सीएमपीडीआई

cmpdi

A Mini Ratna Company

STUDY ON CARRYING CAPACITY

OF

RIVERINE ECOSYSTEM

LAKHANPUR PHASE-II OCP

MAHANADI COALFIELDS LIMITED

December, 2018

STUDY ON CARRYING CAPACITY

OF

RIVERINE ECOSYSTEM

LAKHANPUR PHASE-II OCP

MAHANADI COALFIELDS LIMITED

Job No. 094718052

December, 2018

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ANNEXURES

LIST OF PLATES

THE CONTRIBUTORS

1. **Shri Pushkar, GM (Environment), CMPDI (HQ)**
2. **Shri Abhijeet Sinha, Chief Manager (Mining/Environment)**
3. **Shri V.K. Pandey, Sr. Manager (Environment), CMPDI (HQ)**
4. **Dr. Vinita Arora, Sr. Manager (Environment), CMPDI (HQ)**
5. **Shri Amarjeet Singh, Deputy Manager (Environment), CMPDI (HQ)**
6. **Shri Abhishek Kumar, Deputy Manager (Environment), CMPDI (HQ)**
7. **Shri N. Bhatnagar, Assistant Manager (Environment), CMPDI (HQ)**
8. **Shri Manish Dohre, Assistant Manager (Environment), CMPDI (HQ)**
9. **Dr Pramod Kumar, Functional area Expert (Ecology & Biodiversity), CMPDI (HQ)**
10. **Shri Neeraj Kumar, Deputy Manager (Environment), CMPDI, RI-VII**
11. **Mrs Subhashree Patnaik, Deputy Manager (Environment), CMPDI, RI-VII**
12. **Shri Praveen Shrivastava, Assistant Manager (Environment), CMPDI, RI-V**
13. **Miss Dipti Mohan Pillai, MT (Environment), CMPDI (HQ)**

CHAPTER-I: INTRODUCTION

1. INTRODUCTION

Lakhanpur Expansion OCP is planned in part of the Belpahar-III geological block which is located in the southern part of Ib valley coalfield. This coalfield is the southern middle part of lower Gondwana basin of Sone Mahanadi Valley and occupies an area of about 1460 sq.km. with potential coal bearing area of around 1050 sq.km. The Ib River coalfield lies in between latitude 21°31' to 22°14' North and longitude 83°32'00" to 84°10'00" East and falls mainly in Sundergarh, Jharsuguda and Sambalpur districts of Odisha. The Project Report for Lakhanpur Opencast, 5.0 MTY capacity of Ib-valley coalfield was prepared in April, 87 and approved in January, 92 vide letter No.43011/ 43/87-CPA, dt.22.1.92. The mine started coal production from 1992-93 and has been completed in March, 2000. Further, project report (PR) for Lakhanpur OC Expansion, 10.0 MTY (5.0 MTY incremental capacity) was sanctioned in February, 2004 at an additional capital of Rs.98.74 crores. The same was declared completed in March, 2010. Further Lakhanpur OCP expansion (Phase-II) Capacity 15.00 MTY (5.00 MTY incremental) was sanctioned in September 2008. The same has been prepared to cater to the projected demand on MCL and is part of '***Emergency Coal Production Plan'*** of Coal India Limited.

Ib-valley coalfield (also known as Ib-river coalfield) is located in Jharsuguda, Sambalpur and Sundergarh districts of Orissa between latitudes $21^0$42'15" to $21^0$47'10" N and longitudes $83^0$48'11" to $83^0$52'38" E in topo-sheet No.64 (O/13). The coalfield is named after the river Ib, a tributary of the river Mahanadi. The Howrah-Mumbai railway line passes through the coalfield. The nearest rail head is Belpahar. The location map showing Odisha Coalfield in shown in **Plate-I.**

Mining in this coalfield in south-eastern part started with the support of available infrastructures around Brajrajnagar Township in the first half of this century. The first UG mine to start was Himgir Rampur colliery (1909) and subsequently Orient UG mine No.1 (1940).

Environmental Clearance (EC) was accorded by MoEFCC, Govt. of India for Lakhanpur OC Expansion, 15.0 MTY (5.0 MTY incremental) vide Letter No.J-11015/638/2007-IA.II(M), dated 12.5.2008. Again Environmental Clearance (EC) was granted by MoE&CC, Govt. of India for Lakhanpur OC Expansion, 15.0 MTY to 18.75 MTY (under clause 7(ii) of EIA notifications 2006) vide Letter No.J-11015/398/2012-IA.II(M), dated 21.5.2014 for existing mining lease area of 2389.6 Ha.

1.1 LOCATION AND COMMUNICATION

Lakhanpur opencast expansion (Phase-II) project (21.0 MTY) is proposed in Belpahar-III geological block of Rampur tract of Ib-valley coalfield, falling in the south of Lilari nallah. The block area falls between latitudes 21°42'15" N to 21°47'10"N and longitudes 83°48'11"E to 83°52'38"E and is included in Survey of India topo-sheet no.64/O/13 of 1:50,000 RF. It is situated to the south of Howrah-Mumbai Railway line, between Belpahar and Brajrajnagar railway stations. The nearest railway station is Belpahar at a distance of about 8.00 kms.

The project is connected by road to Brajrajnagar & Jharsuguda in Odisha and Raigarh in the State of Chhatisgarh. Jharsuguda is connected to Sambalpur by SH-10 and NH-6 & NH-42.

The location map of the project is shown in **Plate-II**.

