in case of total failure of entire protection system or due an illicit act/sabotage.

System Safety: The plant is well designed to prevent any chance of explosion. However, to prevent any untoward incidents, the following measures have been adopted.

i. The protection system of H_2 Plant is designed such that at 20% of lower explosive limit it gives alarm and at 40% of lower explosive limit the plant trips automatically.

ii. Gas purity will be monitored continuously and if the purity is less than 99%, the gas will be vented out to the atmosphere and the plant will be shut down automatically. However, the purity of H_2 gas is maintained 99.8%.

iii. Hydrogen gas sensors are provided in the plant and cylinder storage area which are interlocked to the plant tripping system.

iv. All electrical equipment including lighting fixtures are explosion poof in the entire plant.

v. Hydrogen holder / lines are purged with N_2 first before start-up and shutdown.

vi. Prohibition of unauthorized persons in the plant and posting of security guard.

Response Procedure:

a. Evacuate all non-essential workers from the affected area and keep all passages, doors etc., clear for rescue operations.

b. Start rescue operation immediately after ensuring that there would be no consequent explosion chances.

c. Any Fire in the exploded area shall be fought from safe distance and with utmost care.

(b) Explosion in Fuel Oil Pump House:

There is a remote chance of explosion in the Fuel Oil tanks at FOPH, if total failure of entire protection system or an illicit act/sabotage takes place.

System Safety: The measures to prevent chances of fire and explosion are explained at Sl.No. II(c) above.

(c) Coal Dust Explosion:

Coal dust can explode when they are suspended in air in Conveyor galleries, crusher house, bunker area, track hopper and transfer points. A coal dust explosion may occur if the coal dust is present in the concentration between UEL & LEL limits i.e., 30-2000 grams/m^3 of air and also a source of ignition like sparks caused by friction or static electricity.

System Safety: However, measures are adopted to prevent the chances of explosion in the design stage itself. To prevent the accumulation of dust, dust suppression systems are available at strategic locations.

(d) Boiler Explosion:

Whenever Boiler gets pressurised due to non-evacuation of steam, there are chances of Boiler explosion.

System Safety: Various interlocks and protections are available for Boiler to taken care off to avoid Boiler explosion.

(e) Turbo-Generator Explosion:

H_2 gas explosion is a possible hazard in Generator.

System Safety: the generator is designed to withstand explosion. Seal oil system is also provided for the generator to prevent the leakage of H_2 gas. And also the H_2 gas purity is continuously monitored and maintained always above 99%. All the H_2 cylinders are checked for high purity.

Response Procedure: The response procedure for (b), (c), (d) & (e) shall be same as given for (a) above.

(f) Transformer Fire & Explosion:

The possibility of Fire & Explosion hazards in transformers are due to;

- Failure of terminal bushings and flash-over.
- Sudden gas pressure formation due to transformer internal faults and subsequent failure of explosion vents and pressure release devices may cause explosion of transformer and fires.
- Accumulated leakage of oil from different parts of transformers and spurious sparking nearby.

System Safety: All the transformers are provided with adequate inbuilt and external protection systems and monitoring devices. However, to control the fire, the following measures have been adopted.

- Emulsifier system with deluge valve and fire detection devices on all transformers having capacity more than 16 MVA.
- Oil soaking pits with gravel fill beneath all the transformers.
- Fire Separation walls between transformers.
- Adequate number of Fire extinguishers.

Response Procedure:

a) Isolate transformer from both sides, if it is not automatically de-energized.
b) Stop forced oil circulating pump and forced air-cooling fans in service, wherever provided.
c) Use water spray to cool the hot part, wherever provided.
d) If oil has splashed out of transformer and also has caught fire, use only foam to extinguish fire. Do not use water.

B 3.4. LIQUID CHEMICAL RELEASE (Spill Containment & Cleanup):

There are chances of spill-over/leakage of HCl & NaOH from storage tanks and also due to bursting of acid/alkali lines in DM Plant. There are chances of chemical burns due to contact with acid/alkali.

System Safety: Dyke walls are provided to contain any overflow/leakage of acid/alkali from tanks which can be transferred in to the standby tank. The spill over, if any beyond the dyke, will be collected in neutralization pit.

Response Procedure in case of leakage of Hydrochloric Acid / Sodium Hydroxide

a) If leakage is from a Storage Tanks:

Any leakage from the storage tanks will be collected in the dyke provided, from where it will be recovered, if possible, and water flushed subsequently.

Non-key personnel should be kept away.

Material Safety data-sheet of respective chemical should be referred.

If recovery of acid/alkali is not possible, then the same shall be neutralized properly, before discharging to the drains. In case of contamination of land, the soil shall be neutralized properly with alkali/acid as the case may be.

b) If leakage is from a Pipeline:

Leakage of acid/alkali from a pipeline may either be from flange or from pipe itself:

a. The pump should be switched off first.
b. Isolate the pipeline.
c. The pipeline should be drained.
d. The defect should be attended either by repairing the defective part or replacing it, preferably by blanking wearing Face - shield, Acid / Alkali - proof suit & hand - gloves.
e. Chemicals spill on the body, if any should be immediately washed using drench showers/ eye wash fountains.
f. Area should be flushed with water.
g. Minor spillage can be neutralized by spreading lime powder.
h. Water should be sprayed on leakage point to suppress toxic / corrosive fuming.
i. Non-key personnel should be kept away.

Note : Water should not be sprayed on the leaking tank / pipeline.

Response Procedure in case of release of Ammonia Solution from the carboys

If leakage is from a Storage Tanks:

Any leakage from the storage tanks will be collected in the dyke provided, from where it will be recovered, if possible, and water flushed subsequently.

Non-key personnel should be kept away.

B 3.5. RELEASE OF WATER/ASH SLURRY:

Breach or sabotage of reservoir bund/ash dyke bund. This may affect the down stream habitants near reservoir. There were no villages on the downstream side of the reservoir at Gadarwara. However, if Ash bund breaches there are no any likely villages affected.

B 3.6. Medical (Handling of multiple injuries):

In the event of major emergency like massive chlorine gas leakage or Hydrogen Gas explosion (either at H_2 Plant or at TG building) or major fire in FOPH, there would be multiple injuries / multiple casualties. In such cases, the entire Medical Team arrives immediately at the site of emergency and put up Medical camp at a safer location with beds, stretchers and all necessary medical aids. External medical help shall be called for including the voluntary organization like Red Cross, medical staff from mutual aid organizations and near by hospitals.

On receipt of victims, the medical team shall prioritize according the seriousness, hopes of survival, type of injury etc., and start treatment or first aid and if necessary refer the cases to empanelled hospitals with a prior intimation/ briefing of case history along with a medical attendant.

Company Ambulances and ambulances of mutual aid organizations or of near by hospitals & other organizations shall be utilized for shifting of casualties. Services of 108 of Govt. of MP shall also be taken.

All the first aiders (employees of the company) who got First aid training through St. John Ambulance shall assist the medical team in such eventual situations.

First aid and Medical treatment procedure for Chlorine affected casualties is given at ***Annexure - 3*** (Detailed information about Chlorine)

B 3.7. Utility failure procedures:

In case of any Emergency, if the power fails, it would affect the emergency operations at large. A Diesel Generator of 2000 KVA is available in the plant to cater for power needs in the event of any emergency. Apart from the 2 nos. of DG sets of 500 KVA, battery operated flood lights, torch lights have been made available with EMD and Operation Departments.

B 3.8. Individual Unit Emergency Procedures, Emergency Start-up & Shut down procedures:

There are set procedures for Individual Unit Emergency, emergency start-up / shut down are available with Operation Department.

B 3.9. Detailed Operating Manual (for each unit & utility system):

There is a detailed Operation Manual for each part of the power plant which has been made available with the Operation Department.

B 3.10. Measures for Wind Storm / Heavy Rain:

a) Suspending all works at height.
b) Possibility of suspending operations /processes which are water/moisture sensitive shall be seriously considered.
c) Protection from flying of roof sheets due to gales.
d) Storm water drains shall be attended immediately to avoid clogging of drains.
e) The possibility of reverse flow of water from the factory premises outlets shall be examined and effective steps like provision of isolation etc shall be ensured.
f) The possibility of rain water flooding in the plant and possible consequences of marooning of plant roads, entry of water into main plant, off-sites, stores, tank farms etc., shall be examined and steps shall be taken to handle such situations effectively.
g) Storages of hazardous materials especially drums, carboys etc., in open areas shall be rechecked and shall be properly secured under shade with elevated floor level.
h) Review of probabilities for collapse of tall structures, street lights, old constructions and temporary constructions etc, more so in the construction

activity if any under progress. The probability of falling structures, and street lights and other flying objects on the equipment, pipelines containing the hazardous chemicals shall be specially reviewed.

i) Unnecessary movements of persons in the open areas within the premises shall be discouraged during the heavy gales. Even essential movements of persons shall be predefined in such a way that open area movements are limited to bare minimum during gales.

j) Care towards the possible shortcomings in electrical wiring, equipment when subjected to rain and gales shall be exercised.

k) Emergency power back up shall be rechecked.

l) Adequate quantity of diesel shall be stored for continuous running of generators if necessary.

m) Adequate quantity of dry food shall be stored for consumption of persons remained in the plant.

n) All battery backups for communications, UPS etc shall be kept fully charged. Spare batteries shall be kept handy.

o) Medical officer shall be remained in the plant if possible or at least a trained first aider shall remain in the plant till the normalcy is restored.

p) Firefighting systems shall be checked and adequate quantity of foam shall be kept ready.

B 3.11. EVACUATION, ASSEMBLY POINTS AND HEAD COUNT

B 3.11.1. Evacuation & Assembly Points:

In case of emergency, the non essential personnel should be evacuated from the incident area and also from adjacent areas. Evacuation should be to a predetermined assembly point in a safe part of the works. In case of Chlorine release the safe assembly point should be decided based on the wind direction, distance from the release etc. Considering such particular cases, two Assembly Points have been identified at Gadarwara.

The persons, those are not part of immediate response teams, would evacuate their work area and report at the designated Assembly Point. The decision to evacuate the work area will be taken by CIC after getting feedback from the WIC/Shift In-charge. Evacuating visitors would be the responsibility of the concerned officer. Department Head should take care to evacuate any handicapped person in his area.

B 3.11.2. Assembly Points:

There are two assembly points AP-1 and AP-2 have been identified in the plant. These points are also indicated in the Plant Layout drawing.

Assembly Point	Location	Who should assemble
AP-1	Along Compressor House	Decision would be taken by the CIC after consulting the WIC
AP-2	Safety Excellence Centre	
AP-3	Along CHP Control Room	

B 3.11.3. Head-Count & Responsibility:

It is important to be able to account for personnel during an emergency, but it can be particularly difficult. Because of visitors, contractors, shift changes, holidays and sickness absence, it is normally not practical to maintain a detailed roll of personnel on site at any one time. Therefore, detailed lists of contractors and their employees on site should be maintained by concern HODs, with similar list of visitors. From this exercise it is possible to identify the missing people who might have been in the area of Emergency, the WIC should be informed and arrangements made to organise a

further search.

Head Count Team & Its Functions:

A two-member team headed by HR Officer (Time Office) will man the designated Assembly Point. These persons would carry out the head-count and report any unaccounted person to the ECC. He will take the help of concerned HODs/Sectional Heads for employees, contractors' employees and visitors.

Functions:

(1) Collate lists of nominal roll of those believed to be on the site (from the time office data) and contractors' employees (from detailed list of Contractors) working in the affected area.

(2) Check against the nominal roll (excluding those who are in Emergency Control Centre and the teams at Site Emergency).

(3) Appeal people to remain calm and assemble without causing panic.

(4) Find out if anyone is missing and inform WIC and rescue team.

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CHAPTER – B 4

RESOURCES

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B 4.0. RESOURCES

B 4.1. Resources for Fire Emergency

Gadarwara Super Thermal Power Station and its auxiliary plants are provided with adequate Fire detection alarm systems and protection Systems to detect and extinguish any out break of fire.

B 4.1.1. Various Fire Protection Systems and facilities in the plant:

a) **Fire Water Pump Houses:** Fire Water Pump houses located near Boiler-1 provided with two water storage tanks each of 2300 M^3 capacity (total 4600 M^3 cap). The source of water for fire water tanks is raw water. Fire water pump house consists of the following equipments.

Equipment	*Capacity*	*No. of Pumps in FWPH*
Pumps for Hydrant System	*410 M^3/hr at 105 MWC each*	*03 nos. (Electric motor driven horizontal Centrifugal type)*
	410 M^3/hr at 105 MWC each	*01 no. Diesel Engine driven as standby*
Pumps for Water Spray System	*410 M^3/hr at 105 MWC each*	*01 no. Electric Motor driven horizontal Centrifugal pump*
	410 M^3/hr at 105 MWC each	*01 no. Diesel Engine Driven as standby*
Jockey pumps	*75 M^3 /hr at 105 MWC*	*02 nos. (Electric Motor Driven Centrifugal type) 1 Main + 1 Standby*

The pressurization of feeding lines/mains of both hydrant system and water spray system is done through reciprocating air compressors, jockey pumps and hydro pneumatic tank. The primary purpose of this system is to compensate water and pressure loss in hydrant and spray network and maintained the system pressure at a pre determined set value of 8.8. kg/cm^2.

A Booster pump house is located near the boiler-1 area. The Booster Pump House has two nos. pumps suitable for Parallel operation. One is Electric Motor driven (Main Pump) and other Diesel Engine driven (Stand by) pump, each of capacity 137 M^3/hr and 56 MWC head. The Booster pumps are put into service to boost the pressure in internal risers in boiler floors, TP-6, 7, 8 & 9, in order to maintain a minimum pressure

of 3.5 kg/cm^2 at the highest landing valve. The Booster pumps discharge line is feeding only internal hydrants of boiler floors higher elevations 40 mtr. and above.

b) Hydrant System:

The spacing of hydrants (outdoor) is 45 mtr. in general and for internal hydrants (Landing Valves) spacing is 30 mtr. (max). A minimum running pressure of 3.5 kg/cm^2 is available at the farthest point and the velocity of flow of water is generally not acceding 5 mtr. Per Second at any where in the system

Suitable hose cabinet/box containing two lines of 7.5 mtr. long hoses, branch Pipe and nozzle are provided and mounted adjacent to each internal hydrant. Hose Boxes containing two lengths of 15 mtrs. long hoses and branch pipes with nozzles are provided and mounted adjacent to each external hydrant and central hose cabins located at different locations.

Number of Hydrants/Monitors provided in the Plant:

Type of Hydrant	**In Stage-I**
Single Hydrants	210
Double Hydrants	03
Foam Hydrants	04
Landings Valves	181
Water Monitors	37
Total Hydrants	*435*

Water Monitors are also provided in addition to hydrants for boiler area, Fuel Oil Storage Tanks, ESP area, CHP area, Coal Stock Yard.

Areas covered with hydrant system:

The following areas of Gadarwara STPS are covered with this system.

01. Complete Main Plant and other Auxiliary building, 765 KV Switch Yard, Switch Yard Control Room building.
02. Fuel Oil unloading headers and Transformer Yards.
03. Water Treatment/De-mineralizing plant, complete Coal handling plant including conveyors, bunker, transfer points, crusher house, track hopper, coal stock yard etc.

04. Fire Station building, permanent stores, canteen, Administrating Building, Gate complex, Circulating Water Pump House, Hydrogen Gas plant, Construction Stores and Raw Water Pump House.

c) Water Spray System:

The water required for water spray system is handled by separate pump from fire water storage tanks as stated above. The minimum running water pressure at any spray nozzle in case of HVW spray system is in no case be below 3.5 kg/cm^2 and does not exceed 5.0 kg/cm^2. Similarly, in case of MVW spray stem it is in no case be below 1.4 kg/cm^2 and does not exceed 3.5 kg/cm^2. However, for cable vaults/spreader rooms and cable galleries a minimum running pressure of 2.8 kg/cm^2 is achieved at the hydraulically remotest nozzle/sprayer.

Automatic operation of the system is achieved by using deluge valve trigged by quartzite bulb detector on a pipe ring charged with water at pressure. However, the deluge valve of cable vault is actuated through fire detection and alarm panel upon sensing fire by smoke detector of ionization and optical type cross zoning principle supplemented by linear heat sensing cable. For areas having static height above 28M additional pressure switch on wet detection line are provided for required interfacing and operation of solenoid valves to facilitate deluge operations. Facility for manual initiation of deluge valve locally is also provided.

Water for medium velocity spray system for light diesel oil is taken from separate high velocity water/medium velocity water spray header. Design density for spray system of fuel oil tanks is 03 LPM per M^2 of surface area.

When a fire occurs spray equipments are designed to apply water in finely divided droplets traveling at high or medium velocity to give protection to oil tanks, structures, Transformer, Coal Bunker, Coal Conveyors, Cable spreaders, Rooms etc. by cooling by controlled burning of flammable liquids and by the dilution of explosive gases.

If fire did occur, then spray system could prevent dangerous increase of pressure inside the containing vessels, and protect the supporting structure against failure cause by high temperature.

Areas covered with Water Spray System:

The following areas of Gadarwara Super Thermal Power Station are covered with water spray system.

01. Areas covered by Automatic High velocity Water Spray System.

a. Generation Transformers, start up/stand by transformers, Unit Transformers, Unit auxiliary Transformers and Service Transformers in Switch Yard.
b. Diesel Generator Set, Boiler burner fronts (Oil guns and Coal guns).
c. Turbine Oil tank room consisting of main oil tank, Unit oil purifier, Turbine oil coolers.
d. Central lube oil tanks.
e. Boiler feed pumps, lube oil tanks, coolers, consoles.
f. Generator Seal Oil unit, Seal Oil pump unit.
g. Turbine oil panel pipe lines in main plant.