1.2 TOPOGRAPHY, DRAINAGE AND CLIMATE

The feature of the area is as under:

- The topography of the block is plain to moderately undulating.
- The area is gently sloping towards east.
- The highest and lowest elevations of the area are 250 m and 198 m above mean sea level respectively.
- The drainage is controlled by Lilari nullah which discharges into Hirakud reservoir. One tributary (seasonal) of Lilari nullah namely, Phulijhor flows from west to east within the mine area with its catchment area to the west of the block.

The surface master plan of the project area is shown in **Plate-III**.

1.3 MINE BOUNDARY

The mine boundary of the Lakhanpur Phase-II OCP is defined as under:

Quarry-1

This is the northern quarry. Lilari Nallah separates it from the workings of Lilari Opencast project. Southern boundary is fixed such that the immediate diversion of Phulijhor Nallah does not become necessary.

→ **North:** Floor boundary is fixed after considering the present surface boundary and leaving a surface barrier of approximately 60m against Lilari nallah.
→ **East:** 1 m thick coal line in the in-crop of Lajkura seam.
→ **South:** Floor boundary is fixed considering existing embankment against the Phulijhor nallah.
→ **West:** Floor boundary is almost fixed along block boundary.

Quarry-2

Quarry-2 forms the central part of the selected quarry area and is adjacent to Quarry-1. Phulijhor nala which flows on the northern side of the quarry will have to be diverted before starting of this quarry.

- → **North:** Shares the southern boundary of Quarry-1.
- → **East:** 1m thick coal line in the in-crop of Lajkura seam
- → **South:** An arbitrary line midway between final southern boundary & northern boundary of Quarry-2.
- → **West:** 70m / 80m floor contour.

Quarry-3

This is the last quarry in sequence and coal production starts from the 17th year and continues upto the 25th year *i.e.* the terminal year of the project.

- → **North :** Shares the southern boundary of Quarry-2
- → **East:** 1m thick coal line in the in-crop of Lajkura seam.
- → **South:** Approximate 6-7 m iso-thickness line of dirt bands.
- → **West :** 90m floor contour

1.4 GEOLOGY OF THE MINE

Geological Structure

The beds strike in a NE-SW direction in the northern part, assume a N-S trend in the central part and SSE-NNW in the southern part. The overall configuration is thus of a broad antiform. The dip of the strata varies from NW in northern part, due west in the central part and WSW in southern part. The dip ranges from 4^{o} to 6^{o}. The block has been traversed by 8 normal faults ranging in throw from 2m to 70m. However, within the mining block 2 nos. of faults (F3F3 & F11F11) have been deciphered and ranging in throw from 2m to 5m.

Coal Seams

All the three main coal seams of the Ib-River coalfield *viz.*Ib, Rampur and Lajkura seams have been encountered within the block besides Parkhani and Belpahar seams which occur in the down dip side. Only Lajkura seam has been described in details as only Lajkura seam has been considered for mine planning.

TABLE-1.1: SEQUENCE OF COAL SEAMS OF BELPAHAR SECTOR-III BLOCK

Seam/Section	Thickness (m)		Parting (m) with the lower seam	
	Min.	Max.	Min.	Max.
Belpahar	1.49	4.20	68.16	72.67
Parkhani	0.20	5.18	75.28	110.52
Lajkura	20.88	33.53	41.65	96.22
Section A (Rampur Top-I)	0.35	3.75	0.45	10.10
Section-B (Top) (Rampur Top-II part)	0.18	3.83	0.31	3.12
Section-B (Bot) (Rampur Top-II part)	0.12	2.59	1.28	24.93
Section-C	0.12	3.83	3.98	12.56
Section-D (Rampur Bot-I part)	0.11	2.44	2.61	18.43
Section-E (Rampur Bot-II part)	0.62	5.45	5.85	35.55
Ib Top	0.09	6.20	0.80	9.58
Ib-Bottom Ib-Comb.	0.15 4.42	8.00 10.95	-	-

1.5 MINING TECHNOLOGY

The proposed mining block represents presence of moderately flat single coal seam with intermediate varying parting. Thick seams occur at shallow depth in wide area having power grade coal reserve. So this will make the project most viable by adopting opencast mining method. Geo-mining characteristics of different quarry sections are as under:

TABLE-1.2: GEO-MINING CHARACTERISTICS OF THE MINE

Sl. No.	Particulars	Unit	Phase-I	Phase-II	Total
1	Floor Area*	ha	1080.67	137.92	1218.59
2	Surface Area*	ha	1317.00	124.64	1441.64
3	Reserve**	Mt	215.89	48.01	263.90
4	Overburden**	Mcum	523.47	158.92	682.39
5	Stripping Ratio**	Cum/t	2.42	3.31	2.59
6	No. of seams		1	1	1
7	Strike length (Along Floor)	m			
a)	Maximum				2900
b)	Minimum				1600

Sl. No.	Particulars	Unit	Phase-I	Phase-II	Total
8	Strike Length (Along surface) in m				
a)	Maximum				3100
b)	Minimum				1800
9	Depth	m			
a)	Maximum		165	155	165
b)	Minimum				12
10	Avg. Gradient				1 in 12 - 1 in16.8
11	Life**	Yr	11	3	13
12	Dip rise length	M			2200-2500
13	Avg. thickness of Lajkura seam				24.04
15	Avg. thickness of dirt band	M			3.56

* Including the excavated area

** As on 01/04/2017 at capacity of 21 MTY

Reserve has been assessed considering general practice of 10% geological loss and around 5% mining loss. Around 45 to 46 Mt additional reserve can be extracted in absence of these losses.

The seam gradient varies from 3.7^{o} to 5^{o} and thickness, including all bands, ranges from 21.84 m to 31.11m in the full thickness area. Though the seam gradient is favourable for application of dragline in overburden it has not been considered in the approved report for the following reasons:

i) The coal seam is thick and has to be worked in a number of benches.
ii) The presence of separable bands in the seam makes the system rigid and complicated. Further, if the bands are not separated and bulk mining is adopted, there will be deterioration in the coal quality.
iii) Initial lead-time for procurement of dragline is more and it will also be underutilized during the initial years due to shallow cover.

Therefore, it is envisaged to adopt shovel-dumper combination as per the existing practice in overburden. Considering the high annual production capacity of 21.0Mt and corresponding yearly overburden removal, higher capacity of shovel and dumpers are suggested for overburden removal.

1.6 LAND REQUIREMENT

The details of land requirement under approved Mining Plan (Capacity: 21.0 MTY) is as below:

TABLE-1.3: LAND REQUIREMENT OF THE PROJECT

(Area in Ha)

Purpose	Existing			Additional			Total		
	Forest	Non-forest	Total	Forest	Non-forest	Total	Forest	Non-forest	Total
Quarry Excavation	243.1	1198.54	1441.64	--	--	--	243.1	1198.54	1441.64
Safety zone for blasting	52.8	653.66	706.4	--	--	--	52.8	653.66	706.4
OB dump	OB area of 38.40 ha falls in safety zone								
Infrastructure	6.33	181.67	188	--	--	--	6.33	181.67	188
Rationalization of project boundary	26.6	122.36	148.96	--	--	--	26.6	122.36	148.96
Mining lease area	328.83	2156.17	2485	--	--	--	328.83	2156.17	2485
Residential Colony	--	60	60	--	--	--	--	60	60
Resettlement Site	--	152	152	--	--	--	--	152	152
Grand Total	**328.83**	**2368.17**	**2697**	**--**	**--**	**--**	**328.83**	**2368.17**	**2697**

No additional land will be required for implementation of the peak 21.0 MTY project, as it is proposed within the same mine boundary of earlier approved 15 MTY PR. So, no additional provision for land has been made.

1.7 COAL MINING, OB REMOVAL AND TRANSPORTATION

Shovel-dumper system of mining for overburden removal has been already adopted for running mine. This system is very flexible and also offers convenient mining operations to deal with sudden occurrences of unworkable or poor quality patches and change of floor position due to repeated faulting and varying seam gradient and thickness. It also offers flexibility for easy transition to any other technology or equipment configuration. The technology is well known and advantageous to get skilled manpower. So shovel-dumper mining method has been adopted for overburden removal and the same has been suggested for remaining life of the mine. Considering the annual target of 21.0 MT and corresponding yearly overburden removal, higher capacity of shovel and dumpers are suggested for overburden removal.

The top soil of 30 cm will be excavated and stacked separately or utilized directly for covering the backfill. At present 5.0 cum electric rope shovels, 5.1 cum hydraulic shovels and 3.7/2.7 hydraulic shovels or backhoes are deployed for

overburden removal. As per earlier approved mining plan, considering large quantity of overburden to be removed (about 40-50Mcum/year) it was proposed to deploy 8.5-10 cum hydraulic shovels/backhoe for top overburden removal. 3.7cum/2.7cum hydraulic shovels and backhoes would be generally deployed for removal of bands. However in recent years, 2 working patches in quarry-1 and one patch in quarry-2 overburden is being excavated & transported through outsourcing means. Increase in production will be done through deployment of more departmental HEMM or increasing load of outsourcing agencies.

In the present mine, coal is being extracted either by using surface miner through outsourcing agencies or by departmental surface miner. Any additional coal production will be done by using surface miner through outsourcing agencies or by departmental means.

Surface miners will be working in windrowing method. In windrowing mode the cut material is directly discharged behind the machine without using a conveyor. Therefore, the cutting operation is independent from the truck loading operation, but the coal has to be re-handled by the front end loader which in turn loads the coal into the dump truck. For many reasons, the higher productivity in windrowing method compensates the re-handling cost. In addition, no belt wear and operating cost for conveyor will arise when working with windrowing mode of operation.

While working the barrier between quarry-1 & quarry-2, it will be necessary to re-handle some overburden already backfilled along common boundaries. HEMM deployed for overburden removal will also re-handle this overburden.

1.8 COAL HANDLING & DISPATCH ARRANGEMENT

At present, the coal produced from the mine is dispatched to OPGC and to Y-curved siding for basket linkage for further dispatch though Howrah-Mumbai main line.

A coal handling plant (CHP) for Lakhanpur open cast project was constructed and commissioned. The CHP consisted of crushing complex (Feeder breakers), conveyor and truck loading hopper for dispatch to Y-curve siding. Subsequent to introduction of blast free coal production, the Feeder Breakers and other accessories have been shifted to other mines for their better utilization. Out of total production approximately 3.50 MTY of coal is dispatched through MGR for OPGC. Part of remaining coal (around 7.0 MTY for year 2016-17) is being transported through Y-curve siding which is located at a distance of 14-15 kms, remaining part of coal production is also being transported through Lakhanpur siding no-7 and Belpahar siding no 3 & 6 near eastern side of Belpahar OCP. Coal transportation from pit top/stock to the siding is being done through outsourcing transport arrangement.