02. Areas covered by Automatic Medium Velocity Water Spray System.

a. All Cable galleries and cable vaults.
b. Coal conveyor Transfer points, Crusher House and all the Coal Conveyors
c. Fuel oil tanks, storing fuels of flash point less than 65 degree Centigrade
d. Fuel oil pumping stations.

d) Automatic Foam Injection System:

Water for foam system is tapped from hydrant system. Aqueous Film Forming Foam (AFFF) with low expansion ratio is being used. Two nos. of Foam Storage Tanks of capacity 2700 liters each, are provided in Fuel Oil Storage area and Pump House with the following arrangement.

01. Automatic Foam protection system is provided for the liquid surface of fuel oil tanks i.e. heavy furnace oil and light diesel oil tanks.
02. Automatic fixed foam protection system is consisting of the following.
    a) Two nos. foam concentrate discharge pumps of capacity 10 M^3/hr at 120 MWC head. One of them is electric motor driven and other one is diesel engine driven pump.
    b) Two nos. foam concentrate discharge tanks of same capacity filled with foam concentrate.
    c) Foam maker for individual liquid fuel oil storage tanks with adequate no. of discharge outlets for each of the liquid fuel oil tanks
    d) Inter connecting piping, isolation valves, Check valves, Instrumentation and control etc.

03. In addition to the above, foam hydrants are also provided as appropriate as a supplementary hose stream for spill fires.
04. The operation of foam injection system is automatic by means of fire detection system provided for each of the tank, with a provision for manual operation. Auto/Manual selector switch is provided in the foam pump local control panel.
05. All pipelines are laid over ground on RCC pedestals.
06. The system is designed with the foam application rate not less than 5 LPM per M^2 (for fixed roof type tank) of liquid surface area suitable for at least minimum 30 minutes operation. Foam concentrate being used is of 3 % low expansion AFFF type.

e) Inert Gas (IG541) Extinguishing System :

Areas Covered by the System: Control Equipment rooms of main plant building, Central Control Room, Computer Room etc.

The system is of high or low pressure 100% Stand by/Reserve cylinders (filled with IG541 inert gas) with standby/Reserve selector switch are provided. Common Cylinder bank with use of directional valves is used for protection of multiple risks. Minimum design concentration is 34.2% or Inert system and discharge time is 2 minutes maximum for release of 95% of extinguishing gas.

In case of fire (as conform through cross zone concept), signal receives to control panel and after time delay (Set between 0 - 120 Seconds) this signal transmits to operate electrical solenoid (Actuator) provided on pilot cylinder valve assembly. Operation of solenoid valve releases gas enabling to operate the valve fully.

Additional secondary pilot cylinders are used in the system from the cylinder bank which subsequently operates through main pilot cylinder and/or with the use of gas from manifold through flex hose accomplishing complete operation of the system.

Manual Remote Release: Remote release is accomplished by pressing the push button after breaking the glass at a “Manual release push button station”. Once the button has been pressed, the extinguishing gas will be released as described above.

Manual Emergency Release: In the unlikely event of power failure the system can be activated by the manual pull lever on the electrical actuator located on the Cylinder Valve and consequently opening the manual over write on the distribution valve for release to the desired area.

(f). Foam Hydrant System:

Foam Hydrants are provided in Fuel Oil Pump House area. Purpose of providing this system is to combat the fire of fuel oil tanks in dyked area occurs due to spill over of oil. Water for Foam Hydrants is tapped from hydrant system.

(g). Fire Extinguishers:

Fire Extinguishers are deployed in all the buildings of entire plant as per the requirements and in accordance with the guide lines of IS: 2190-1992. The following quantities of Fire Extinguishers are deployed at various locations of the plant.

Sl. No.	*Type of Extinguishers*	*Cap.*	*Qty*
1	Water Type Extinguishers	09 Ltr.	150
2	CO2 Type Extinguishers	4.5 Kg.	150
3	CO2 Type Extinguishers	22.5 Kg.	30
4	DCP Type Extinguishers	06 Kg.	125
5	DCP Type Extinguishers	50 Kg.	25
6	Mech. Foam Type Extinguishers	09 Ltr.	60
7	Mech. Foam Type Extinguishers	50 Ltr.	05
	Total No. of Extinguishers		**545**

B 4.1.2. MICRO PROCESSOR BASED FIRE DETECTION AND ALARM SYSTEM

The installation practices adopted for fire detection and alarm system are in accordance with NFPA 72 BS 5839 Part - 01. The no. of detectors, spacing and their locations are determined taking into consideration the obstruction due to floor, beams, cable trays, ducts etc. so that complete coverage of the area protection is obtained. Zones covered by individual detectors are overlap and no blind zones are left. All detectors are wired on fault tolerant class 'A' style. Smoke detectors are so located, as to have coverage of 25 M^2 and special care has been taken to install detectors with in beam pockets. In cable vault the linear heat sensing cable is run in zig zag fashion (with included angle of minimum 90 degree). At least in each of top tray, bottom tray and in every alternate tray. Linear heat sensing cable is provided to give an alarm as well as for automatic operation of water spray system. For automatic operation of

water spray deluge system ionization smoke detectors as well as photo electric smoke detectors are provided. Operation of any one of these detectors will give an alarm. However, these detectors are cross zoned so that the signal for automatic actuation of water spray deluge system is obtained only when at least one detectors of each type operate simultaneously. Ionization and photo electric type smoke detectors are provided in control equipment room, CCR, Computer Room of main plant building for auto operation of inert gas system. Ionization smoke detectors where ever used have source activity less than 1 micro curie in line with Department of Atomic Energy guide lines.

The Centralized Fire Alarm and Detection System with a computerized and analogue addressable system including a central monitoring station is located in the Control Room. This system will indicate the fire location and will display the occurrences visually and audibly both locally at the applicable areas and centrally at Control Room. The sensing of fire is accomplished through various types of detectors (multi sensor detector /beam detector/ probe type heat detector / LHS cable / IR detector / manual call point. The system also includes the following:

a) Ionization type smoke detectors of low voltage dual chamber type. The photo electric smoke detectors will respond quickly to smoke that is optically dense. Each detector has built in address switch for individual addresses. The sensitivity of each detector is adjustable from panel. Coverage area does not exceed 25 Sq meters per smoke detector.
b) The inter face unit is suitable for connecting conventional detectors such as LHSC and normally opened type alarm initiating devices such as pressure switches, flow switches, level switches, potential free contacts etc. in the addressable loop.
c) The fire alarm control panel functions as a communication inter face between processing unit and sensors. This panel has facility to process the input signal and control all the input data received from initiating and indication devices.
d) Fire alarm control panel has filters to ignore false alarm and increase sensitivity to real fire from sensor.
e) The system has a provision for automatic sensitivity, i.e., as the detectors get polluted due to environment, its alarm limit is raised so that the deference between the immediate value of measuring signal and alarm limit practically

remains constant. If detectors are polluted to a limit and need cleaning, the control panel will give a warning.

f) The fire alarm control panel has LCD display to indicate the address of each device and clear text about the location of alarm/trouble. It will record the event with in the nonvolatile system historical memory.

g) Fire Alarm Control Panel has printer to print out the alarm/trouble occurrences.

h) The CPU is serving as the system's central processor. The Software is designed specially for fire alarm annunciation system applications and provide to monitor status for processing alarms according to priorities controlling processing communication and synchronizing all system activities.

i) The video display unit is the primary operator for data retrieval, alarm and annunciation commands and programming functions.

j) Field testing facility is provided by the system for either the complete system or a specified area while maintaining full function of areas which are not under test.

k) Each device individually identifiable for its type, its zone location, Alarm set value, Alarm and trouble indication by a unique alpha numeric label.

l) The Software logic modules and system data base is programmable using a MS Windows compatible program on PC Pentium. The system Software program is password protected and include full upload and download capability and out in program upload and down load through the PC the capability of alarm reporting is retained. The configuration of PC is from the latest available range with colour monitor of industrial grade.

m) The system includes Software for system data base historical event logging logic and operating system. The system requires no manual input to initialize in the even of a complete power down condition. It will return to an online status as an operating system, performing all program functions upon power restoration.

n) Activation of any fire alarm initiating device will display a message describing the device originating the alarm condition at the central monitoring station and at the repeat annunciation panel and will initialize the associated protection system are receipt of trouble report. It will display at the fire alarm control panel the origin of supervisory condition or origin of trouble condition as the case may be. It will also record accurately the event, the time of occurrence and the device initiating the same.

o) System configuration is menu driven and capable of being operated by a person with no previous computer programming experience.

p) In addition to the central monitoring station at Unit No.1, an annunciation panel is also provided in fire water pump house. This panel will indicate status of pumps, system pressure, hydrant system in operation, water spray system in operation etc. The central monitoring station will give audio visual annunciation for fire in each of risk areas, status of protection systems such as “Water spray on”/ “Gas system injected” status of fire water pumps, trouble status of detector cabling for detection associated with spray systems etc. Status of pumps of foam pump house and booster pump house will be provided on their respective local control panels and also major annunciation will be repeated to annunciation panel of fire water pump house.

q) Each set of batteries are capable of twelve hours back up supply in case of power supply failure.

r) The batteries are of SMF type lead acid maintenance free.

s) All the circuits from the detectors to the panels and the circuits from the panels to the actuating devices are closed loop type and are supervised for fault conditions. The trouble signal is annunciated in the respective panels also.

Details of the areas covered with fire detection system using various types of fire detectors:

01. Cable vaults / cable spreader rooms in main plant building and Switch Yard Control room buildings are covered with smoke detectors of both ionization and photo electric type in cross zoning principle supplemented with linear heat sensing cable are used to detect fire. The detection system is also hooked up with deluge system for automatic spraying of water in respective zone.
02. Switch Gear/MCC Rooms are provided with Smoke Detectors of ionization type for detection of fire in these areas
03. Control Room/ Control Equipment Room/ Computer Room are provided with Smoke Detectors of ionization types for detecting fire in above areas, however in addition to this photo electric type smoke detectors are also used for above false ceiling area. The cables associated with the control equipment room protection,

fire extinguishing system and its detection system as well all conveyor detection system are short term fire proof type.

04. Battery and battery charger rooms are fitted with Heat detectors operating on electronic principle for detecting fire in these rooms to avoid spurious operation of smoke detectors due to fumes, smoke and dust present in these areas.
05. Lube oil system, lube oil storage tanks and purifiers, Fuel Oil pump House, Coal handling plant / conveyors, BFP lube oil tanks, coolers, consoles etc. In all these areas quartzite bulb heat detectors are used to detect fires. LHS cable in addition to this is provided only for conveyors.
06. Oil filled transformers are fitted with Quartzite bulb as detectors.
07. Fuel Oil Tanks and Oil piping in the vicinity of tank form area are fitted with Quartzite bulb heat detection for automatic MVW spray system for cooling outside of tanks and pipe lines in the vicinity of tank. For foam system operations, Electrical Heat Detectors spot types are provided inside the FO Tank. Electrical Heat Detectors are of 'Rate - Compensated Type'.
08. Supply and return air ducts are fitted with Smoke Detectors of both ionization and photo electric type to detect the fire.
09. False Ceiling areas above Control Room are fitted with smoke detectors of both ionization and photo electric type to detect the fire.

B 4.1.3. FIRE STATION:

A full pledged Fire Station is available in the Plant which is managed by CISF-Fire Wing. The Fire Station has been equipped with all the required equipments for efficient operation of fire squad. The equipments include the following items mainly.

1. One multi-purpose fire Tender of 2500 Ltrs water capacity as per IS: 10460 : 2005 with all accessories as listed in relevant Indian standard
2. One multi-purpose fire Tender of 4000 Ltrs water capacity as per IS: 10460 : 2005 with all accessories as listed in relevant Indian standard
3. One Foam Tender as per IS: 10460 : 2005 with all accessories as listed in relevant Indian Standard.(to be procured)
4. One DCP Tender as per IS: 10993 : 1984 with all accessories as listed in relevant Indian Standard.

5. One no. Fire Jeep with Trailor Pump as per IS: 944 with all accessories as listed in relevant Indian Standard. (to be procured)
6. 10 Nos. Breathing Apparatus Sets.
7. 04 Nos. Fire Proximity Suits.
8. 02 Sets of First Aid Kits.
9. 02 Nos. Telescopic Ladders.
10. 02 Nos. Blower cum Exhausters, etc.

B 4.1.4. PERSONNEL INFRASTRUCTURE:

There is trained strength of 45 personnel are posted, CISF is manning the Fire station round the clock for fire prevention duties, stand by/hot job duties etc.

B 4.2. Resources for Toxic Leak

There has been a multilayer detection and protection system integrated to the Chlorination System at DM Plant (Ref. the Fig. B.4.2.). The resources for combating chlorine gas leakage includes, gas detectors provided near every possible leak sources, auto chlorine absorption system, manual leak arresting kits, ejection of water curtains(using hydrant water/ fire tender water) in the direction of wind.

Fig.B.4.2. Multilayer Chlorine leak protection system

B 4.2.1. Toxic Gas Detectors: 7 nos. of high sensitivity Chlorine gas detectors have been provided in the Chlorination Plant. These detectors are tested & calibrated at regular periodicity by C&I Department.

B 4.2.2. Equipment for plugging the leak: 3 nos. of Chlorine Leak arresting kits with all accessories are made available at Chlorination Plant for use of Operator / maintenance team to arrest the Chlorine leak from the Chorine Tonners. The operators are trained to use these kits effectively and timely in the event of any chlorine leakage from the container.

B **4.2.3. Trained manpower for plugging the leak:** The operators of DM plant/Chlorination Plant have been trained in use of Chlorine Leak Arresting kits. These operators shall be called for assistance, in case if they are on Off-duty during chlorine leak emergency. *List of Trained Manpower is at Annexure-1 (Table-k*).

B 4.3. Containment & Clean-up Resources:

Location / plant	Hazardous material	Resources	
		Containment	Clean-up
Chlorination Plant	Liquid Chlorine spills	The drains are connected to neutralization pit.	Water washing using hydrant water.
Acid/Alkali Storage tanks	HCl and NaOH	Dyke wall having capacity equallent to tank capacity. All drains connected to neutralization pit.	Water washing using hydrant water.
Fuel Oil Storage Tanks	LDO	Dyke wall having capacity equallent to tank capacity. All drains in the dyke wall are connected to Oil collection pit. From the pit, the collected oil shall be transferred to the tanks thro' transfer pumps.	The oil in the dyke is pushed to the pit manually. Soap water washing is done using hydrant water.
Power Transformers	Transformer Oil	Transformer foundation pit having equallent containment capacity of transformer tank with a draining arrangement to oil soak pit. Oil in the soak pit shall be collected in to drums.	Gravel from the pit is removed and both gravel and floor is washed with soap water.

B 4.4. Medical & First Aid: The following Medical and First aid facilities have been created at NTPC Gadarwara.

a. A 25 bedded Medical Centre (Hospital) is located at Township which is 1 KM from the Plant and is under construction. 4 regular and 2 adhoc doctors are already

posted. Various health care services are organized under Registration, Outpatient services, Diagnostic Services, In-patient Services and Emergency Services. The 24-hour health care service is ensured through shift doctors. The Ambulance services are available for immediate transfer of critical patients to higher centers for secondary and tertiary care. The patient care in emergencies is to provide immediate medical care and then secondary and/ or tertiary health care, in empanelled Hospitals. Out -patient care of the patients are also provided though regular doctors and visiting consultants. Health care of people residing in the periphery of NTPC GADARWARA is taken care of by organizing health camps and providing free treatment to the patients as corporate social responsibility.

b. Plant First Aid Centre has been setup in the Main Plant which extends 24 hour first aid services at Plant area with qualified Doctor, paramedical staff and essential first aid facilities. Ambulance service is also available at First aid centre.

B 4.4.1. Locations of First aid boxes : First Aid boxes are made available at the following locations of the plant. These boxes shall be inspected by a paramedic on regular basis for expired medicines, if any and to recoup the box with required material.

1. 765 KV Switchyard Control Room
2. DM Plant Control Room
3. Fuel Oil Pump House Control Room
4. CHP Control Room
5. Track Hopper Control Room
6. Plant Control Room (UCB)
7. Ash Handling Control Room
8. NTPC Stores (near Canteen)
9. CISF Fire Station Control Room
10. Hydrogen Plant Control Room
11. Admn. Building
12. Raw Water P/Hs Control Room
13. CW Water P/Hs Control Room
14. Central Stores
15. Office of GM(P)
16. Office of GM(O&M)
17. Office of GGM

B 4.4.2. Trained First aiders:

The paramedical staff strength of 15 persons deployed in the hospital and Plant First Aid Centre are trained first aiders. In addition to them employees of NTPC and employees of various outsourcing agencies working in the plant have been provided training on First Aid through St. John Ambulance certified trainer. These trained first

aiders shall assist the Medical Team in case of emergency. *List of First Aiders is given as Annexure – 1(Table-L).*

B 4.4.3. Internal medical facilities & supplies:

The Medical Centre is equipped with the following personnel, infrastructure and facilities.

i. General Doctors: 02 (NTPC) + 02 (Adhoc)
ii. Visiting Consultant Doctors: 04 (Gen. Physician, Dental, Ophthalmology and Pediatrician)
iii. Paramedical Staff:
    a) Staff Nurses & First Aider cum Dressers: 14
    b) Physiotherapist: 01
    c) Ambulance Drivers: 04
    d) Ambulance attenders : 02
iv. Ambulances :02 (out of which one is BLS)
v. In-patient services :
    a) Rooms/wards : 12
    b) Beds : 25
    c) ICU : 01
    d) Stabilization Centre : 01 (with 19 mandatory equipments)
vi. Essential infrastructure like Cardiac Monitor (defibrillator), Pulse-oxy meter, ECG Machines, Nebulizer etc. are made available in the Hospital.
vii. Physiotherapy Unit is available consisting of Cervical & Lumber Traction, Ultrasonic Therapy, Muscle Stimulator, Interferential Therapy, Continuous Passive Motion, Treadmill, Parallel Bar, Shoulder Wheel, Static Cycle, Wax Bath, etc.
viii. All diagnostic and investigation services are established with NABL accredited diagnostic centers for collecting samples at NTPC Medical Centre and submitting of reports online.