Around 10.00 MTY coal from pit bottom will be transported up to pit top by departmental/ out sourcing. From pit top through reclaim feeder the coal will be transported by conveyor to washery, then washed coal will be transported by conveyor to SILO for further rail transport. For the above proposal tendering is in advance stage.

The infrastructure map of the study area is shown in **Plate-IV**. The study area map is shown in **Plate-V**.

1.9 GENESIS OF THE STUDY

The mine has received environmental clearance for production of 21.00 MTY of coal vide letter no. J-11015/391/2012-IA.II(M) dated 28 February, 2018. The copy of environmental clearance letter from MoE&CC is attached as **Annexure-I** to this report.

Under Clause 4(xi) of Environmental Clearance, it was stipulated by MoE&CC that "*in view of the mining potential of the area and the prevailing environmental concerns, carrying capacity of the riverine eco-system shall be studies through some expert agency to assess impact on the environmental components*".

Additionally, Clause 4(xii) of the same EC order also states that, *"A mitigation plan based on the study to be submitted to the MOEF&CC Regional Office/SPCB and displayed on company's website."*

This study has been undertaken to prepare a report on the riverine ecosystem of Lakhanpur Phase-II OCP and mitigation plan based on the study to comply with the stipulation of MoEF&CC.

CHAPTER-II: LITERATURE SURVEY

2. HUMAN WELL BEING AND FRESH WATER

Ecosystem services are the benefits provided to people, both directly and indirectly, by ecosystems and biodiversity. In "Ecosystem- The Millennium Assessment", fresh water is recognized as a ''*provisioning*'' service as it refers to the human use of fresh water for domestic use, irrigation, power generation, and transportation. However, fresh water and the hydrological cycle also sustain inland water ecosystems, including rivers, lakes, and wetlands. These ecosystems provide cultural, regulating, and supporting services that contribute directly and indirectly to human well-being through recreation, scenic values, and maintenance of fisheries. Fresh water also plays a role in sustaining freshwater-dependent ecosystems such as mangroves, inter-tidal zones, and estuaries, which provide another set of services to local communities and tourists alike. The ecosystem services provided by fresh water and hydrologic cycle are provided in Table-2.1. The trade-offs between these differing uses of fresh water and inland water systems can be balanced in the midst of increasing demand for all types of human benefit derived from fresh water.

TABLE-2.1: ECOSYSTEM SERVICES* PROVIDED BY FRESH WATER AND THE HYDROLOGIC CYCLE

Provisioning Services	Regulatory Services	Cultural services	Supporting services
Water (quantity and quality) for consumptive use (for drinking, domestic use, agriculture and industrial use)	Maintenance of water quality (natural filtration and water treatment)	Recreation (river rafting, kayaking and fishing as a sport)	Role in nutrient cycling (role in maintenance of floodplain fertility), primary production
Water for non-consumptive use (for generating power and transport/ navigation)	Buffering of flood flows, erosion control through water/land interactions and flood control infrastructure	Tourism (river viewing)	Predator/prey relationships and ecosystem resilience
Aquatic organism for food and medicines		Existence values (personal satisfaction from free flowing rivers)	

**Many of the provisioning, regulatory, and cultural services can be enhanced through development of water resources (large-scale navigation can be increased by creating slackwater systems using dams); however, there are often off-setting losses or trade-offs between these service categories, such as loss of rapid transport downstream to locals or those seeking recreation.*

2.1 CONDITIONS, TRENDS, AND DIRECT DRIVERS IN FRESHWATER SERVICES AND INLAND WATER ECOSYSTEMS

In the past century, increasing human population and advancing levels of social and economic development have led to a rapid increase in the demand for freshwater provisioning services. In its natural state, fresh water varies considerably in terms of its availability in time and space. Water resources development—the construction of dams and irrigation channels, the construction of river embankments to improve navigation, drainage of wetlands for flood control, and the establishment of inter-basin connections and water transfers has the aim of reregulating the natural hydrograph to meet human needs.

This has resulted in the replacement of naturally occurring and functioning systems with highly regulated and modified human engineered systems. These ''*developed*'' systems have typically been designed solely for the satisfaction of the major human consumptive uses (irrigation or municipal and industrial use) or non-consumptive use (hydropower and navigation).

These structural and capital-intensive responses—particularly large dams—have greatly augmented the natural availability of fresh water provisioning services. In the last 20 years alone, more than 2.4 billion people have gained access to water supply and more than 600 million have gained access to sanitation (World Water Commission, 1999). *At the same time, these supply responses have themselves become direct drivers of ecosystem degradation*. The impacts of water resource development are two-fold: less water remains in the ecosystem and the distribution and availability of the remaining water often has a different pattern from that present under natural conditions. It is estimated that the amount of water withdrawn from inland water systems has increased by at least 15 times over the past two centuries. As a result, humans now control and use more than half of the continental runoff to which they have access. *The impact of withdrawals, though, is not evenly spread and it is estimated that about 80% of the global population is living downstream of only 50% of Earth's renewable water supplies. Changes to the hydrograph and related physical, chemical, and biological processes have substantially degraded the condition of inland water ecosystems globally.*

A related consequence of water resource development has been reduced water quality. Caused through the pollution of in-land water ecosystems, this has occurred in parallel with the growth of urban, industrial, and agricultural systems. The major pollutants affecting water quality include nutrients, which drive

eutrophication; heavy metals; nitrogen and sulphur based compounds, which cause acidification of freshwater ecosystems; organic compounds; suspended particles, both organic and inorganic; contaminants such as bacteria, protists, or amoebae; and salinity. According to the World Water Commission, more than half of the major rivers of the world are seriously polluted. The presence of these pollutants depletes the capacity of rivers and associated inland and coastal ecosystems to provide clean water for social and economic uses. Changes in the condition of freshwater and associated inland water ecosystems have also occurred at the hands of other direct drivers such as species introductions, land use change, and climate change. The summary of the direct drivers is provided in Table-2.2.