B 4.4.4. Hospitals nearby :

In the near vicinity of NTPC Gadarwara, the following major Government / Industrial Hospitals are available.

1. Govt. Civil Hospital, Gadarwara (16 KM)

2. Govt. District Hospital, Narasinghpur (40 KM)
3. Dayal Patho Services, Gadarwara

NTPC Gadarwara has empanelled the following hospitals at Bhopal (225 KM) and Jabalpur (135 KM).

1. Jabalpur Hospital and Research Centre, Jabalpur (135 KM)
2. Bansal Hospital, Bhopal
3. Chirayu Hospital, Bhopal

B 4.5. Personal Protection:

The following Personal Protective Equipments shall be made available for handling plant emergencies.

Sl. No.	Name of the PPE	Availability	
		Quantity	Location
1	Self Contained Breathing Apparatus	15	Fire Stn.
		05	DM Plant
		02	UCB
2	Acid/Alkali proof full body suits with hood	02	DM Plan
3	Aluminized Full body suits with hood	02	Fire Stn.
4	Fire proximity suits	05	Fire Stn.
5	Water jell blankets	06	Fire Stn.
6	Gum Boots	100	Stores
7	Safety Belts	50	Stores
8	Fall Arrestors	20	Stores
9	Safety Nets	20	Stores
10	Gas Masks with Canister suitable for Chlorine and Acid fumes	02	DM Plant
11	Barricading Tape rolls	50	Stores

B 4.6. Wind Direction / Speed Indicators:

Automatic Weather Monitoring Stations (AWMS) have been provided at Main Gate of the Plant and at three other locations on periphery of about 3 Kms from the plant. The AWMS at main gate will give various weather parameters like, wind direction, wind speed, temperatures, relative humidity, solar radiation, rain fall, evaporation etc. The data of all these parameters is logged and recorded in the system. The hourly data is monitored and recorded. This data is made available online in PCs and also displayed at various plant and township locations through digital display boards.

B 4.7. Mobilization of Internal Resources:

B 4.7.1. Affected Plant : All emergency resources of the affected plant, like PPEs, emergency tools & tackles available under the custody of the concerned plant

operation personnel shall be handed over to the rescue & maintenance team leaders for their used during handling of emergency.

B 4.7.2. Fire tender / Ambulance: Fire tenders shall be under the control of Asst. Commandant, CISF-Fire wing which will be mobilized according to the nature and extent of Fire. Plant Ambulance shall immediately rush and report to Works Incident Control soon after receiving the emergency message. However once the medical team arrives at incident site along with ambulances of Medical center, the plant ambulance shall also join the medical team.

B 4.7.3. Employees and visitors shifting to assembly points: The responsibility for shifting of visitor of the day to the notified Assembly Point shall lies with the concerned officer who called them inside. He should ensure that all visitors are assembled at assembly point and reported to the officer incharge at Assembly point.

B 4.7.4. Plant Vehicles: Once emergency is declared, all company vehicles shall report to head of Transport Team for further instructions.

B 4.7.5. Energizing Fire hydrant / Foam or other specified protection system:

A team comprising of AGM(Operation), AGM(MM-OS), Inspector(CISF-Fire), the duty Operator and maintenance technicians (Mechanical and C&I) shall organize for running of fire hydrant system and ensuring water pressure at Fire Water Pump House. They shall also decide to whether additional pumps required to be operated and arrange for the same.

They shall organize for start of foam hydrant, foam pourer system in case of fire emergency at Fuel Oil Pump House and other specified fire protection systems.

B 5. Procedure for returning to the normal operations

After cessation of emergency, Works Incident Controller will communicate to Chief Incident Controller about it. After verification of status, CIC will communicate to announce the "All clear" by instruction to sound the **"ALL CLEAR SIGNAL".**

B 6. Interface and lines of communications with off-site officials

(The contents of this topic shall be prepared after meeting with District Disaster Management Group, Narsinghpur before finalizing the Disaster management Plan.)

C. Emergency Assistance Telephone Roster

In case of emergency or mock-drill, all the Disaster Management team leaders should be informed by Shift Charge Engineer or his deputy by briefing about the incident. An emergency assistance telephone roster is made available in this document ***as Annexure-5***. This roster consisting of contact numbers of all the leaders of various teams constituted for Disaster Management, Mutual Aid organizations, empanelled hospitals, external institutions and authorities.

D. Training and Mock Drills on Disaster Management Plan

D 1. TRAINING :

Without training and rehearsals no disaster management plan can be successful. It should be made known to all the employees so that each knows his or her role in the event of emergency.

Every employee including the contractors' employee shall be provided detailed one-day training on Disaster Management Plan of Gadarwara at HR-EDC. Subsequently, refresher program shall be conducted every year. However, in case of any major changes made in DMP, additional programs shall be conducted to communicate to all the employees.

Head of HR-EDC and Head of Safety shall be responsible to organize in a planned manner the above said programs.

D 2. MOCK DRILLS:

The Mock Drills should be carried out step by step as stated below.

First Step:

Test the effectiveness of communication system.

Second Step:

Test the speed of mobilization of the plant emergency teams.

Third Step:

Test Emergency isolation and shut down and remedial measures taken on the system.

Fourth Step:

Conduct a full rehearsal of the actions to be taken during a major emergency.

The Disaster Management Plan should be periodically revised based on experiences gained from the Mock Drills. The Mock drills shall be conducted once in every three months.

D 2.1. Documentation:

The review outcome including apparent defects during mock-drills, other short comings if any, action plans for bridging the gaps, revision of DMP etc., shall be properly documented. Head of Safety shall be responsible for maintaining documentation.

E. Updating the Plan :

Emergency planning rehearsals and exercises shall be monitored by observers not involved in the exercise, and preferably independent of the site, e.g. senior officers from emergency services and factories inspectorate etc. After each exercise, the plan shall be thoroughly reviewed to take account of omissions or short comings and accordingly it is continually refined and updated. The changes in the plan shall be properly communicated to all the concerned.

E 1. Responsibility :

Head of Safety shall be responsible to undertake the plan appraisal and updating.

E 2. Protocol & Methodology and Revision of Plan

To evaluate the efficacy of Disaster Management Plan and to monitor the mock-drills, the Disaster Management Efficacy Monitoring Committee has been formed which meets once in every three months after conducting a mock-drill.

Station Head	- Chairman of the Committee
Head of O&M	- Vice Chairman
	(Alternative to Chairman in his absence)
Head of Project	- Member
Head of Operation	- Member
Head of Maintenance	- Member
Head of Medical	- Member
Head of HR	- Member

Head of CISF	- Member
Head of C&M	- Member
Head of Safety	- Convener

The committee shall review the following activities:

a) Functioning of Emergency Control Centre and availability of all facilities etc., as mentioned in the plan and its functional healthiness.

b) Ensure that all facilities as required under the plan from within or from nearby industries/aid centers under mutual assistance scheme or otherwise are available.

c) Ensure that the necessities under Mutual Aid Scheme are properly documented and the concerned employees are fully aware in this regard.

d) Ensure that area employees are fully aware to fight any emergency like sealing of chlorine leakage, fire fighting or other such causes.

e) Ensure that all employees are trained about their responsibilities/duties. They all are aware about evacuation routes, direction of evacuation and the equipments to be used during evacuation or the method of evacuation.

f) Evaluation of communication of the Disaster Management Plan to all segments of employees including evaluation of behavior of employees and others.

g) Ensure that all employees are fully trained in first aid, use of desired equipments including breathing apparatus, first aid box etc., are available at the desired location.

h) Ensure that all warning alarms are functional. Public address system is in healthy condition.

i) Ensure continual refining and updating of Disaster Management Plan.

E 3. Plan distribution list

Sl.No.	*Distributed to (Designation)*	*Date of Distribution*	*Remarks, if any*
1	Submitted to Director, HIS, GoMP, Indore	28.09.2020	For Approval
2	One hard copy to CGM / Occupier	28.09.2020	
3	One hard copy to GM(O&M) and Factory Manager	28.09.2020	For implementation
4	Soft Copy in NTPC Gadarwara Intranet	28.09.2020	For implementation

ANNEXURES

Annexure - 1

DISASTER MANAGEMENT TEAMS

The disaster management teams are dynamic and take changes as and when the employees get transfer or change of department. Hence the Annexure-1 shall be reviewed and revised once in every three months.

(a). SUPPORT TEAM TO CHIEF INCIDENT CONTROLLER

Sl No	Name Sh/Shri	Desg.	Dept.	Intercom No.		Mobile No.
				Off.	Res.	
01	Vinay Garg	GM	TS	5200	4200	9926999836
02	Ram Bhajan Malik	GM	Project	5350	4308	9650990113
03	Rachna Singh Bhal	GM	HR	5040	4540	9650993502
04	Dhanjay Shrikhande	AGM	EMG	5493	4204	9004497016
05	Gulbir Singh Chauhan	AGM	Safety	5090	-	9650992681
06	Neeraj Kumar	DC	CISF	-	1019	8130758331

(b). SUPPORT TEAMS TO WORK INCIDENT CONTROLLER

(a) TECHNICAL RESPONSE TEAM

Sl No	Name Sh/Shri	Desg.	Dept.	Intercom No.		Mobile No.
				Off.	Res.	
01	Probal Mundle	GM	Oprn	5656		9650991402
02	Manish Jain	AGM	FM	5673	-	9650993815
03	Kanchan Sing	AGM	Oprn	5540	4207	9425178495
04	Balkrishna G Setty	AGM	Envt. Mgt.	5192	-	9425827630
05	Vikas Dubey	DGM	AHP	5401	4101	9425304752

(b) FIRE AND RESCUE TEAM

Sl No	NAME Sh/Shri	Desgn.	Dept.	Phone No.		Mobile No.
				Off.	Res.	
01	Santosh Tiwari	AGM	Oprn	5490	1212	9424140766
02	Narendra Singh	AC	CISF/Fire	-	1010	7905262065
02	Harendra Singh	Inspector	CISF /Fire	-	1011	8447720100
03	Sudesh Chaudhary	Sr. Manager	ME	5358	3135	9425823148
04	Vivek Vishnoi	Dy. Mgr.	Safety	5094	3236	6265158644

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(c) MEDICAL RESPONSE TEAM:

Sl No	Name Sh/Shri	Desgn.	Dept.	Phone No.		Mobile No.
				Off.	Res.	
01	Dr. Milind Mannohar Sabde	CMO	M&HS	5100	4604	8004941288
02	Dr Alkeshbhai Rathva	GDMO	M&HS	5101		9879670793

(d) MAINTENANCE TEAM

Sl No	Name Sh/Shri	Desgn.	Dept.	Phone No.		Mobile No.
				Off.	Res.	
01	Anil Baweja	GM	Mech Maint	5155	-	9650990620
02	Ajay Dhamaniya	AGM	Elec. Erec.	5331	4104	9425819270
03	Arun Narayan	AGM	Elec. Maint.	5630	4304	7440406455
04	Amit Thakur	DGM	FM	5665	4507	8527597182
05	Prasanjit Roy	Sr. Mgr.	Mech.	5607	3142	9425283114

(e) SECURITY AND TRAFFIC CONTROL TEAM:

Sl No	Name Sh/Shri	Desgn.	Dept.	Phone No.		Mobile No.
				Off.	Res.	
01	Neeraj Kumar Patel	AC/Exe.	CISF	1032	-	9718981205
02	Vinod Harode	Inspector	CISF	1021	-	9425169836
03	Kapil Nigam	DGM	HR	5043	3221	9425816616
04	T.K. Soni	Asst Mgr	HR	5046	3121	9425283183

(f) ADMINISRATIVE TEAM:

Sl No	Name Sh/Shri	Desgn.	Dept.	Phone No.		Mobile No.
				Off.	Res.	
01	Akhila Patnaik	DGM	HR	5041	-	9424209178
02	Rohit Saxsena	Mgr.	HR	5044	3131	9425219979
03	Hari Shankar Joshi	Asst. Mgr	HR	5045	-	9425283703

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(g) SAFETY TEAM:

Sl No	Name Sh/Shri	Desgn.	Dept.	Phone No.		Mobile No.
				Off.	Res.	
01	Mayank Singh Sachan	AGM	MTP	5502	1210	9650991281
02	Girish Choudhary	DGM	Ash Handling	5402	3231	9425222250
03	Anup Mahashabde	Sr.Mgr.	Safety	5093	3301	9425816793

(h) COMMUNICATION TEAM

Sl No	Name Sh/Shri	Desgn.	Dept.	Phone No.		Mobile No.
				Off.	Res.	
01	Dipak Sahoo	GM	Elect. Maint	5429	1202	9437041758
02	Vijay Kumar Kanaujia	AGM	IT	5202	1207	9650994442
03	Sunil Rai	DGM	IT	5241	3226	9470001662
04	Kalyan Dhakad	Jr. Engg Gr-IV	IT	5243	2254	9425816475

(i) TRANSPORTATION TEAM

Sl No	Name Sh/Shri	Desgn.	Dept.	Phone No.		Mobile No.
				Off.	Res.	
01	Bharat Mishra	GM	ME	5351	-	9425036510
02	Deepak Tripathi	DGM	C&M	5016	-	9424141776
03	Devendra Manohar Dandekar	Asst Mgr.	HR	5047	-	9406928121

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(j) TRAINED MANPOWER TO PLUG THE CHLORINE LEAK

Sl. No.	Name Sh/Shri	Desgn	Deptt	Mobile No.
1.	Omkar Singh	DGM	Chemistry	9415244692
2.	Salvaraj Joseph Nadar	Sr. Manager	Chemistry	9425823229
3.	Ghanshyam Singh	Manager	Chemistry	9425222166
4.	Shyam Bihari Gupta	Dy. Mgr.	Chemistry	9425281075
5.	Mrinal Kanti Ghosh	Dy. Mgr.	Chemistry	9406711493
6.	Purushotham Katla	Officer	Chemistry	8074594704
7.	Purushotham Katla	Officer	Chemistry	8074594704

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Annexure-2

DETAILED INFORMATION ABOUT CHLORINE

CHEMICAL NAME & SYNONYMS	Chlorine
CHEMICAL FORMULA	C12
U.N.NUMBER	1017
U.N.CLASSIFICATION/NATURE	Class-2
CHARACTERISTICS/NATURE	Liquid in cylinders, Gas at Atmospheric temperature and pressure.
BOILING POINT DEG.C	-34.05 at 1 atm. Pr.
VAPOUR PRESSURE (mm Hg)	6.3 atm at 200 C
SOLUBILITY IN WATER	Slightly soluble
APPEARANCE AND ODOR	Greenish Yellow (gas). Clear amber (Liquid).Suffocating and pungent.
SPECIFIC GRAVITY	1.468 AT 00 C and 3.617 atm (liquid C12)
THRESHOLD LIMIT VALUE	1 ppm
MELTING POINT Deg.C.	-101 at 1 atm.
FIRE & EXPLOSION HAZARD	Neither liquid nor gaseous Chlorine is explosive or flammable by itself, but both react readily with many. Organic substances, usually with the evolution of heat and in some cases resulting in explosion.
HEALTH HAZARD NATURE	Corrosive Liquid
EFFECTS OF OVER EXPOSURE	Causes headache, restrostermal burning Nausea, Painful breathing, Sweating, eyes, nose, throat irritation, coughing, vomiting, increase in respiratory & pulse rate. Massive inhalation causes pulmonary oedema, fall of blood pressure and in a few minutes cardiac arrest.
EMERGENCY & FIRST AID	For eye and skin contact flush with plenty of water. Apply artificial respiration only if he is not breathing. Consult a Physician.
SPILL OR LEAKAGE STEPS TO BE TAKEN IN CASE CHLORINE IS RELEASED.	If a leak occurs keep the leaking valve on the upper side by rolling the cylinder to prevent discharge of liquid.
SPECIAL RESPIRATORY	Self contained breathing Apparatus.

PROTECTION	
PROTECTIVE GLOVES	Rubber or PVC
EYE PROTECTION	Goggles giving complete protection to eyes.
OTHER PROTECTIVE EQUIPMENTS	Rubber Aprons and Boots. Eye wash showers should be with the clean water.

HAZARDS OF CHLORINE AT DIFFERENT ATMOSPHERIC CONCENTRATIONS:

CHLORINE CONCENTRATION		DEGREE OF HAZARD
0.1-0.5	0.3-1.5	No noxious long term effect
0.5	1.5	Slight odor (tentative limit)
1-3	3-6	Definite odor, Irritation of eyes and nose
30	90	Intense coughing fits
40-60	120-180	Exposure without effective respirator for 30-60 minutes or more may cause serious damage.
100	300	May cause lethal damage
1000	3000	Danger to life even after a few deep inhalations.

HEALTH HAZARD:

Chlorine is mucous membrane and respiratory system irritant. It reacts with body moisture to form acids and at high concentration. It acts as an asphyxiant by causing cramps in the muscles of larynx and swelling of the mucous membranes. The presence of chlorine in the atmosphere is, to some extent, detectable by its characteristic odor and irritant properties. Consequently in the event of leakage, workers usually have sufficient warning to escape and avoid excessive exposure.

ACUTE EXPOSURE:

1. First Symptoms of exposure to chlorine are irritation to mucous membranes of eyes, nose and throat, which increases to smarting and burning pain – this irritation to the chest.
2. A reflex cough develops, which may be intense and often associated with pain behind the breast bone, the cough may lead to vomiting.
3. Cellular damage may occur with excretion of fluid in the alveoili which may prove fatal if adequate treatment is not given immediately (complete rest, Oxygen therephy, immediate transfer to hospital). Vomit frequently contains blood due to lesions of the mucous membrane caused by the gas.

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4. Other common symptoms include headaches, general indisposition anxiety and feeling of suffocation.
5. Massive inhalation produces pulmonary edema, fall of blood pressure and in a few minutes cardiac arrest.

CHRONIC EXPOSURE

Chlorine concentration considerably higher than current thereshold values may occur without being immediately noticeable; men rapidly looses their ability to detect the odor of chlorine in small concentrations.

1. Prolonged exposure to atmospheric Chlorine concentration of 5 ppm results in the disease of bronchi and predisposition to tuberculosis.
2. Lung studies have indicated that concentration of 0.8 to 1.0 ppm causes permanent, although moderate, reduction in pulmonary function.
3. Acne is not unusual in persons exposed for long period of time to low concentration of C12 and is commonly known as “CHLORANCE”.
4. Tooth enamel damage may also occur.

FIRST AID FOR CHLORINE EXPOSURE :

GENERAL :

- Caution-proper personal protective equipment should be worn to ensure your safety.
- Remove exposed persons to uncontaminated areas as quickly as possible.
- Remove contaminated clothing.
- Wash contaminated parts of the body with running water.
- Give nothing by mouth if the person is unconscious or convulsing.
- Call a physician at the earliest.
- Give assurance to the victim to alleviate his anxiety.

FIRST AID IN CASE OF CHLORINE GAS INHALATION

In case the victim is not breathing.

- Remove him to fresh air.
- Give artificial respiration immediately.
- Administer Oxygen by inhalation, as soon as possible, utilizing the services of trained personnel.

In case victim is breathing:

- Place patient in comfortable position.
- Encourage him to have slow deep regular breathing.

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- Administer Oxygen by inhalation, as soon possible, utilizing the services of trained personnel.
- Keep victim warm; keep him at rest.
- Render any other necessary first aid, if needed.
- Give assurance to the victim to alleviate his anxiety & obtain his co-operation.
- In severe cases position victim in chair. Have the victim lie down with the head trunk elevated to 45-60 position.

Effect of Chlorine on eyes:

- Flush eyes immediately with copious amounts of tepid running water for a minimum of 15 minutes.
- Hold eyelids apart of ensure complete irrigation of eye and lid tissues.
- Do not attempt chemical neutralization of any kind.
- Refer to a physician.

LIQUID CHLORINE SKIN CONTACT:

- Flush contaminated skin with copious amounts of running water for minimum of 15 minutes. Remove clothes from the victim's body, while in the shower, to ensure irrigation of all contaminated skin.
- Do not try chemical neutralization or apply any ointments to damaged skin.
- Refer to a physician if irritation persists after irrigation or if skin is broken or blistered.

CHLORINE EXPOSURE – MEDICAL RELIEF MEASURES:

For mild cases give the following:

- Cough syrup – 2 tea spoon (10 ml)
- Erasma – Ghlorospred + strepsil tablets.
- Hot tea or water to drink.

NOTE:- ONLY TRAINED PERSONS SHOULD GIVE THE ABOVE TREATMENT. IT IS ALWAYS ADVISABLE TO CONTACT QUALIFIED DOCTOR IN ALL SUCH CASES.

MEDICAL MANAGEMENT OF CHLORINE EXPOSURE :

GENERAL PRINCIPLES:

- All individuals who have been exposed to acute over exposure to chlorine gas by inhalation should be sent for medical treatment.
- For acute chlorine exposure no specific antidote is known. Prompt supportive measures can be taken to obtain good therapeutic results.

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- Victim's anxiety should be alleviated by communicating with him the various procedure undertaken and elicit has co-operation in breathing exercise.
- Position victim in chair. In severe cases the victim should lie down with the head trunk elevated to 45-60 degree position.
- Encourage the victim to take slow, regular respirations.
- Use of intermittent positive pressure breathing apparatus helps in minimizing the risk of pulmonary edema.
- Humidity air.

MEDICINES AND FACILITIES TO BE KEPT IN THE HOSPITAL:

Oxygen Cylinders.	.Injection Deriphylsind
Injection Periphyllin	Injection Lazix
Injection Decadron	.Injection Coramine
Erasma Tablets	Calroped Trablets
Lasix Tablets.	Strepsils/Lozenges.
Glucose Saline	I.V.Sets
5ml Syringes	2 ml Syringes.
Injection Needles	Stretchers

PREDICTING THE AREAS WHICH WILL BE AFFECTED BY THE CHLORINE CLOUD:

When a massive chlorine leak takes place in the plant, the escaping gas will spread to the neighboring areas. The spreading of chlorine cloud will depend upon the wind direction and speed and the amount of chlorine escaped.

BACKGROUND INFORMATION ON THE INITIAL ISOLATION AND PROTECTIVE ACTION DISTANCES TABLES:

The modeling of accident scenario carried-out to support the table was based on a range of package sizes used to transport each chemical. A "SMALL SPILL" refers to an incident with a container size equal to or smaller than 55 gallon drum (e.g. a small cylinder). A "LARGE SPILL" refers to a larger container size (e.g. one tone cylinder, a tank truck or railcar).

The releases from a given container (Toner) could be of three evaporation from a liquid pool, direct release of gaseous vapors into the air, or a combination of both, for evaporating liquid pools, the evaporation rates were calculated assuming a sunny day with 35 o C (95 o F) Deg air passing over the liquid pool. The maximum pool size for a "SMALL SPILL" that forms a liquid was assumed to be 48 feet. A "LARGE SPILL" was assumed to form a maximum liquid pool 60 feet in diameter.

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MATERIAL SAFETY DATA SHEETS

Annexure-3

1. CHLORINE

1. CHEMICAL IDENTITY

Chemical Name : CHLORINE — Chemical Classification : Toxic
Synonyms : Chlorgas, CLX, Bertholite — Trade Name

Formula Cl_2 — C.A.S. No. 7782-50-5 — U.N.No.: 1017

Regulated Identification
Shipping Name : Chlorine — Hazchem Code : 2XE
Codes/Label : Class 2.3, Toxic — Hazardous Waste ID No. : 17

HAZARDOUS INGREDIENTS	C.A.S.No	HAZARDOUS INGREDIENTS	C.A.S. No.
1. Chlorine	7782-50-5	3.	
2.		4.	

2. PHYSICAL / CHEMICAL DATA

Boiling Pt/Range : -34.04 — Physical State : Liquid/gas — Appearance : Greenish Yellow

Melting/Freezing Pt : - 105.5 — Vapour Pressure @ 35^0 C : 5.83x10+3mm Hg at 25^0 C — Odour : Pugent suffocating odour

Vapour Density : 2.5 (Air = 1) — Solubility in water at 30^0 C g/100ml : 0.57 g/100ml water @30^0 C — Others : Soluble in Alkalies, Chlorides and alcohols

Specific Gravity (Water = 1) : 1.4085 at 20^0 C (at5216 mmHg) — pH

3. FIRE/EXPLOSION HAZARD DATA

Flammability : No — LEL % : — Flash Point ^{0}C (OC) :

TDG Flammability : — UEL % : — Flash Point ^{0}C (CC) :

Auto ignition Temperature C : Not Pertinent
Explosion sensitivity to Impact : Stable
Explosion sensitivity to static Electricity : Stable
Hazardous Combustion Products : when heated, it emits highly toxic fumes
Hazardous Polymerization : Will Not Occur

Combustible Liquid	:No	Explosive Material	: No	Corrosive Material	: Yes
Flammable Material	:No	Oxidiser	: Yes	Others	
Pyrophoric Material	:No	Organic Peroxide	: No		

4. REACTIVITY DATA

Chemical Stability : Stable at normal temperatures and pressures

Incompatibility with other material : Combustible substances, finely divided metals.

Reactivity : Violent reaction with alcohols, explosive reaction with metals, potentially dangerous reaction with sulfides, trialkyl boranes. At normal temperatures dry chlorine does not attack steel, copper bronze etc. Moist chlorine is corrosive.

Hazardous Reaction Products : Taxic products are generated when combustibles burn in Chlorine.

5. HEALTH HAZARD DATA

Routes of entry : Inhalation Ingestion Skin & Eyes.

Effects of Exposure/ symptoms : Inhalation : Feeling of burning and suffocation, coughing, choking, laryngeal edema hypoxia and , in high concentrations, syncope and almost immediate death and may follow. Pulmonary edema is common after severe exposure. Skin : Demal explosure may cause erythema, pain irritation, and cutaneous burns. Eyes : Green hair, dental enamel erosion, inflammation of the eye, and nasal and throat irritation may occur. Anosmia is reported. Ingestion: Vomiting may occur following initial explore. Others : Death may result from suffocation.

Emergency Treatment :
Inhalation : Remove the victim to fresh air area, support respiration, give oxygen, if necessary
Skin : Remove contaminated clothing and wash exposed area thoroughly with soap and water. A physician should examine the area if irritation or pain persist.
Eyes : Flush with large amount of water for at least 15 mins. Seek Medical Aid Immediately for all types of exposures.
Ingestion : Seek Medical assistance.

LD50(Oral-rat) : Not Listed — STEL : 1 ppm

Permissible Exposure Limit : 1ppm (3 mg/m^3) — Odour Threshold : 0.0020 mg/l (water), 0.31ppm (air)

TLV (ACGIH) : 0.5 ppm — LC50 (rat) mg/kg : 260-344 ppm/1 hr.

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NFPA Hazard Singnals:	Health	Flammability	Reactivity	Special
	4	0	0	O

6. PREVENTIVE MEASURES

Personnel Protective Equipment **:** Provide PVC gloves, gumboots, rubber overcoat, heal mask, self-contained breating apparatus

Handling : Keep locked up and out of the reach of children (if sold to general public). Keep container in a well ventilated place. Container of this material may be hazardous when emptied.

Storage : Store in a cool, dry, relatively isolated, well ventilated place. Store in steel pressure cylinders in a cool, dry and outdoors or in well ventilated, detached or segregated areas of non combustible construction. Keep out of direct sunlight and away from heat and ignition sources. Cylinder tempartures should never exceed 51 dec C. Isolate from incompatible material . Store cylinders upright on a level floor secured in position and protected from physical damage. Use corrosion resistant lighting and ventilation systems in the storage area. Keep cylinders cover on. Lable empty cylinders. Store full cylinders separately from empty cylinders. Avoid storing cylinders for more than six months. Comply with applicable regulations for the storage and handling of compressed gases.

Precautions : Avoid contact with liquid vapours.

7. EMERGENCY/FIRST AID MEASURES

Fire :
Fire Extinguishing Media : Dry Chemical, Carbon dioxide, water spray, fog or foam.

Special Procedure : Keep the containers cool by spraying water if exposed to heat or flame. Wear self-contained breathing apparatus. Shut off gas supply. If not possible, let the fire burn.

Unusual Hazards : Container may explode in heat of fire. Poisonous gases are produced in fire.

EXPOSURE
First Aid Measures:
Inhalation : Remove the victim to fresh air area, support respiration, give oxygen, if necessary.
Skin : Remove contaminated clothing and wash exposed area thoroughly with soap and water. A physician should examine the area, if irritation or pain persists.
Eyes : Flesh with large amounts of water for at least 15 mins. Seek medial aid immediately.
Ingestion : Seek medial assistance.
Antidotes/Dosages : Oxygen.

SPILLS
Steps to be taken : Shut off leaks if without risk. Allow the gas to burn under control. Neutralize with dilute caustic soda (NaOH) or Soda ash (Na_2CO_3)
Waste Disposal Method : Refer 'Additional information'

8. ADDITIONAL INFORMATION / REFERENCES

Spillage control: Keep material out of water sources and sewers. Attempt to stop leak if without undue personal hazard. Do not apply water to point of leak in tank car or container. Apply water spray or mist to knock down vapours. Vapor knockdown water is corrosive or tixic and should be diked for containment. Land spill : Dig a pit, pond, lagoon, holding area to contain liquid or solid material. Dike surface flow using soil, sand bags, foamed plyurethane, or foamed concrete. Absorb bulk liquid with fly ash or cemented powder. Neutralize with dilute caustic soda (NaOH) or Soada ash(Na_2CO_3). Water spill: Add dilute caustic soda (NaOH). If dissolved, in region of 10 ppm or greater concentration, apply activated carbon at ten times the spilled amount. Use mechanical dredges or lifts to remove immobilized masses of pollutants and precipitates.
In case of large gas escapes, the presence of cloud can be marked with ammonia with which it will turn into a most. Run away from the gas clouds in a direction perpendicular to the wind direction. Avoid liquid chlorine from leaking and body contact. Persons with pulmonary diseases should aoid the exposure. Bring the leaking portion of the cylinder to the uppermost position, so that only the gas escapes and not the liquid.

9. MANUFACTURERS/SUPPLIERS DATA

Name of Firms	:	Contact Person : in Emergency	
Mailing Address	:	Local Bodies Involved :	,
Telegraphic Telex No:	.	Standard Packing :	
Telegraphic Address	:.	Term Card Details/Ref	:
Others	:		

10. DISCLAIMER

Information contained in this material data sheet is believed to be reliable but not representation, guarantee or warranties of any kind are made as its accuracy, suitability for a particular application or results to be obtained from them. It is up to the manufacturer/seller to ensure that the information contained in the material safety data sheet is relevant to the product manufactured/handled or sold by him as the case may be. The Government makes no warranties expressed or implied in the respect of the adequacy of this document for any particular purpose.

Reference: CPCB software

Chlorine

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2. SODUM HYDROXIDE

1. CHEMICAL IDENTITY

Chemical Name : SODIUM HYDROXIDE Chemical Classification : Explosive, Reactive, Oxidizing, Corrosive
Synonyms none : Caustic Soda, Soda lye, Lye, Sodium hydrate Trade Name :

Formula: NaOH C.A.S. No. 1310-73-2 U.N.No.: 1823/1824

Regulated Identification
Shipping Name : Sodium hydroxide, Solid/Solution Hazchem Code : 2W / 2R
Codes/Label : Class 8, Explosive, Reactive, Oxidizing, Corrosive
Hazardous Waste ID No. : 16

HAZARDOUS INGREDIENTS	C.A.S.No	HAZARDOUS INGREDIENTS	C.A.S. No.
1. sodium Hydroxide	1310-73-2	3.	
2.		4.	

2. PHYSICAL / CHEMICAL DATA

Boiling Pt/Range ^{0}C : 1388 Physical State : Solid Appearance : Colourless to white, solid (flakes, beads, granular form)
Melting/Freezing Pt ^{0}C: 323 Vapour Pressure @ 35^{0}C : 1mm Hg at 739^{0}C Odour : Odourless
Vapour Density : 2.5 Solubility in water Others : Soluble in alcohol, methanol and
(Air = 1) at 30^0 C g/100ml : 1.1 kg/L glycerol
Specific Gravity : 2.13 at 25^0 C pH : 13-14 (soln.)

3. FIRE/EXPLOSION HAZARD DATA

Flammability : No LEL % : Flash Point ^{0}C (OC) :
TDG Flammability : UEL % : Flash Point ^{0}C (CC) :

Autoignition Temperature C : Not Pertinent
Explosion sensitivity to Impact : Stable
Explosion sensitivity to static Electricity : Stable
Hazardous Combustion Products : Emits toxic fumes of Na_2O
Hazardous Polymerization : Will Not Occur

Combustible Liquid	:No	Explosive Material	: No	Corrosive Material	: Yes
Flammable Material	:No	Oxidiser	: No	Others	
Pyrophoric Material	:No	Organic Peroxide	: No		

4. REACTIVITY DATA

Chemical Stability : Stable
Incompatibility with other material : Water, acids, flammable liquids, organic halides, metals, Al, Sn, Zn, nitromethane
Reactivity : Vigorous reaction with organic halides, metals, nitro compounds.
Hazardous Reaction Products :

5. HEALTH HAZARD DATA

Routes of entry : Inhalation Ingestion Skin & Eyes.

Effects of Exposure/ symptoms : Inhalation : Causes small burns to upper respiratory tract and lungs, mild nose irritation. Ingestion: causes severe damage to mucous membrane. Severe scaring or perforation may occur. Eyes : Severe damage. Skin: Causes severe burns.

Emergency Treatment :
Inhalation : Remove the victim from exposure. Support respiration, give oxygen, if necessary
Skin : Get Medical aid. Flush skin with plentyof soap and water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Discard contaminated clothing in a manner which limits further exposure.
Eyes : Get medical aid. Do not allow victim to rub or keep eyes closed. Extensive irrigation is required (at least 30 mins).
Ingestion : Do not induce vomiting. If victim is conscious and alert, give 2-4 cupfuls of milk or water. Get Medical aid immediately.

LD50(Oral-rat) : Not Listed STEL :
Permissible Exposure Limit : 2 mg/m^3 Odour Threshold :
TLV (ACGIH) : 2 mg/m^3 LC50 (rat) mg/kg :

NFPA Hazard Signals:	Health	Flammability	Reactivity	Special
	3	0	0	

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6. PREVENTIVE MEASURES

Personnel Protective Equipment **:** Avoid contact with solid or liquid. Provide side covered safety goggles, face shield, dust type respirator, rubber shoes and rubber gloves.

Handling : Wash thoroughly after handling. Do not allow water to get into the container because of violent reaction. Minimize dust generation and accumulation. Avoid contact with eyes, skin, and clothing. Keep container tightly closed. Avoid ingestion and inhalation. Use with adequate ventilation. Discard contaminated shoes.