TABLE-2.2: SUMMARY OF DIRECT DRIVERS (POSTEL AND RICHTER 2003)

Human Activity (Direct Driver)	Impact on Eco-systems	Services at Risk
Dam construction	Alters timing and quantity of river flows. Water temperature, nutrient and sediment transport, delta replenishment, blocks fish migrations	Provision of habitat for native species, recreational and commercial fisheries, maintenance of deltas and their economies, productivity of estuarine fisheries
Dike and levee construction	Destroys hydrologic connection between river and floodplain habitat	Habitat, sport and commercial fisheries, natural floodplain fertility, natural flood control
Diversions	Depletes stream flow	Habitat, sport and commercial fisheries, recreation, pollution dilution, hydropower, transportation
Draining of wetlands	Eliminates key component of aquatic ecosystem	Natural flood control, habitat for fish and waterfowl, recreation, natural water purification
Deforestation/ land use	Alters runoff patterns, inhibits natural recharge, fills water bodies with silt	Water supply quality and quantity, fish and wildlife, habitat, transportation, flood control
Release of polluted water effluents	Diminishes water quality	Water supply, habitat, commercial fisheries, recreation
Overharvesting	Depletes species populations	Sport and commercial fisheries, waterfowl, other biotic populations
Introduction of exotic species	Eliminates native species, alters production and nutrient cycling	Sport and commercial fisheries, waterfowl, water quality, fish and wildlife habitat, transportation
Release of metals and acid forming pollutants into the atmosphere	Alters chemistry of rivers and lakes	Habitat, fisheries, recreation, water quality

Human Activity (Direct Driver)	Impact on Eco-systems	Services at Risk
Emission of climate altering air pollutants	Potential for changes in runoff patterns from in-crease in temperature and changes in rainfall	Water supply, hydropower, transportation, fish and wildlife habitat, pollution dilution, recreation, fisheries, flood control

Indirect Driving Forces

Most water-related problems, although caused by direct drivers such as water abstraction and pollution, are ultimately a product of indirect drivers. The development of water resources over the past century has been largely a result of the need to supply expanding populations with food, energy, and domestic and industrial water supplies and to facilitate opportunities for transport.

Economic growth has further served to enhance the demand and consumption of freshwater services. However, given the public as well as private good characteristics of fresh water, most water-related problems are ultimately a product of indirect drivers associated with the economic nature of fresh water in all its guises—and the manner in which this nature is accommodated or not by the institutional arrangements that govern the production, allocation, distribution, and consumption of freshwater services. The economic characteristics of fresh water, when combined with the dynamic nature of the hydrological cycle, present special challenges in the case of freshwater.

The potential for fresh water or ecosystems to have multiple uses, some of which will be private goods and others of which will either be perfect public goods or variations such as common pool or toll goods, creates this management challenge, as each type lends itself to a different management regime. The market failure associated with public good characteristics suggests a need for mechanisms of social coordination in the form of institutional arrangements that can define, and adaptively manage, the level of provision and allocation of these goods and services that is desired by society.

Governance and the role of economic incentives are therefore critical indirect drivers with respect to balancing competing demands for freshwater. *The inadequate governance associated with water resource development, particularly a single-minded, engineering-economic approach to the ecosystems services that inland water systems provide, has led to significant social and environmental impacts; impacts that have disproportionately affected the rural poor that rely on the natural functioning of inland water ecosystems.*

In the last two decades, increased attention has been paid to the importance of considering water as an economic commodity. This has provoked considerable concern and controversy with respect to financing water infrastructure and water pricing, noticeably with regard to privatization of municipal water supply, as well as with the application of market approaches, particularly with respect to the

development of water markets and the use of payment systems for watershed services.

The discussion above highlights that water is in fact a resource that is often multi-functional and heterogeneous in nature. It is therefore not amenable to simple classification as either a public good or a private good. While water may be managed more successfully when its ‘‘economic’’ characteristics are recognized, due to its public good attributes, the solution will not be to treat it as a *uni-dimensional commodity*. Conversely, simply assuming freshwater is a public good in all contexts and uses is equally likely to lead to ruin. Rather, there is a need to respond to the inherent complexity of fresh water and work in an adaptable fashion toward site-specific solutions that accommodate the attributes and uses of fresh water in the local context.