Storage : Store in tightly closed container. Store in a cool, dry, well-ventilated area away from incompatible substances, corrosives area. Store protected from moisture.

Precautions :

---

7. EMERGENCY/FIRST AID MEASURES

Fire :

Fire Extinguishing Media :

Special Procedure : Keep the containers cool by spraying water if exposed to heat or flame.

Unusual Hazards : Toxic gases are produced.

EXPOSURE

First Aid Measures:

Inhalation : Remove the victim from exposure. Support respiration, give oxygen, if necessary.

Skin : Get Medical aid. Flush with plenty of soap and water for atleast 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Discard conntaminted clothing in a manner which limits further exposure.

Eyes : Get meical aid. Do not allow victim to rub or keep eyes closed. Extensive irrigation is required(at least 30 mins).

Ingestion : Do not induce vomiting. If victim is conscious and alert, give 2-4 cupfuls of milk or water. Get Medical aid immediately.

Antidotes/Dosages :

SPILLS

Steps to Be taken : Sweep and collect without making dust. Wash the surface with plenty of water and soap.

Waste Disposal Method : Seal all waste in vapour-tight plastic bags for eventualdisposal.

---

8. ADDITIONAL INFORMATION / REFERENCES

Vigorous reaction with 1,2,4,5 – Tetrchlorobenzene has caused many industrial explosions and forms extremely toxic 2,3,7,8 – Tetrachlorodibenzodioxin. Under proper conditions of temperature, pressure and state of division, it can react or ignite violently with acetic acid, acetaldehyde, acetic anydribe, acolein, acrylonitrile, allyl alcohol, allyl chloride.

---

9. MANUFACTURERS/SUPPLIERS DATA

Name of Firms	:	Contact Person : in Emergency	
Mailing Address	:	Local Bodies Involved :	,
Telegraphic Telex No:.		Standard Packing :	
Telegraphic Address :.		Term Card Details/Ref :	
Others	:		

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Reference: CPCB software

Sodium Hydroxide

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3. SULPHURIC ACID

1. CHEMICAL IDENTITY

Chemical Name : Sulphuric acid — Chemical Classification : Corrosive
Synonyms none : Oil of vitriol, Battery acid, Chamber acid, Spent sulphuric acid — Trade Name :

Formula: H_2SO_4 — C.A.S. No. 7664-93-9 — U.N.No.: 1830

Regulated Identification
Shipping Name : Sulphuric acid — Hazchem Code : 2W / 2R
Codes/Label : Class 8, Corrosive
Hazardous Waste ID No. : 16

HAZARDOUS INGREDIENTS	C.A.S.No	HAZARDOUS INGREDIENTS	C.A.S. No.
1. Sulphuric acid	7664-93-9	3.	
2.		4.	

2. PHYSICAL / CHEMICAL DATA

Boiling Pt/Range ^{0} C : about 290^0 C — Physical State : Liquid — Appearance : Colourless to dark brown, Oily liquid
Melting/Freezing Pt ^{0} C: 10.31^0 C — Vapour Pressure @ 35^0 C : 5.93x10-5mm Hg at 25^0 C — Odour : Odourless, choking when hot
Vapour Density : 3.4 (Air = 1) — Solubility in water at 30^0 C g/100ml : Miscible — Others : Miscible with alcohol
Specific Gravity (Water = 1) : 1.8 g/cm^3 — pH : 1 N sol=0.3, 0.1 N sol=1.2, 0.01N sol=1.2

3. FIRE/EXPLOSION HAZARD DATA

Flammability : No — LEL % : — Flash Point ^{0}C (OC) :
TDG Flammability : — UEL % : — Flash Point ^{0}C (CC) :

Autoignition Temperature C :
Explosion sensitivity to Impact : Stable
Explosion sensitivity to static Electricity : Stable
Hazardous Combustion Products : Emits toxic fumes of SOx
Hazardous Polymerization : Will Not Occur

Combustible Liquid	:No	Explosive Material	: No	Corrosive Material	: Yes
Flammable Material	:No	Oxidiser	: Yes	Others	:
Pyrophoric Material	:No	Organic Peroxide	: No		

4. REACTIVITY DATA

Chemical Stability : Stable
Incompatibility with other material : Organic chlorates, carbides, fulminates, picrates, metal

Reactivity : Powerful acidic oxidizer, ignites or explodes on contact with many materials like acetic acid, acetone cyanohydrin, (acetone+HNO3), (acetone + K2CR2O7), acetonitrile, acrolein, acrylonitrile

Hazardous Reaction Products : Reacts with many metals to form flammable hydrogen gas which forms explosive mixtures with air. Reacts with water to produce heat and toxic and corrosive fumes.

5. HEALTH HAZARD DATA

Routes of entry : Inhalation Ingestion Skin & Eyes.

Effects of Exposure/ Symptoms : Inhalation of vapour from hot cone, acid may cause injury to lungs. Swallowing may cause injury or death. Contact with skin or eyes causes severe burns. Very dilute solution causes dermatitis. Exposure causes bronchitis.

Emergency Treatment :
Inhalation : Observe the victim for delayed pulmonary reaction. Move him to fresh air. Give artificial respiration.
Skin : Remove clothes and shoes. Do not use oil or ointment. Flush affected area with plenty of water.
Eyes : Wash with plenty of water for 15 mins.
Ingestion : Give plenty of water to drink, do not induce vomiting. Seek medical aid.

LD50(Oral-rat)	: 2140 mg/kg	STEL	:
Permissible Exposure Limit	: 1 mg/m^3	Odour Threshold	: 1 mg/m^3
TLV (ACGIH)	: 0.2 mg/m^3	LC50 (rat) mg/kg	: 347 ppm/1 hr.

NFPA Hazard Signals:	Health	Flammability	Reactivity	Special
	3	0	2	W

6. PREVENTIVE MEASURES

Personnel Protective Equipment **:** Do not eat or drink at work place. Provide safety shower, eye was basin, safety goggles/face shield respirator (self contained or airline), rubber shoes, rubber gloves, rubber apron.

Handling : Wash thoroughly after handling. Remove contaminated clothing and wash before reuse. Do not get in eyes, on skin, or on clothing. Keep container tightly closed. Do not ingest or inhale. Do not allow contact with water. Use only in a chemical fume hood. Discard contaminated shoes. Keep from contact with moist air and steam.

Storage : Do not store near combustible material. Keep container closed when not in use. Store in cool, dry, well-ventialted area away from compatible substances. Store protected from moisture.

Precautions : Avoid contact with the material.

---

7. EMERGENCY/FIRST AID MEASURES

Fire :
Fire Extinguishing Media : Dry chemical or carbon dioxide. Do not use water.
Special Procedure : Keep the containers cool by spraying water if exposed to heat or flame.
Unusual Hazards : Poisonous gas may be produced.

EXPOSURE
First Aid Measures:
Inhalation : Observe victim for delayed pulmonary reaction. Move him to fresh air. Give artificial respiration.

Skin : Remove clothes and shoes. Do not use oil or ointment. Flush affected area with plenty of water.
Eyes : Get medical aid. Do not allow victim to rub or keep eyes closed. Extensive irrigation is required(at least 30 mins).
Ingestion : Give plenty of water to drink, do not induce vomiting. Seek Medical aid.
Antidotes/Dosages :

SPILLS
Steps to be taken : Shut off leaks if without risk. Contain leaking liquid on sand or earth. Do not absorb on sawdust or other combustibles.
Waste Disposal Method :

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8. ADDITIONAL INFORMATION / REFERENCES

Sensitivities to Sulphuric acid mists or vapours vary with individuals. Contact with water creates violent reaction generating much heat and splattering of hot acid. Attacks many metals, liberating hydrogen which is inflammable and form explosive mixture with air.

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9. MANUFACTURERS/SUPPLIERS DATA

Name of Firms :
Contact Person in Emergency :
Mailing Address :
Local Bodies Involved : ,
Telegraphic Telex No:.
Standard Packing :
Telegraphic Address :.
Term Card Details/Ref :
Others :

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Reference: CPCB software

Sulphuric Acid

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4. FERRIC CHLORIDE

1. CHEMICAL IDENTITY

Chemical Name : FERRIC CHLORIDE
Synonyms none :
Chemical Classification : Corrosive
Trade Name :

Formula: $FeCl_3$ C.A.S. No. 7705-08-0 U.N.No.: 1773

Regulated Identification
Shipping Name : Ferric Chloride Hazchem Code : 3W / 2R
Codes/Label : Class 8, Corrosive
Hazardous Waste ID No. : 16

HAZARDOUS INGREDIENTS	C.A.S.No	HAZARDOUS INGREDIENTS	C.A.S. No.
1. Ferric Chloride	7705-08-0	3.	
2.		4.	

2. PHYSICAL / CHEMICAL DATA

Boiling Pt/Range ^{0}C : 316^{0}C	Physical State : Solid	Appearance : Solid,
Melting/Freezing Pt ^{0}C: 306^{0}C	Vapour Pressure @ 35^0 C : not applicable	Odour :
Vapour Density : 5.61 (Air = 1)	Solubility in water at 30^{0}C g/100ml : soluble in cold water	Others :
Specific Gravity (Water = 1) : 2.9	pH : 2 (acidic)	

3. FIRE/EXPLOSION HAZARD DATA

Flammability : No	LEL % :	Flash Point ^{0}C (OC) :
TDG Flammability :	UEL % :	Flash Point ^{0}C (CC) :

Autoignition Temperature C :
Explosion sensitivity to Impact : NA
Explosion sensitivity to static Electricity : NA
Hazardous Combustion Products : NA
Hazardous Polymerization : Will Not Occur

Combustible Liquid	:No	Explosive Material	: No	Corrosive Material	: Yes
Flammable Material	:No	Oxidiser	: No	Others :	
Pyrophoric Material	:No	Organic Peroxide	: No		

4. REACTIVITY DATA

Chemical Stability : Stable
Incompatibility with other material : May undergo hazardous decomposition, condensation or polymerization.
Reactivity : May become self-reactive under conditions of shock or increase in temperature or pressure
Hazardous Reaction Products : May react violently with water to emit toxic gases

5. HEALTH HAZARD DATA

Routes of entry : Inhalation Ingestion Skin & Eyes.
Effects of Exposure/ symptoms : Very hazardous in case of ingestion. Hazardous in case of skin contact (irritant), of eye contact (irritant), of inhalation. Severe over-exposure can produce lung damage, chocking, unconsciousness or death.

Emergency Treatment :
Inhalation : Observe the victim for delayed pulmonary reaction. Move him to fresh air. Give artificial respiration.
Skin : Remove contaminated clothes and shoes. Place victim under deluge shower. Flush affected area with plenty of water.
Eyes : Wash with plenty of water for 15 mins.
Ingestion : Give plenty of water to drink, do not induce vomiting. Seek medical aid.

LD50(Oral-rat)	: 900 mg/kg [rat]	STEL	:
Permissible Exposure Limit	: 1 mg/m^3	Odour Threshold	: 1 mg/m^3
TLV (ACGIH)	: 2 mg/m^3	LC50 (rat) mg/kg	:

NFPA Hazard Signals:	Health	Flammability	Reactivity	Special
	3	0	2	W

6. PREVENTIVE MEASURES

Personnel Protective Equipment **:** Provide safety shower, eye was basin, safety goggles/face shield, vapour/dust respirator, synthetic apron.

Handling : Wash thoroughly after handling. Remove contaminated clothing and wash before reuse. Do not get in eyes, on skin, or on clothing. Keep container tightly closed. Do not ingest or inhale.

Storage : Keep container closed when not in use. Store in cool, dry, well-ventilated area.

Precautions: Avoid contact with the material.

---

7. EMERGENCY/FIRST AID MEASURES

Fire :

Fire Extinguishing Media : NA

Special Procedure : Keep the containers cool by spraying water if exposed to heat or flame.

Unusual Hazards : NA

EXPOSURE

First Aid Measures:

Inhalation : Allow the victim to rest in a well ventilated area. Seek immediate medical attention.

Skin : Remove contaminated clothes and shoes. Do not use oil or ointment. Wash affected area with plenty of water and non abrassive soap. Be particularly careful to clean folds, crevices, creaes and groin. Cold water may be used. If irritation persists, seek medical attention.

Eyes : Check for and remove any contract lenses. Immediately flush eyes with running water for at least 15 mins. Keep eye lids open. Cold water may be used. Do not use an eye ointment. Seek medical help.

Ingestion : Give plenty of water to drink, do not induce vomiting. Seek Medical aid.

Antidotes/Dosages :

SPILLS

Steps to be taken : Use appropriate tools to put the spilled solid in a convenient waste disposal container. If necessary, neutrlise the residue with a dilute solution of sodium carbonate.

Waste Disposal Method :

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8. ADDITIONAL INFORMATION / REFERENCES

The substance is toxic to lungs, mucous membranes. Never add water to this product. Avoid shock and friction. In case of large spill, do not touch spilled material. Use water spray to reduce vapours. Prevent entry into sewers, basements ad confined areas.

---

9. MANUFACTURERS/SUPPLIERS DATA

Name of Firms	:	Contact Person : in Emergency	
Mailing Address	:	Local Bodies Involved :	,
Telegraphic Telex No:.		Standard Packing :	
Telegraphic Address :.		Term Card Details/Ref :	
Others	:		

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Reference: CPCB software

Ferric Chloride

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5. HYDROGEN

1. CHEMICAL IDENTITY

Chemical Name : HYDROGEN
Synonyms none :
Chemical Classification : Flammable, Reactive
Trade Name :

Formula: H_2 | C.A.S. No. 1333-74-0 | U.N.No.: 1049

Regulated Identification
Shipping Name : Hydrogen
Codes/Label : Class 2.1, flammable, reactive
Hazardous Waste ID No. : 17
Hazchem Code : 2SE

HAZARDOUS INGREDIENTS	C.A.S.No	HAZARDOUS INGREDIENTS	C.A.S. No.
1. Hydrogen	1333-74-0	3.	
2.		4.	

2. PHYSICAL / CHEMICAL DATA

Boiling Pt/Range ^{0} C : -252.8^0 C
Physical State : Gas
Appearance : Colorless
Melting/Freezing Pt ^{0} C: -259.2deg C @ 54 mm Hg^0 C
Vapour Pressure: 1.24X10+6 mm Hg at 25 deg C
Odour : Oderless
Vapour Density (Air = 1): 0.07
Solubility in water : 1.7 mg/L (20 deg C)
Others :
Specific Gravity (Water = 1) : 0.069 (gas); 0.0700 @ BP (liq)

3. FIRE/EXPLOSION HAZARD DATA

Flammability : Yes
LEL % : 4.1
Flash Point ^{0}C (OC) :
TDG Flammability : 2
UEL % : 74.2
Flash Point ^{0}C (CC) :

Autoignition Temperature C 400
Explosion sensitivity to Impact : Stable
Explosion sensitivity to static Electricity : Explodes
Hazardous Combustion Products : NA
Hazardous Polymerization : Will Not Occur

Combustible Liquid	:No	Explosive Material	: Yes	Corrosive Material	: No
Flammable Material	:Yes	Oxidiser	: No	Others	:
Pyrophoric Material	:No	Organic Peroxide	: No		

4. REACTIVITY DATA

Chemical Stability : Stable
Incompatibility with other material : Water. No chemical reaction with common materials but low temperature causes most materials to become very brittle.

Reactivity : Violent reaction or ignition with air + catalysts (platinum and similar metals containing absorbed oxygen or hydrogen), bromine, iodine, dioxane + nickel , lithium, nitrogen trifluoride, nickel + oxygen, oxygen difluride, Pd + isopropyl alcohol.

Hazardous Reaction Products : It forms sensitive explosive mixtures with bromine, chlorine, iodine heptafluride, chlorine dioxide, dichlorine oxide, dinitrogen oxide.

5. HEALTH HAZARD DATA

Routes of entry : Inhalation, Ingestion, Skin and Eyes.

Effects of Exposure/ symptoms : It is an inert, non toxic gas. In high concentration acts as a simple asphyxiant. If atmosphere does not contain enough oxygen, inhaltion can cause dizziness, unconsciousness or even death. Contact of liquid with eyes or skin causes freezing similar to burn.

Emergency Treatment :
Inhalation : If victim is unconscious (due to oxygen deficiency), move him to fresh air and apply resuscitation methods; call physician.
Skin : Treat for frostbite, soak the skin in lukewarm water. Seek medical aid.
Eyes : Treat for frostbite.
Ingestion : Seek medical assistance.

LD50(Oral-rat) :
Permissible Exposure Limit : Asphyxiant
TLV (ACGIH) :
STEL :
Odour Threshold :
LC50 (rat) mg/kg :

NFPA Hazard Signals:	Health	Flammability	Reactivity	Special
	0	4	0	

6. PREVENTIVE MEASURES

Personnel Protective Equipment **: Avoid contact with liquid or gas. Provide safety googles, face shield, insulated gloves and long sleeved, trousers worn outside boots or over high-top shoes, self - contained breathing apparatus containing air (never use oxygen).**

Handling : Containers of this material may be hazardous when emptied. Since emptied containers retain product residues (vapor, liquid, and/or solid), all hazard precautions given in the data sheet must be observed.

Storage : Store in a cool, fire-proof, well ventilated area, separated from other cylinders, preferably in open air.

Precautions:

---

7. EMERGENCY/FIRST AID MEASURES

Fire :

Fire Extinguishing Media : Stop flow of gas. Let fire burn under control.

Special Procedure : Keep the containers cool by spraying water if exposed to heat or flame..

Unusual Hazards : Flashback along gas trail may occur.

EXPOSURE

First Aid Measures:

Inhalation : If victim is unconscious (due to oxygen deficiency), move him to fresh air and apply resuscitation methods; call physician.