2.2 BASIC INDICATORS OF THE RIVERINE ECO-SYSTEM SERVICES

As per a UN Report titled “A Framework for Freshwater Ecosystem Management - Volume 2: Technical Guide for Classification and Target Setting, 2017, the basic indicators, potential pressures and impact on riverine ecosystem services are summarized hereunder:

TABLE-2.3: BASIC INDICATORS, POTENTIAL PRESSURES AND IMPACTS ON RIVERINE ECOSYSTEM SERVICES

CATEGORY	INDICATOR (INCL. DIRECTION OF CHANGE FROM NATURAL)	PRESSURES	CONSEQUENCES: IMPACT ON ECOSYSTEM SERVICES	RELEVANT ECOSYSTEMS
Water quantity and spatial extent	Decrease in quantity and spatial extent Usually due to overuse – *e.g.* direct surface water	Usually due to overuse – *e.g.* direct surface water and groundwater abstraction, or destruction of wetlands due to agricultural or urban expansion	• Decrease in base flows and natural floods. Loss of biological functions that will impact on instream and riparian ecological state, with a decrease in riparian material production (food, building materials, fuel, *etc.*) and instream food production (*e.g.* fish), fragmentation of biological communities and loss of viability of populations. • Potential decrease in the inundation of flood plains and nutrient and sediment transport to the flood plain. • May result in decrease of fish production and decrease in soil quality needed for crop cultivation. • Influence on the freshwater requirements of estuaries and consequent impact on fish production	Rivers and streams, Riparian wetlands, floodplains, lakes and reservoirs, estuaries, ground water ecosystems

CATEGORY	INDICATOR (INCL. DIRECTION OF CHANGE FROM NATURAL)	PRESSURES	CONSEQUENCES: IMPACT ON ECOSYSTEM SERVICES	RELEVANT ECOSYSTEMS
	Increase in quantity (intermittent/seasonal/ perennial for rivers and palustrine wetlands)	Usually due to changes in natural flow regime, such as reservoir releases or inter-basin transfer into a river, reservoir or lake.	• Increased bank and instream erosion and movement of sediments. Deposition of sediments in slow flowing sections (pools) may cause loss of habitat volume for instream biota. Bed armouring (removal of fine sediment due to increased flows) and change in substrate characteristics. Increased risk of invasive plant encroachment in riparian zone. Detrimental changes in the functions and characteristics of the zone. • Results in a change in ecological processes such as food production, and wood production for fuel and building material. Fragmentation of biological communities and potential loss of viability of food (fish) production. Disruption of the migration corridor for biota and the runoff buffering effect of the zone that controls erosion and surface water quality. Introduction of undesirable biota through inter-basin transfers and purposeful introduction of such biota into reservoirs (and lakes). Impact in freshwater–seawater balance in estuaries with possible impact on food production and fish spawning.	Rivers and streams, Riparian wetlands

CATEGORY	INDICATOR (INCL. DIRECTION OF CHANGE FROM NATURAL)	PRESSURES	CONSEQUENCES: IMPACT ON ECOSYSTEM SERVICES	RELEVANT ECOSYSTEMS
Water quality	Increase in nutrients	Originates from point sources (urban areas and industries, fish farms) and non-point sources (e.g. urban runoff, agricultural areas and fish cage aquaculture in lakes and reservoirs)	• May accelerate biochemical rates – e.g. excessive algal growth that may result in development of water column oxygen concentration variations (especially anaerobic conditions) and production of algal toxins. May have an extreme impact on aquatic biotic assemblages and influence food production population. • May enhance growth of riparian vegetation (including fringing or marginal vegetation) and growth of undesirable aquatic macrophytes, and enable the establishment of undesirable and tolerant aquatic fauna. • A decrease in natural flow volume can potentially exacerbate the impact of increased nutrients due to a loss of assimilative capacity and dilution of nutrients.	Lacustrine wetlands, reservoirs, lakes, estuaries
	Oxygen levels	Increase in oxidizable material results in high chemical oxygen demand (COD) from diffuse sources (*e.g.* runoff) or point sources (*e.g.* wastewater discharge) from urban and agricultural areas	• Decreases in oxygen can modify the natural aquatic assemblages and favour low oxygen-tolerant biota. Eventually this will influence food fish populations, with a decrease in desirable species and biodiversity. • High flow releases from a reservoir can result in high turbulence, resulting in dissolved gas super saturation that is detrimental to some fish species (i.e. 'gas bubble disease').	Rivers and streams, lakes, reservoirs, wetlands and estuaries

CATEGORY	INDICATOR (INCL. DIRECTION OF CHANGE FROM NATURAL)	PRESSURES	CONSEQUENCES: IMPACT ON ECOSYSTEM SERVICES	RELEVANT ECOSYSTEMS
		and certain industries. Also closely related to the enhanced biological activity of aquatic organisms due to an increase in nutrients.		
	Acidity	pH decrease can originate from acid mine drainage, and industrial processes and acid rain. Increase can be a result of industrial processes as well as biological activity in some standing water bodies indirectly due to increases in nutrient concentrations.	• Decreases can increase the toxicity of metals and result in the mortality of all but the most tolerant biota. • Water can be rendered unusable without intensive treatment. Increases in pH can be detrimental for aquatic biota and cause physical damage to sensitive fish populations, with eventual impact on fish food production and the shifting of a fish assemblage composition to tolerant species and a loss in biodiversity.	Rivers and streams, wetlands, lakes, reservoirs, estuaries, groundwater

CATEGORY	INDICATOR (INCL. DIRECTION OF CHANGE FROM NATURAL)	PRESSURES	CONSEQUENCES: IMPACT ON ECOSYSTEM SERVICES	RELEVANT ECOSYSTEMS
	Electrical Conductivity (EC)	Industries, urban areas, mines, agricultural runoff and saltwater intrusion due to over-extraction of groundwater.	• Increases generally relate to an increase in salinity. • These may cause a disruption in the populations of sensitive biota. The constituents of the salts that increase EC may also be toxic to some biota (e.g. some magnesium salts). • Depending on the degree of EC change and the salts involved, the aquatic food chain can be changed, resulting in a decrease in desired fish species populations and biodiversity loss.	River, streams lakes, reservoirs, wetlands, estuaries, groundwater

2.3 ECOLOGICAL CHARACTERIZATION: IDENTIFYING KEY ECOSYSTEM COMPONENTS

The ecological condition of an aquatic ecosystem is the result of a complex, interdependent set of physical, chemical and biological elements. Thus, characterizing the system can be facilitated by evaluating key ecosystem components which have important functions in determining ecosystem integrity. These include biological components and hydrologic, sediment, water quality and thermal regimes, along with their associated connectivity and variability.

2.4 BIOLOGICAL COMPONENTS

All development activities that alter the hydrologic and water quality characteristics of a river have some degree of effect on riverine biota and their habitat. These will typically occur at multiple trophic levels. For example, game fish species are valued ecosystem components (VECs) within rivers and maintaining their populations is often a primary concern for social and economic reasons. However, fish communities depend on the function of all lower trophic levels, so they can serve as an overall reflection of the health of the river ecosystem. Primary production supports higher trophic levels as a food source (*e.g.* periphyton) and can provide physical habitat in the form of aquatic macrophytes and riparian vegetation. All these ecosystem components can be affected by alteration to the hydrological, sediment, water quality, and temperature regime, so it is important that numerous indicators, including all trophic levels, be measured as part of a site characterization and monitoring plan.

2.5 HYDROLOGIC REGIME

Flow is the dominant variable determining the form and function of a river. Flow alteration changes the pattern of natural variation and disturbance on a river system. Depending upon the type of in-stream development, this may include converting the river to a lake-like (lentic) ecosystem upstream of the project and modifying the natural flow regime (magnitude, duration, frequency, timing, and rate of change) downstream of the project. Such changes may propagate extensive distances downstream depending on the degree of alteration and river morphology. Understanding the ecological functions provided by the natural flow components is necessary for assessing the potential alteration to ecological condition and VECs.

2.6 SEDIMENT REGIME

Natural rivers have highly variable processes of erosion, transport, and deposition of suspended sediment and bedload sediment that are intricately tied to changes in water velocity, sediment supply and shape, channel slope, and the roughness of channel material. The result is a dynamically changing channel form that produces a diversity of physical habitat important for maintaining ecological integrity. Structures, such as dams, act as sediment traps, interrupting the longitudinal connectivity of the sediment regime, resulting in decreased downstream turbidity and sediment load that may lead to armouring of channels and increased erosion as the system attempts to rebalance itself.

Moreover, reductions in peak flows during freshet can reduce the river's ability to transport materials deposited in the main river by tributaries, potentially resulting in the formation of deltas and other changes in river morphology. Changes in the sediment regime can result in changes to quality, quantity and distribution of habitat for biological components of aquatic ecosystems. In addition, there can be changes in migration and movement patterns and productivity of the system.

2.7 WATER QUALITY AND THERMAL REGIMES

A river's water quality, including the temperature regime, is influenced by a variety of factors, including climate, the geological characteristics of the drainage basin, flow regime, and other factors such as land use patterns. For example, a significant change in the flow regime or creation of a reservoir can alter water temperatures, dissolved gases, nutrients, turbidity/light, and the bio-availability of contaminants within a river. Such changes can affect all trophic levels.

Water temperatures limit and/or determine the distribution and abundance of many riverine species. Temperature influences overall water quality, rates of nutrient turnover, metabolic activity and growth rates, timing of migration and spawning events and the distribution of stream organisms. Hence, a river's thermal regime strongly influences ecological condition. Species-specific thermal preferences and tolerances are critical biological characteristics that define thermal habitat. For example, the conversion of rivers to lake-like ecosystems upstream of dams can alter the thermal regime upwards of 930 km downstream (Olden and Naiman 2010). Depending on the design of the dam, downstream water temperatures may decrease if water is drawn from the cold *hypolimnion* or increase if water is drawn from the warm *epilimnion*. Such fundamental changes to the thermal regime and their potential consequence on aquatic ecosystems, are frequently overlooked, yet are some of the more easily mitigated issues when considering new and, in some cases, existing development.

2.8 INDICATORS

Indicators for the key ecosystem components described in the previous section are summarized in Table-2.3. Indicators for physical and chemical components cover a range of processes and functions thought to be the primary determinants of change in the biological indicators. These include flow, sediment movement, water temperature, and dissolved oxygen. Biological indicators include a variety of measures to assess the structure and function of an ecosystem. Together, the indicators can be used to assess the current state of the aquatic ecosystem and evaluate its ecological condition. However, not all of the indicators are appropriate for every project. The choice of indicators will be part of the decision process for a specific project and will be based on the type of alteration and the characteristics of the site. Additional indicators may also be considered to facilitate comparisons at other sites and to assess cumulative effects. It is also important to keep in mind that multiple indicators can often be sampled using the same method (e.g. water quality, temperature).