Skin : Treat for frostbite, soak the skin in lukewarm water. Seek medical aid.

Eyes : Treat for frostbite..

Ingestion : Seek medical assistance.

Antidotes/Dosages :

SPILLS

Steps to be taken : Shut off leaks if without risk. Warn everybody - explosion hazard.

Waste Disposal Method : To be burnt under control condition.

---

8. ADDITIONAL INFORMATION / REFERENCES

Practically no toxicity, except that is an asphyxiant. Highly dangerous fire and severe explosion hazard when exposed to heat, flame and oxidisers. Flammable or explosive when mixed with air, O2 , Cl2. Vigorous exothermic reactions with benzene + raney nickel catalysts, metals (like strontium, sodium, potassium, barium - above 300 C.) Ventilate at highest points.

---

9. MANUFACTURERS/SUPPLIERS DATA

Name of Firms	:	Contact Person : in Emergency	
Mailing Address	:	Local Bodies Involved :	,
Telegraphic Telex No:.		Standard Packing :	
Telegraphic Address :.		Term Card Details/Ref :	
Others	:		

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Reference: CPCB software

Hydrogen

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6. HYDROCHLORIC ACID

1. CHEMICAL IDENTITY

Chemical Name : Hydrochloric acid — Chemical Classification : Toxic, Corrosive
Synonyms none : Anhydrous hydrogen chloride, Anhydroushydrochloric acid — Trade Name :

Formula: HCl — C.A.S. No. 7647-01-0 — U.N.No.: 1050

Regulated Identification
Shipping Name : Hydrochloric acid — Hazchem Code : 2RE
Codes/Label : Class 2.3, Toxic, Corrosive
Hazardous Waste ID No. : 17

HAZARDOUS INGREDIENTS	C.A.S.No	HAZARDOUS INGREDIENTS	C.A.S. No.
1. Hydrochloric acid	7647-01-0	3.	
2.		4.	

2. PHYSICAL / CHEMICAL DATA

Boiling Pt/Range ^{0}C : -85.06^{0}C — Physical State : Liquid — Appearance : Colorless
Melting/Freezing Pt ^{0}C : -114.9^{0}C — Vapour Pressure : 31701.2 mmHg (21.1 deg C) — Odour : Pungent odour
Vapour Density (Air = 1) : 1.64 g/l — Solubility in water : 82.3 g/100 mL at 0 deg C — Others :
Specific Gravity (Water = 1) : 1.18 g/cm 3

3. FIRE/EXPLOSION HAZARD DATA

Flammability : Yes — LEL % : 4.1 — Flash Point ^{0}C (OC) : 11
TDG Flammability : 2 — UEL % : 74.2 — Flash Point ^{0}C (CC) :

Autoignition Temperature C :
Explosion sensitivity to Impact :
Explosion sensitivity to static Electricity :
Hazardous Combustion Products : At high temperatures, it decomposes into hydrogen and chlorine
Hazardous Polymerization :

Combustible Liquid : — Explosive Material : — Corrosive Material : Yes
Flammable Material : — Oxidiser : No — Others :
Pyrophoric Material : — Organic Peroxide :

4. REACTIVITY DATA

Chemical Stability : Stable - contact with common metals produces hydrogen which may form explosive mixtures with air.
Incompatibility with other material : Hydroxides, amines, alkalis, copper, brass, zinc and many other metals.

Reactivity : Reacts rapidly and exothermically with bases of all kinds. Reacts exothermically with carbonates and hydrogen carbonates to generate carbon dioxide. Reacts with sulfides, carbides, borides, phosphides, many metals to generate flammable hydrogen gas.

Hazardous Reaction Products : Carbon dioxide, flammable hydrogen gas.

5. HEALTH HAZARD DATA

Routes of entry : Inhalation, Ingestion, Skin and Eyes.

Effects of Exposure/ symptoms : Inhalation : Changes in breathing pattern, irritation, changes in pulmonary function, corrosion and edema of the respiratory tract, chronic bronchitis and noncardiogenic pulmonary edema have been observed. Ingestion : Gastritis, burns, gastric hemorrhage, dilation, edema, necrosis, and strictures may occur. Skin : Burns, ulceration, scarring, blanching, and irritation may occur. Eye : Dental discoloration or erosion, bleeding gums, corneal necrosis, inflammation of the eye, eye and nasal irritation, nasal ulceration, nose bleeds, throat irritation and ulceration have been observed.

Emergency Treatment :
Inhalation : Remove person to fresh air; keep him warm and quiet and get medical attention immediately; start artificial respiration if breathing stops.
Skin : Remove and isolate contaminated clothing and shoes. Immediately flush with running water for at least 20 minutes. For minor skin contact, avoid spreading material on unaffected skin.
Eyes : Irrigate exposed eyes with copious amounts of tepid water for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist, the patient should be seen in a health care facility.
Ingestion : Have person drink water or milk; do not induce vomiting.

LD50(Oral-rat) : — STEL :
Permissible Exposure Limit : — Odour Threshold : 7.0 mg/m3
TLV (ACGIH) : 5 ppm(7 mg/m3) — LC50 (rat) mg/kg :

NFPA Hazard Signals:	Health	Flammability	Reactivity	Special
	3	0	1	

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6. PREVENTIVE MEASURES

Personnel Protective Equipment **:** Wear appropriate chemical protective clothing. Wear positive pressure self-contained breathing apparatus.

Handling : Containers of this material may be hazardous when emptied. Since emptied containers retain product residues (vapor, liquid, and/or solid), all hazard precautions given in the data sheet must be observed. Emergency eyewash fountains and safety showers should be available in the immediate vicinity of potential exposure. Do not puncture or incinerate containers.

Storage : Keep away from oxidizing agents, particularly nitric acid and chlorates. Safeguard containers against mechanical injury. Precautions:

---

7. EMERGENCY/FIRST AID MEASURES

Fire :
Fire Extinguishing Media : Extinguish fire using agent suitable for type of surrounding fire. (Material itself does not burn or burns with difficulty.)
Special Procedure : Cool all affected containers with flooding quantities of water. Apply water from as far a distance as possible. Use water spray to knock-down vapors.

Unusual Hazards : Vapors from liquefied gas are initially heavier than air and spread along ground. Some of these materials may react violently with water. Containers may explode when heated. Ruptured cylinders may rocket.

EXPOSURE
First Aid Measures:
Inhalation : Remove person to fresh air; keep him warm and quiet and get medical attention immediately; start artificial respiration if breathing stops.

Skin : Remove and isolate contaminated clothing and shoes. Immediately flush with running water for at least 20 minutes. For minor skin contact, avoid spreading material on unaffected skin.
Eyes : Irrigate exposed eyes with copious amounts of tepid water for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist, the patient should be seen in a health carefacility.

Ingestion : Have person drink water or milk; do not induce vomiting. Antidotes/Dosages :

---------- SPILLS
Steps to be taken : Attempt to stop leak if without undue personnel hazard. Waste Disposal Method : See "Additional information"..

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8. ADDITIONAL INFORMATION / REFERENCES

Material may burn but does not ignite readily.
Contact with common metals produces hydrogen which may form explosive mixtures with air.
Spillage treatment: Keep material out of water sources and sewers. Use water spray to knock-down vapors. Neutralize spilled material with crushed limestone, soda ash, or lime. Do not use water on material itself. Vapor knockdown water is corrosive or toxic and should be diked for containment. Land spill: Dig a pit, pond, lagoon, holding area to contain liquid or solid material. Dike surface flow using soil, sand bags, foamed polyurethane, or foamed concrete.

---

9. MANUFACTURERS/SUPPLIERS DATA

Name of Firms : Contact Person :
in Emergency
Mailing Address : Local Bodies Involved : ,
Telegraphic Telex No:. Standard Packing :
Telegraphic Address :. Term Card Details/Ref :

Others :

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10. DISCLAIMER

Information contained in this material data sheet is believed to be reliable but not representation, guarantee or warranties of any kind are made as its accuracy, suitability for a particular application or results to be obtained from them. It is up to the manufacturer/seller to ensure that the information contained in the material safety data sheet is relevant to the product manufactured/handled or sold by him as the case may be. The Government makes no warranties expressed or implied in the

Annexure - 4

CONTACT NUMBERS OF DISTRICT AUTHORITIES / INDUSTRIAL HEALTH & SAFETY DEPARTMENT

S.No.	NAME OF THE INSTITUTION/ OFFICER	OFFICE	RESIDENCE
1	Collector Narsinghpur	230900	230901
2	Upper Collector (ADM)	232150	
3	Superintendent of Police	230941	230903
4	Commissioner, Labour	0731-2432822 0731-2545645	---
5	Director, Industrial Health & Safety (Indore)	0731-2533482	---
6	Dy. Director, Industrial Health & Safety (Jabalpur)	0761-2429463	---
7	SDM, Gadarwara	07791-255732	---
8	SDOP, Gadarwara	07791- 254888	---
9	Tehsildar, Gadarwara	07792-270301	---
10	Civil Hospital, Gadarwara	07791-254820	---
11	C.E.O.(Jila Panchayat)	230247	---
12	Chief Med. Health Officer	230480	230447
13	Divisional Forest Officer	230624	230457
14	Supt. Engineer (M.P.E.B.)	230630	230631
15	Executive Eng. (M.P.E.B.)	230396	230397
16	Executive Engineer (P.W.D.)	230503	230862
17	S.D.O.(P.W.D.) Electrical	231091	---
18	Public Relation Officer	230438	230982

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Annexure - 5

DETAILED RISK AND CONSEQUENCE ANALYSIS OF NTPC GADARWARA SUPER THERMAL POWER STATION

Introduction

Likely dangers to the NTPC Gadarwara have been assessed through consequence analysis of maximum credible loss scenarios. Consequence analysis deals with the study of the physical effects of potential dangers associated with the hazardous chemicals, their storage and operation, etc. For flammable and explosive chemicals like hydrogen, LDO, etc., consequences on humans/animals and structures are studied in terms of heat radiation and overpressures. For toxic chemicals like chlorine, consequences on humans/animals are studied in terms of concentration and dose-response relationships. The physical impact of heat radiation, overpressure and toxic concentration are shown in Table 1.1, 1.2, 1.3 and 1.4.

The best way of understanding and quantifying the physical effects of accidental release of any hazardous chemical from their normal containment is by means of mathematical modelling. The consequence modelling for different release incidents for NTPC Gadarwara has been done with the help of SAFETI-micro version 5.23 developed by DNV Technica, U K. At present, SAFETI-micro1 is one of the most advanced software for consequence and risk analysis in an industrial plant.

Consequence analysis for any accidental release scenario depends on several factors viz., physical and chemical properties, process details, inventory, storage temperature and pressure, meteorological and topographical conditions, etc.

Table 1.1: Physical Impact of heat radiation

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Radiation Level (kW/m^2)	*Observed Effect*
37.5	Sufficient to cause damage to process equipment and human death.
25	Minimum energy required to ignite wood at indefinitely long exposures (non-piloted)
12.5	Minimum energy required for piloted ignition of wood, melting of plastic tubing, 50% damage level
9.5	Pain threshold reached after 8s; second degree burns after 20 seconds
4	Sufficient to cause pain to personnel if unable to cover the body within 20 seconds; however blistering of the skin (second degree burns) is likely; with no lethality
1.6	Will cause no discomfort for long exposure

Table 1.2: Exposure time necessary to reach the pain threshold

Radiation Level (kW /m2)	Time to pain threshold (second)
19.87	2
11.67	4
9.46	6
4.73	16
1.74	60

Table 1.3: Physical Impact of Explosion Overpressures

Pressure (psig)	Damage Produced by Blast
0.1	Breakage of small windows under strain
0.7	Minor damage to house structures
1.0	Partial demolition of houses, made uninhabitable
2	Partial collapse of walls and roofs of houses
3	Heavy machines (3000 lb) in industrial building suffered little damage; steel frame building distorted
4	Cladding of light industrial buildings ruptured
5	Wooden utility poles snapped; tall hydraulic press (40,000 lb) in building slightly damaged
7	Loaded train wagons overturned
10	Probable total destruction of buildings; heavy machines tools (7000 lb) moved and badly damaged
300	Limit of crater lip

Table 1.4: Physical Impact of toxic concentration

Concentration Level	Observed Effect
Threshold Limit Value (TLV)	Average concentration of the substance in ambient air for a normal 8-hour workday or 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effects.
Short -Term Exposure Limit (STEL)	Maximum concentration of the substance to which workers can be exposed for a period up to 15 minutes continuously without suffering from irritation, chronic tissue change, provided that no more than four executions per day are permitted, with at least 60 minutes between exposure and that the daily TLV is not exceeded.
Immediately Danger to Life and Health (IDLH)	It represents the maximum airborne concentration to which a healthy male worker can be exposed for as long as 30 minutes and still be able to escape without loss of life or irreversible organ system damage.
Lethal Concentration at 50% mortality (LC50)	Lethal concentration levels that kill 50 % of exposed laboratory animals under controlled experiments

1.1 Potential Emergency Scenarios in NTPC Gadarwara

The following potential emergency scenarios have been conceptualized:

(a) Chlorination Plant: Emergency may occur due to heavy release of chlorine.

(b) Hydrogen storage shed/Power house: Emergency may occur due to explosion of hydrogen at power house and storage shed.

(c) LDO storage area: Oil pool fire is the major emergency scenario in fuel oil storage area. Since the combustion is poor in case of pool fire of LDO, it will generate dense smoke, which creates low visibility and asphyxiation of fire crew in the downwind direction.

(d) Coal Conveyors: Emergency scenario in coal conveyors is fire.

(e) Boiler: Emergency scenario may arise when fire breaks out inside the boiler that may lead to explosion of boiler if the water level falls below the recommended safe level and/or due to pulverized coal.

(f) Beaching of ash pond/Reservoir: An off-site emergency scenario may be created.

1.2 Maximum Credible Loss Scenarios (MCLSs)

On-site/off-site Emergency Management Plan for any major emergency is prepared for maximum loss accidents leading to worst-case release scenarios. Maximum credible accident (MCA) can be characterized as accidents with maximum damage potentials. Out of all potential emergency scenarios as mentioned in section 1.1, the following hazardous chemicals which may create major emergencies in NTPC Gadarwara have been considered for the consequence analysis of likely dangers and thereby identification of vulnerable zones:

i) Chlorine

ii) Hydrogen
iii) LDO

The aqueous ammonia stored in HDPE drums at chemical godown (each has capacity of 100 lt) under normal temperature and pressure has not been considered in the consequence analysis because of its low on-site and off-site consequences.
For the preparation of on-site emergency management plan, only the following representative sets of maximum credible loss scenarios have been considered for the case of;

(a) Chlorine

Scenario: Release of Liquid Chlorine through a leak in liquid space of a tonner (hole dia. = 12.5 mm)

Scenario: Release of Liquid Chlorine through a leak in liquid space of a tonner (hole dia. = 12.5 mm)

Scenario: Release of Liquid Chlorine through a leak in vapour space of a tonner (hole dia. = 12.5 mm)

External fire from neighbouring unit or impact failure or any terrorist attack on the tonner may result into catastrophic failure of a tonner.

Since chlorine is a toxic chemical, maximum loss scenarios will be atmospheric dense gas dispersion in the form of vapour/gas clouds. The clouds may drift beyond the boundary limits of hazardous area and could affect the health of people within the plant boundary and/or outside the plant boundary. The spreading of chlorine cloud will depend upon the wind direction and speed and the amount of chlorine escaped.

To assess the likely dangers associated with the above scenarios, maximum downwind distances for dispersed cloud of chlorine for various concentration levels (Table 1.4) and meteorological conditions (Table 1.5) have been considered.

(b) Hydrogen

The hydrogen is an extremely flammable gas and it is lighter than air. Hydrogen gas is colourless, odourless and not detectable by human senses. After release it disperses quickly, mixes with the air and may form the explosive mixture with air. Hydrogen-oxygen and/or Hydrogen-pure air flames are colourless. These colourless flames can flashback and can cause severe burns. It poses the following major hazards:
Fire
Explosion
Chemical Reactions- Violent combustion reaction with oxygen, other strong oxidants causing fire and explosion. Violent reaction with chlorine and fluorine.
The Hydrogen gas is used for cooling purpose in generator section. The hydrogen is brought from outside in Hydrogen Cylinders and used for initial filling of the system before start-up and also for make-up of system during normal operation. The major hazards of fire and explosion associated with hydrogen in the plant are in the following areas:

Hydrogen Cylinder Storage
Hydrogen Piping and Transfer Lines
TG Coolers
The following representative sets of loss scenarios have been considered:
Scenario: Bursting of a Hydrogen cylinder (Inventory = 7.18 m^3 under ambient temperature and pressure of 150 kgf/cm^2).
To assess the likely dangers associated with the fire/explosion scenarios of hydrogen, maximum impact distances for explosion overpressure (psi) for various levels (Table 1.1 and 1.3) have been considered.

(c) LDO

There are two LDO tanks with capacity of 4500 Kl. The dimensions of each tank are as follows:
Diameter = 18 m Length = 19.5 m
Dyke dimension = 74.4 m by 44 m
The following credible loss scenario has been considered:
Pool Fire due to release through the near bottom opening of a tank.
Input parameters
Tank Diameter: 18 meters Tank Length: 19.5 meters
Tank is 80% full
Leaking through opening with diameter: 1 feet
Opening is 1.5 feet from tank bottom

LDO is a flammable liquid and has high flash point of > 66^{O}C. It implies that normally it does not present a major fire hazard. In case of accidental spillage, it will remain within the available dyke. Under major persistent external heat source in the vicinity, pools of LDO can be ignited to start pool fire. For the consequence analysis, n-Heptane as a nearest alkane has been considered.

1.3 Input considered for consequence analysis

1.3.1 Meteorological Information

The probable vulnerable zones because of accidental releases of hazardous chemicals will depend on various factors viz., the amount of quantity stored, storage temperature and pressure, atmospheric stability classes, wind speed and direction etc. During summer season, NTPC Gadarwara experiences temperature more than 40^{O}C with high surface winds and in winter months it may reach below 10^{O}C. During rainy season, relative humidity may reach more than 95%. The prevailing wind direction is WWS (west-west-south) for most of the year except for the winter months, when it is north-westerly. Prevailing atmospheric conditions (meteorological, solar radiation, cloud amount etc.) at the time of accident largely controls the extent of vulnerable zones. The physical state of the atmosphere is usually best described by Pasquill-Gifford stability class A (very unstable) to F (very stable). Table 1.5 explains the details of various stability classes.

Table 1.5: Pasquill-Gifford Atmospheric Stability Classes

Surface wind speed m/s	*Day*			*Night*	
	Incoming Solar Radiation			*Amount of overcast*	
	Strong	*Moderate*	*Slight*	*> 4/8 low clo ud*	*< 3/8 low clo ud*
<2	*A*	*A – B*	*B*		
2 – 3	*A – B*	*B*	*C*	*E*	*F*
3 – 5	*B*	*B – C*	*C*	*D*	*E*
5 – 6	*C*	*C – D*	*D*	*D*	*D*
>6	*C*	*D*	*D*	*D*	*D*

Pasquill-Gifford atmospheric stability conditions are determined on the basis of surface wind speed, solar radiation, cloud amount etc. The atmospheric characteristics of a particular site experience almost all types of stability classes during a season (summer, winter and rainy). For example, in summer months, when the temperature is high for a sufficient amount of time, a particular site may experience unstable (A/B class) condition, neutral (D class) for majority of the time and also stable condition (E/F) in the late night. In winter months, when the solar radiation is weak to moderate with a considerable surface wind speed, the atmospheric conditions may correspond to C/D class, E and F class in the late night and early morning. However, the neutral class (D) of atmospheric condition exists for most of the time in a day in a particular season; and hence it is considered as the most representative class for a particular site and in a particular season (summer, rainy or winter).

The other average meteorological parameters considered in the analysis are as follows: ambient temperature = 35OC, relative humidity = 50%, roughness parameter = 0.17, three stability classes, i.e., B (unstable), D (neutral) and F (very stable) class with wind speeds of 1.5 m/s to 3 m/s.

1.3.2 Flammable, explosive and toxicological levels considered.

Toxicological Impact (Concentration in ppm) for Chlorine	**Flammable Impact (Radiation Intensity levels in kW/m^2) For LDO**	**Explosive Impact (Overpressure levels in psi) for Hydrogen**

RED zone: LC_{50} = 35ppm. ORANGE Zone: IDLH = 10 ppm. BLUE Zone: STEL = 03 ppm.	RED zone: LC_{50} = 37.5 kW/m^2. ORANGE Zone: IDLH = 12.5 kW/m^2. BLUE Zone: STEL = 4.5 kW/m^2.	RED zone: LC_{50} = 7 psi. ORANGE Zone: IDLH = 3 psi BLUE Zone: STEL = 1 psi.

In terms of damage effects, RED, ORANGE and BLUE Zones represent the severe, moderate and low levels respectively. For chlorine, lethal concentration at 50% mortality (LC_{50}) for the exposure duration of 30 minutes has been taken as 35 ppm.

1.4 Discussion of Consequence Results for release of chlorine

1.4.1 Outdoor release of chlorine

(A) Consequence Results in tabular form

The consequence results for chlorine vapour cloud for the release scenarios considered under the three stability classes and wind speed of 1.5 m/s to 3 m/s are shown in Table 1.6a. The table shows that a chlorine vapour cloud with concentration level of 35 ppm can be felt within the maximum downwind distance of 1356 m from release point when a catastrophic rupture of a chlorine tonner occurs with the release of 900 kg. The frequency of occurrence of catastrophic failure of tonner is very low.

(B) Consequence Results in graphical forms

The consequence analysis results for chlorine vapour cloud are also shown in graphical forms in terms of footprint of cloud for various concentration levels and variation of centerline concentration of cloud with distance from release. The cloud footprint depicts the impact zones or area affected by the various concentration levels of chlorine in the downwind direction after release. For example, the red contour in Figure 1.1a represents the area affected by the concentration level of 35 ppm after 133.5 seconds from release. The magenta contour in this figure represents the area affected by the concentration level of 35 ppm after 261.5 seconds. The blue contour in this figure represents the area affected by the concentration level of 35 ppm after 289.5 seconds. All these results correspond to the worst-case scenario of catastrophic failure of a tonner resulting to 900 kg of chlorine under D class and wind speed of 3.0 m/s. Similarly, Figure 1.1b and 1.1c depict the foot prints of chlorine cloud for leak scenarios from liquid space and vapour space respectively under neutral stability class (D) with wind speed of 3.0 m/s and for IDLH concentration level (10 ppm).

Drawing No. 1.2 and 1.3 show the overlay of consequence zones on the NTPC plant layout.

Similarly, maximum downwind distances for indoor release with scrubber systems

are also shown in Table 1.6b. It is seen that the downwind effect distance in very stable atmosphere (F class) and low wind conditions (1.5 m/s) is more than that for unstable (B class) and neutral classes (D class). Under neutral stability class with 3 m/s wind speed, the maximum effect distance corresponding to IDLH concentration of chlorine cloud is 598 m from release point.

Variation of centreline concentration versus distance for the worst-case and alternative case scenarios are shown in Figure 1.2. This figure may be used by the district administration to get the level of concentration at the various distances of their interest.

Table 1.6a: Maximum Impact Distances/End point distance due to Catastrophic Failure of a chlorine Tonner (Modelled quantity = 900 kg- Outdoor)

Sr. No	Description of Scenario	Zone- Conc. Level (ppm)	Maximum downwind distance (in meter) under the following atmospheric conditions		
			F: 1.5 m/s	B: 2.0 m/s	D: 3.0 m/s
1	Worst-Case: Release of Chlorine gas due to catastrophic failure of Single Chlorine Tonner.	Red - LC_{50} (35)	3043	688	1356
		Orange- IDLH (10)	7667	1208	2770
		Blue-STEL (03)	16440	2109	5234
2	Alternative Case: Release of Liquid Chlorine through a leak in liquid space of a tonner (hole dia. = 12.5 mm)	Red- LC_{50} (35)	4785	273	1025
		Orange- IDLH (10)	12560	449	2126
		Blue-STEL (03)	31400	761	4353
3	Alternative Case: Release of Chlorine vapour through a leak in vapour space of a tonner (hole dia. = 12.5 mm)	Red- LC_{50} (35)	1577	111	329
		Orange- IDLH (10)	3533	172	652
		Blue-STEL (03)	7644	277	1267

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Table 1.6b: Maximum Impact Distances/End point distance due to Catastrophic Failure of a chlorine Tonner (Indoor)

Scenario	Concentration (ppm)	Maximum Downwind Effect Distances (in metre) under the following atmospheric conditions		
		F: 1.5 m/s	B: 2 m/s	D: 3 m/s
Catastrophic Rupture of a Tonner Inventory = 900 Kg Storage: Indoor	STEL (3 ppm)	7005	558	1171
	IDLH (10 ppm)	3095	300	598
	LC_{50} (35 ppm)	1258	160	294

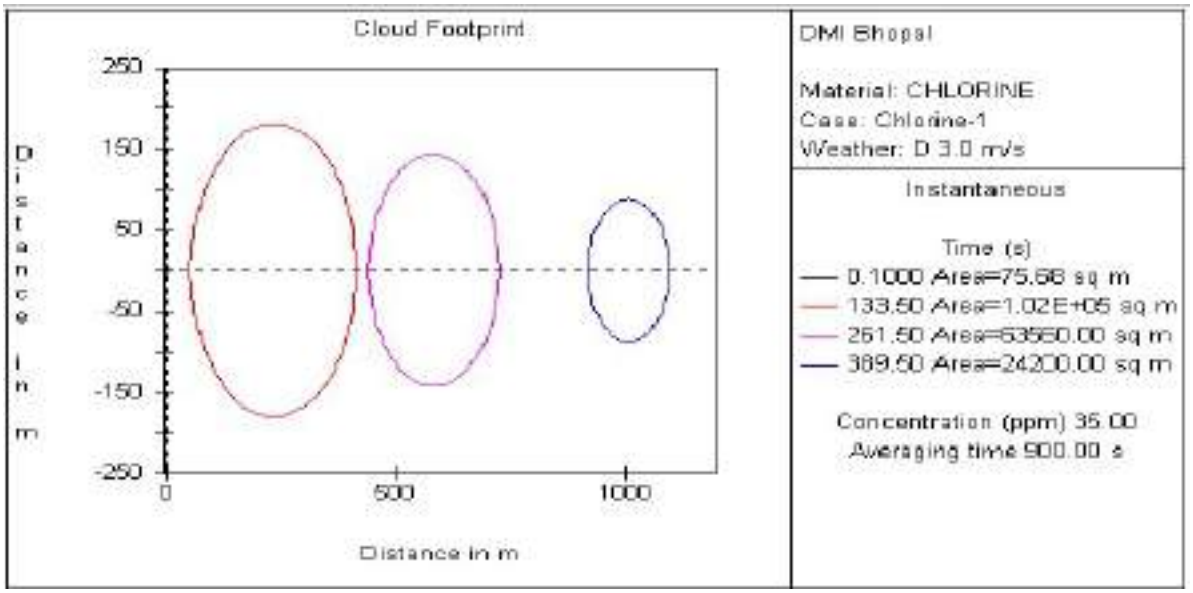

Figure 1.1a: Cloud footprints for the concentration level of 35 ppm (LC_{50}) for the worst case scenario under D; 3.0 m/s.

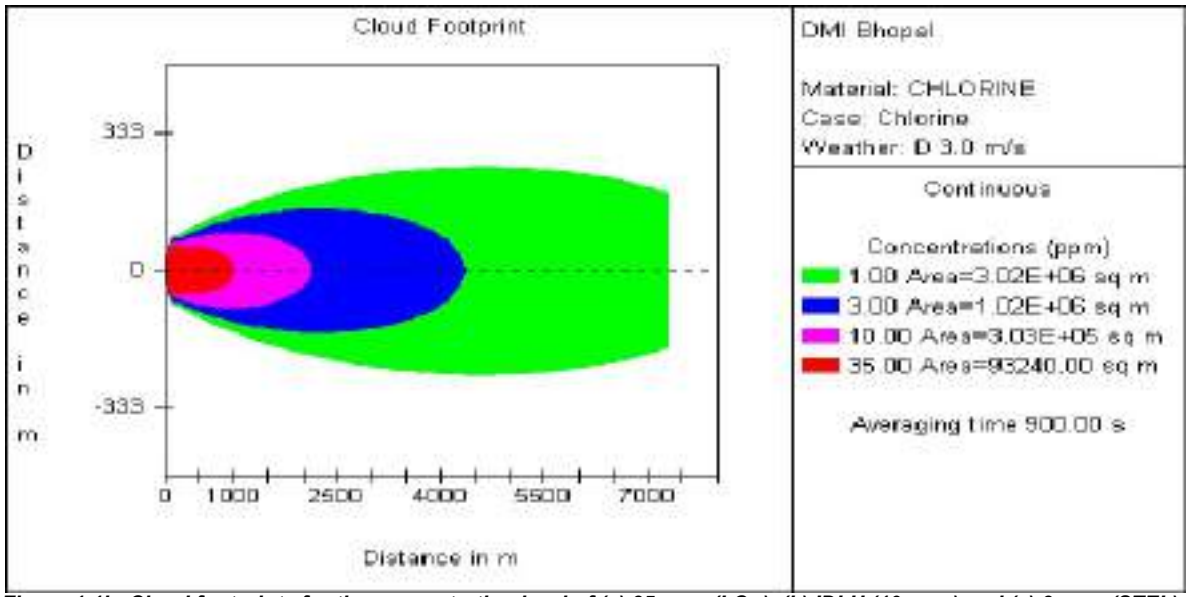

Figure 1.1b: Cloud footprints for the concentration level of (a) 35 ppm (LC_{50}), (b) IDLH (10 ppm) and (c) 3 ppm (STEL) for the leak scenario from liquid space under D; 3.0 m/s.

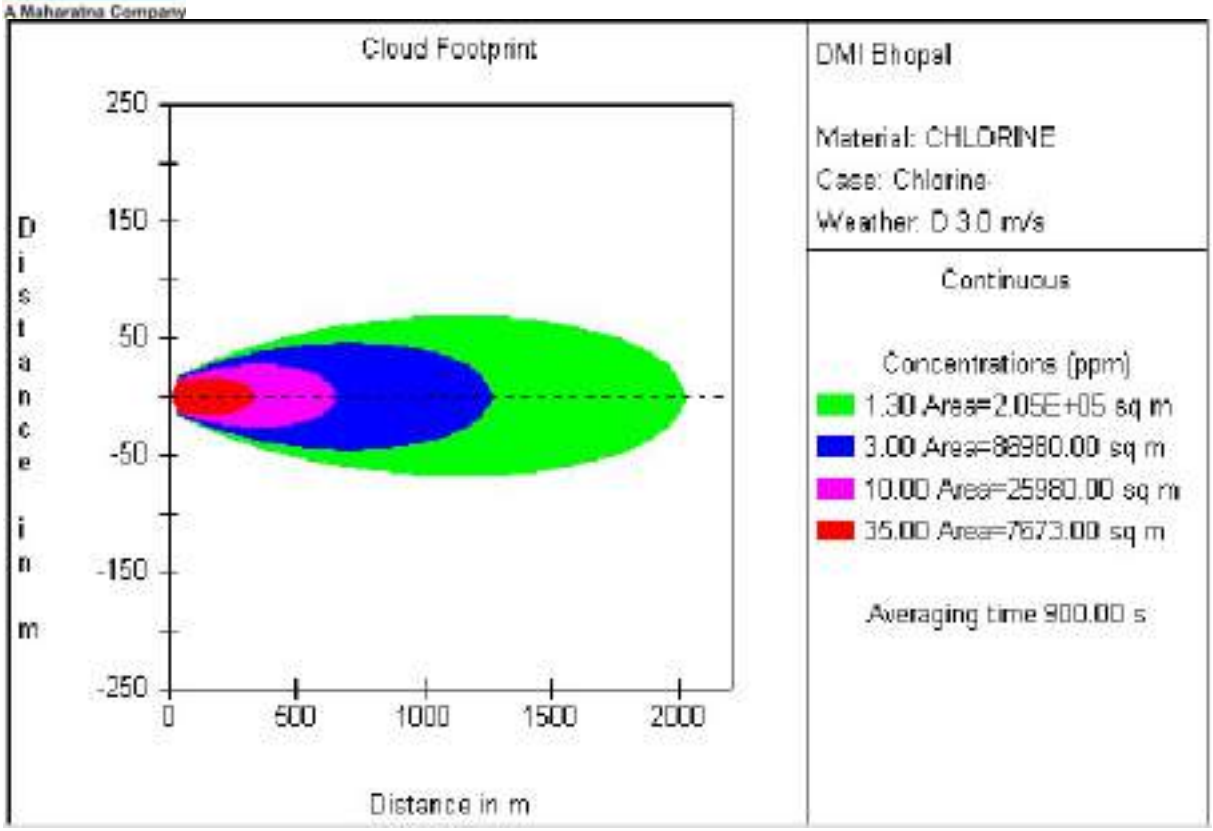

Figure 1.1c: Cloud footprints for the concentration level of (a) 35 ppm (LC_{50}), (b) IDLH (10 ppm) and (c) 3 ppm (STEL) for the leak scenario from vapour space under D; 3.0 m/s.

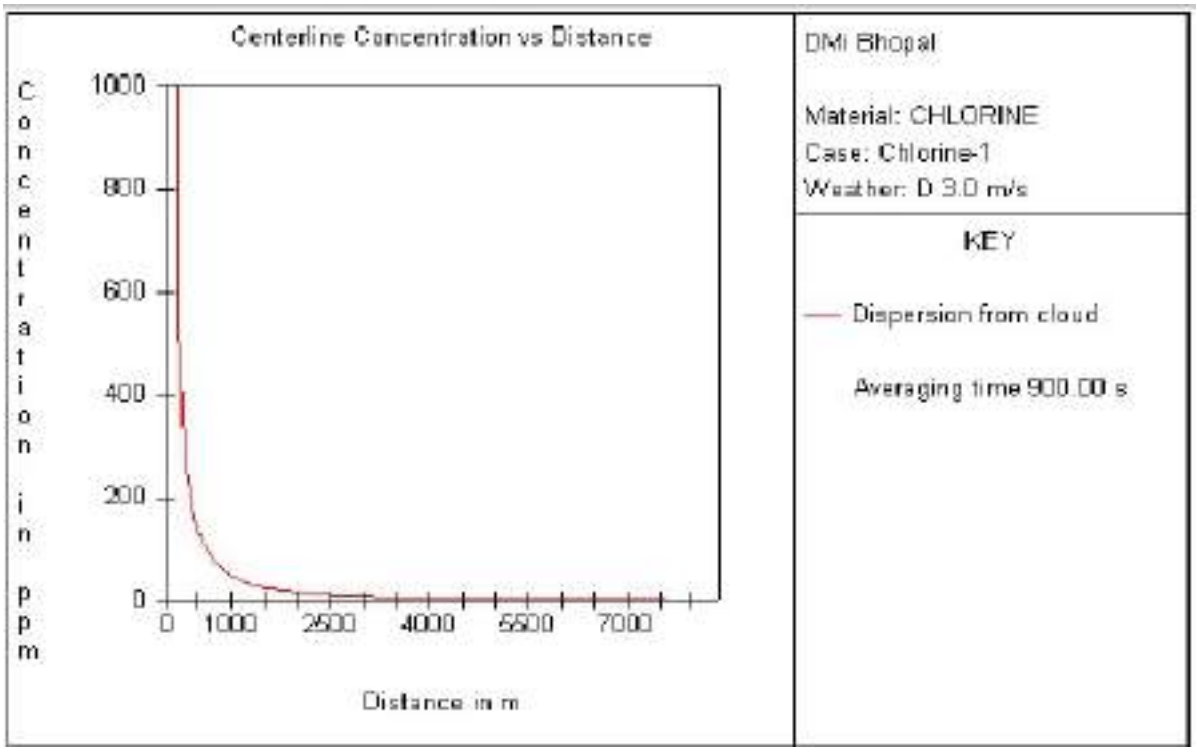

Figure 1.2a: Variation of centreline concentration of Cloud under D; 3.0 m/s for the worst-case scenario.

1.4.2 Consequence analysis of release of hydrogen resulting to fire/ explosion

(a) Consequence Analysis results in tabular form

Since hydrogen has flammable and explosive properties, the major credible release scenario is explosion as shown in Table 1.7. Hydrogen is stored in cylinders with volume 7.18 m3 and at 150kgf/cm2 pressure. Vapour cloud explosion scenario after release from hydrogen cylinders have been considered for the consequence analysis. Since the atmospheric stability conditions have little impact on the end point distances for the considered scenarios, only a representative class (D) of neutral atmosphere with wind speed of 3.0 m/s has been considered. It is seen from the table 1.7 that about 119 m from the location of cylinder will be susceptible for explosion overpressure level of 3 psi.

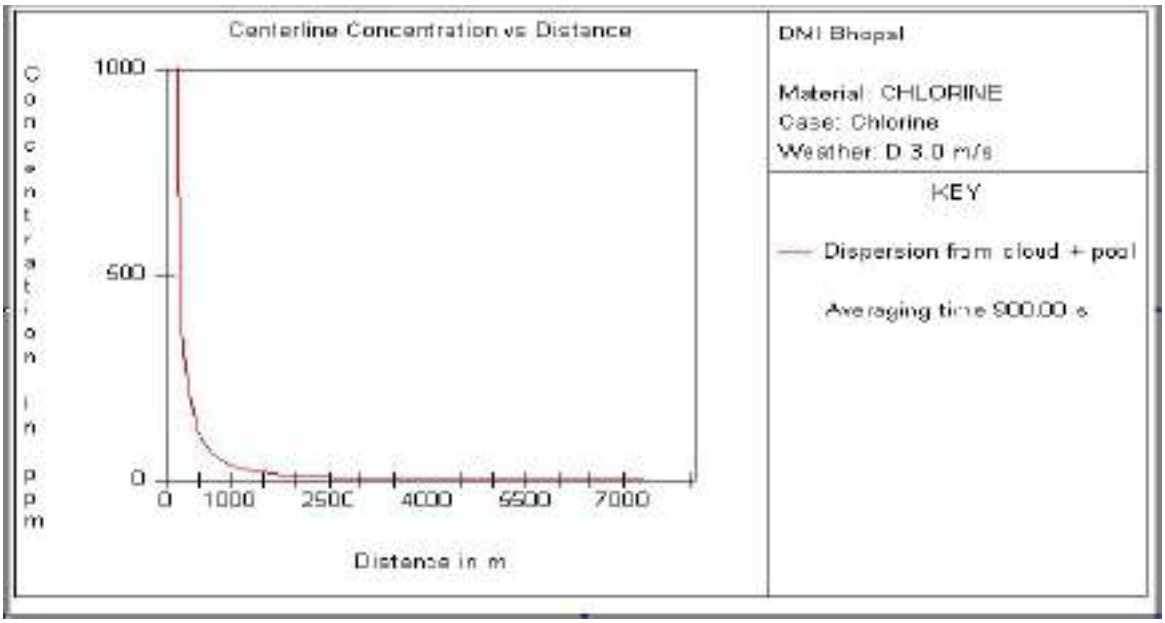

Figure 1.2b: Variation of centreline concentration of Cloud under D; 3.0 m/s for the leak scenario from liquid space of a tonner.

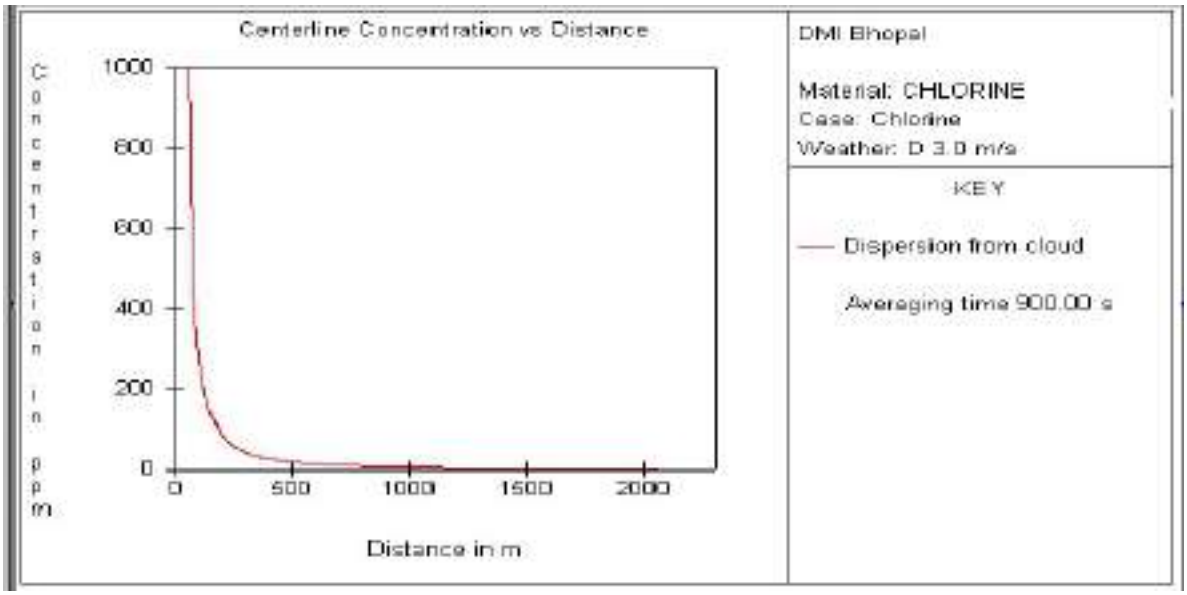

Figure 1.2c: Variation of centreline concentration of Cloud under D; 3.0 m/s for the leak scenario from vapour space of a tonner.

Table 1.7: Maximum Affected Distances (Meter) for explosion scenarios of Hydrogen under neutral stability class (D) and wind speed of 3.0 m/s

Scenario	Maximum Affected Distances (Meter) to Overpressures (psi) for Explosion		
	1 psi	3 psi	7 psi
Bursting of a Hydrogen Cylinder (Inventory = 7.18 cubic m at ambient temperature and pressure of 150 kgf/cm^2)	128	119	Never reached

1.4.3 Consequence analysis of fire on LDO pool

Maximum impact distance to thermal radiation from pool fire under D; 3 m/s is shown in Table 1.8. The maximum flame length will be 61 m.

Table 1.8: Maximum Affected Distances (Meter) for pool fire of LDO under neutral stability class (D) and wind speed of 3.0 m/s

Scenario	Maximum Affected Distances (in meter) Corresponding to the following levels		
	Thermal Radiation (in kW/m^2) levels for pool fire		
	4.5 kW/m^2	12.5 kW/m^2	37.5 kW/m^2
Pool fire scenario of LDO (80 % capacity of a tank)	156	92	47

1.5 Likely to be affected areas due to major scenarios

As per the consequence analysis of major loss scenarios considered, the vulnerable zones/likely to affected areas due to the accidental release of toxic chlorine cover all major plant locations up to which LC_{50} level concentration can be felt if the release of chlorine is not controlled in time. Due to loss scenarios of hydrogen and LDO, the impact zones cover the immediate vicinity surrounding the location of fire/explosion.

Table 1.9: Likely to be affected areas due to catastrophic release scenario of chlorine in NTPC Gadarwara under D class and wind speed of 3.0 m/s.

Scenario	Likely to be affected areas within LC_{50} concentration level (35 ppm) of chlorine
Release of Chlorine gas due to catastrophic failure of a Chlorine Tonner	Drawing No. 1.1 and Drawing No. 1.2 (Vicinity map)

1.6 Limitation of the consequence analysis

It is obvious that the consequence modelling results, viz., estimation of probable vulnerable zones/maximum downwind distances for specific concentration levels are *conservative and these will vary* if the meteorological (mainly atmospheric stability

classes, wind speed and direction, turbulence) and topographical conditions (industrial area/congestion, open) vary even with the same inventory, storage pressure and temperature etc. Actually any mathematical expression of physical events has some limitations. The properties of chemicals, release conditions, meteorological data are all used as ideal data which can have variation in the actual condition. Therefore, the consequences of hazardous incidents will have varying accuracy. Many types of hazardous incidents can only be assessed by making a variety of simplifying assumptions. Many times an ideal simple mode of failure could not be identified in real disaster event. A number of apparently independent events can occur at a time because of some simple events. Similarly, failure rates (catastrophic etc.) of a tanker of cylinder or vessel etc. are also statistical averages depending upon the reporting accuracy. Also all these failure rate data used in analysis are generated in the western developed countries which may not be always same for here. Thus consequence analysis results have a lot of subjective input and should not be considered an end in itself. These results should be used in judicious manner utilizing practical knowledge and common wisdom.

The present document highlights the impact of likely dangers arising out from the accidental release of chemicals and/or fire and explosion if occurred and not controlled in time. However, the likely dangers from any terrorist activity, sabotage or the occurrence of natural disasters, like earthquake and flood cannot be ruled out. For such incidents, worst-case scenarios can be considered.

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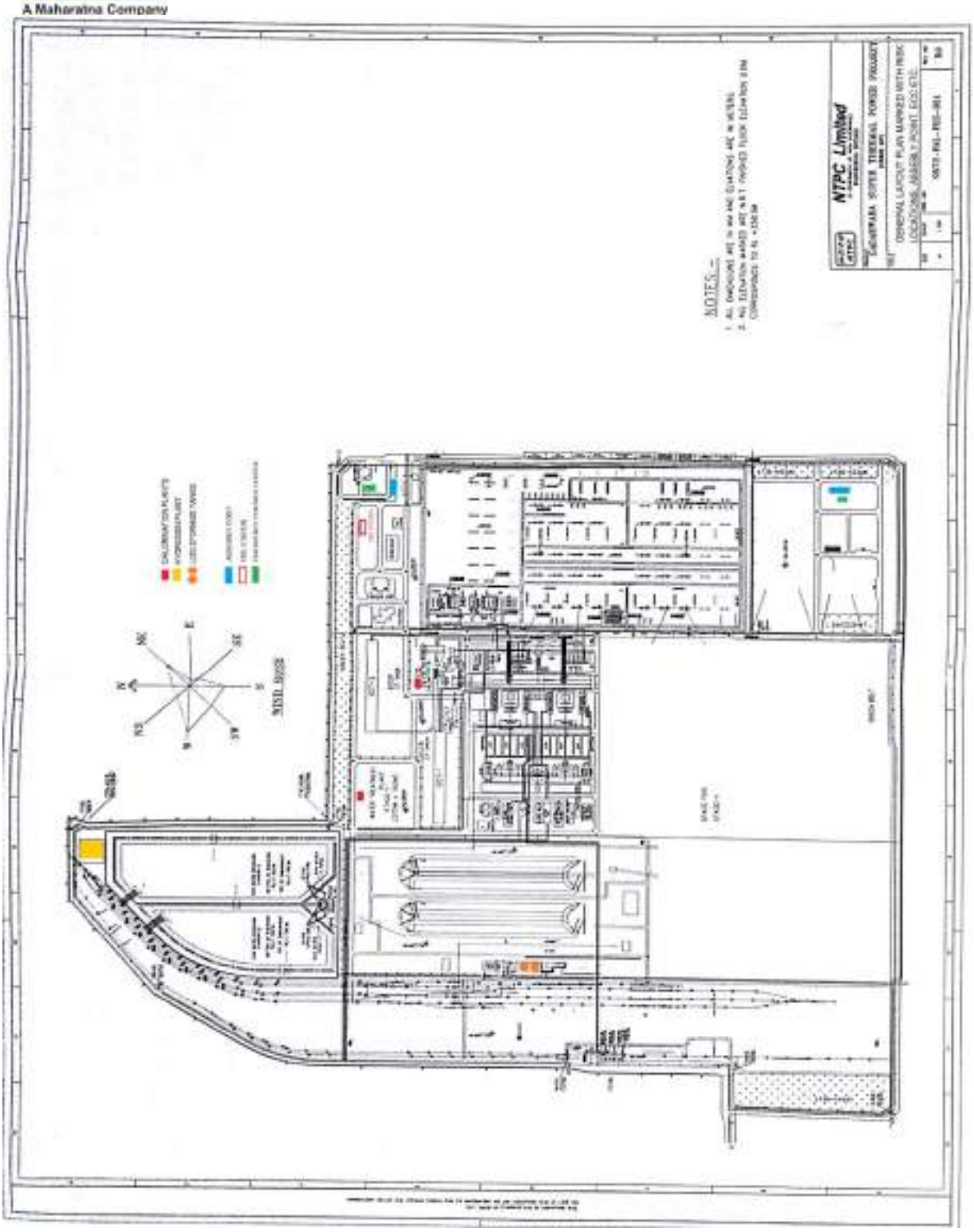

Drawing 1.1 Risk Analysis – General Layout Plan Map

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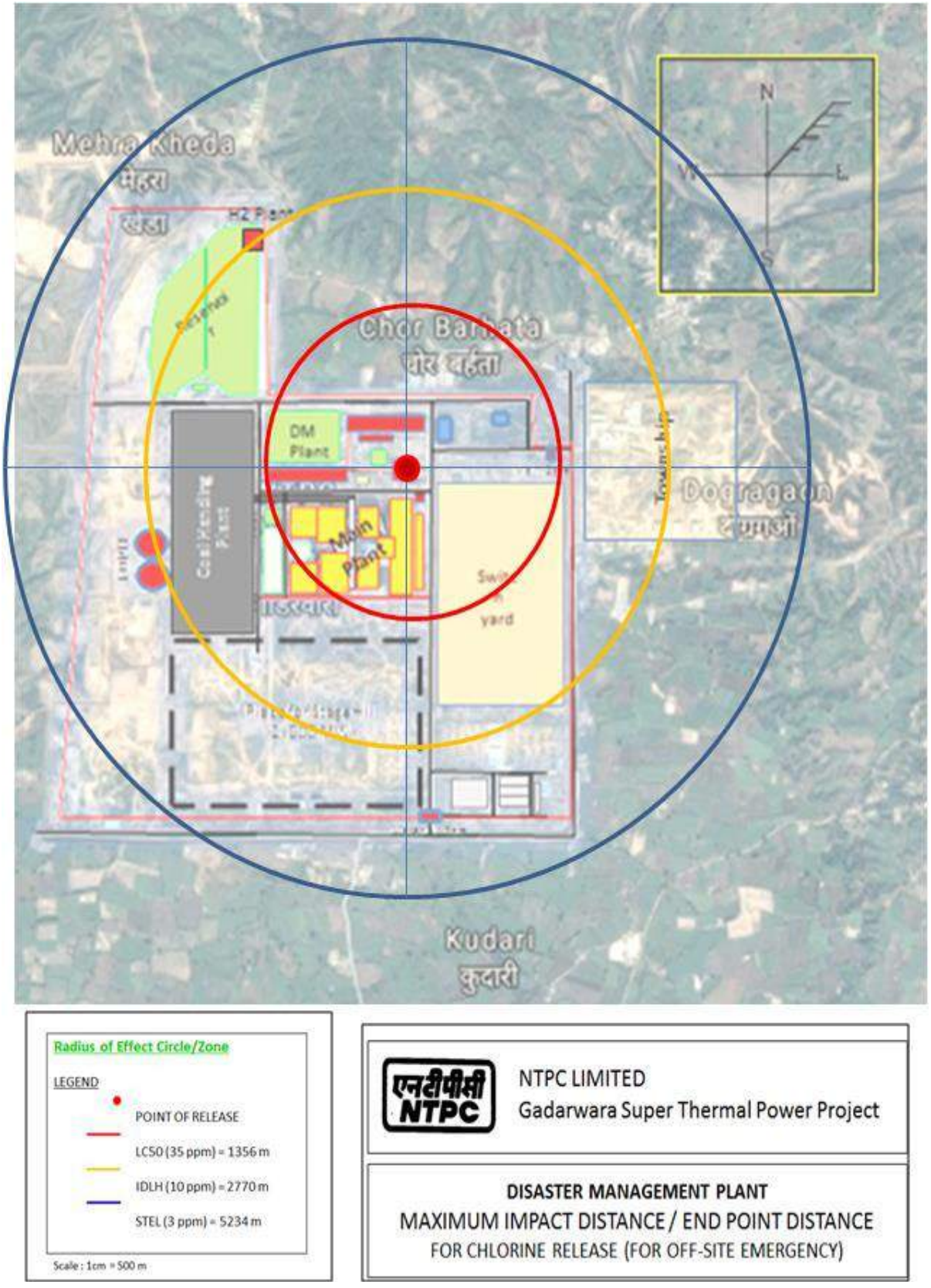

Drawing 1.3: Risk Analysis - Vicinity Map

References

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