FIGURE-2.1(A): POND SITE IN LAKHNAPUR II OCP – THE ORIGIN OF PHULIJHOR NALLA

FIGURE-2.1(B): POND SITE IN LAKHNAPUR II OCP – THE ORIGIN OF PHULIJHOR NALLA

FIGURE-2.1(C): POND SITE IN LAKHNAPUR II OCP – THE ORIGIN OF PHULIJHOR NALLA

FIGURE-2.1(D): POND SITE IN LAKHNAPUR II OCP – THE ORIGIN OF PHULIJHOR NALLA

FIGURE-2.2: AREA NEAR TINGISMAL POND IN STUDY AREA

FIGURE-2.3: SAMPLING OF MICRO-INVERTEBRATES AT THE POND SITE

FIGURE-2.4: SAMPLING OF MICRO-INVERTEBRATES AT THE POND SITE

FIGURE-2.5: VIEW OF TINGISMAL POND IN THE STUDY AREA

FIGURE-2.6: ORIGIN OF PHULIJHOR NALLA AND ITS ROUTE IN THE LAKHANPUR PHASE-II MINE SITE

FIGURE-2.7(A): SAMPLING OF MICRO-INVERTEBRATES IN PHULIJHOR NALLA

FIGURE-2.7(B): SAMPLING OF MICRO-INVERTEBRATES IN PHULIJHOR NALLA

FIGURE-2.7(C): SAMPLING OF MICRO-INVERTEBRATES IN PHULIJHOR NALLA

FIGURE-2.7(D): SAMPLING OF MICRO-INVERTEBRATES IN PHULIJHOR NALLA

FIGURE-2.8: SAMPLING AT LILARI NALLAH

FIGURE-2.9(A): CONFLUENCE OF LILARI AND IB RIVER

FIGURE-2.9(B): CONFLUENCE OF LILARI AND IB RIVER

FIGURE-2.10(A): SAMPLING AT IB RIVER

FIGURE-2.10(B): FIXING OF DO ON FIELD AT TNIGISMAL POND

FIGURE-2.10(C): COLLECTION AND PRESERVATION OF PLANKTON SAMPLE AT TINGISMAL POND

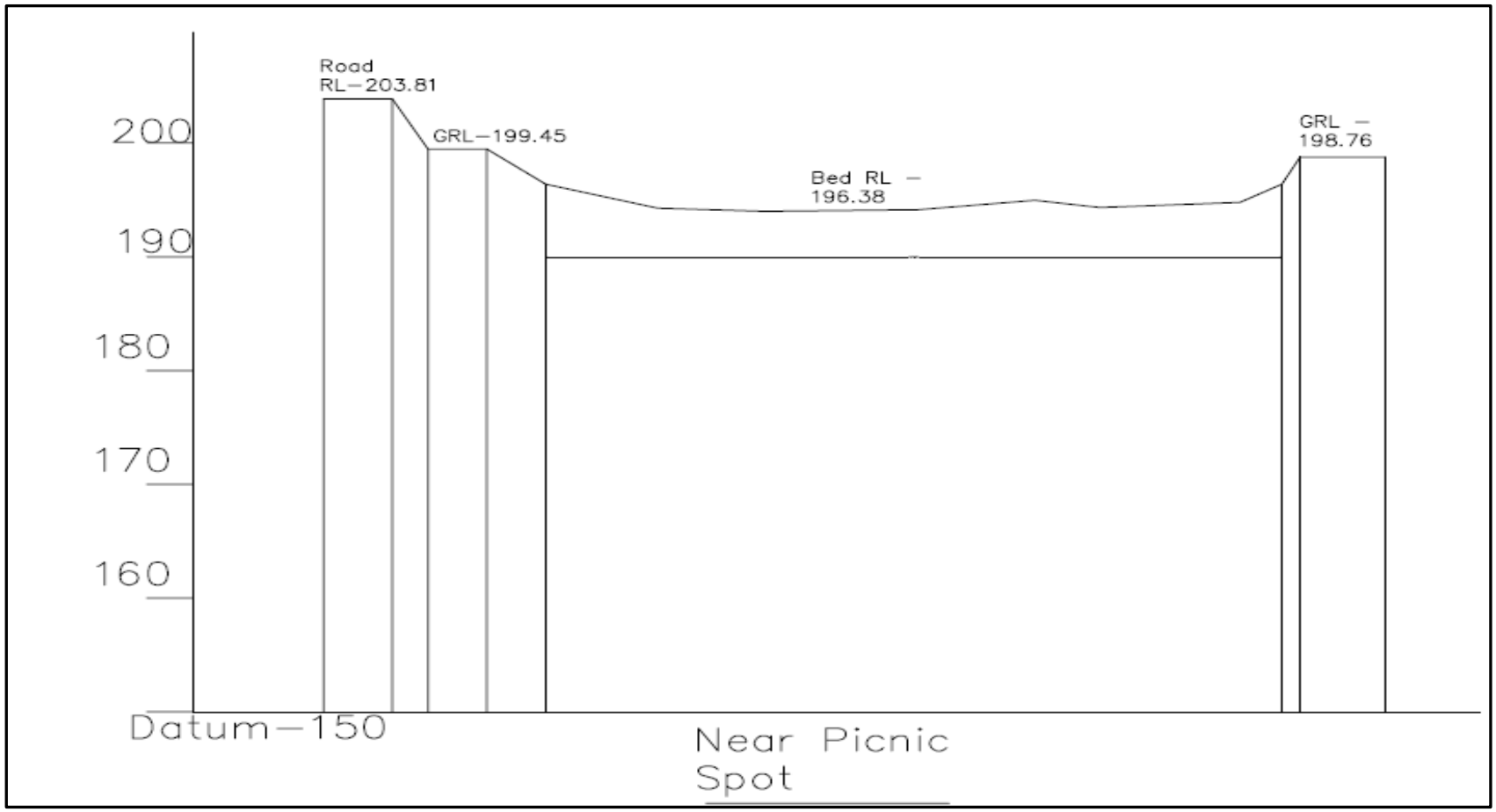


FIGURE-2.11: CROSS-SECTION OF LILARI NALLAH NEAR PICNIC SPOT

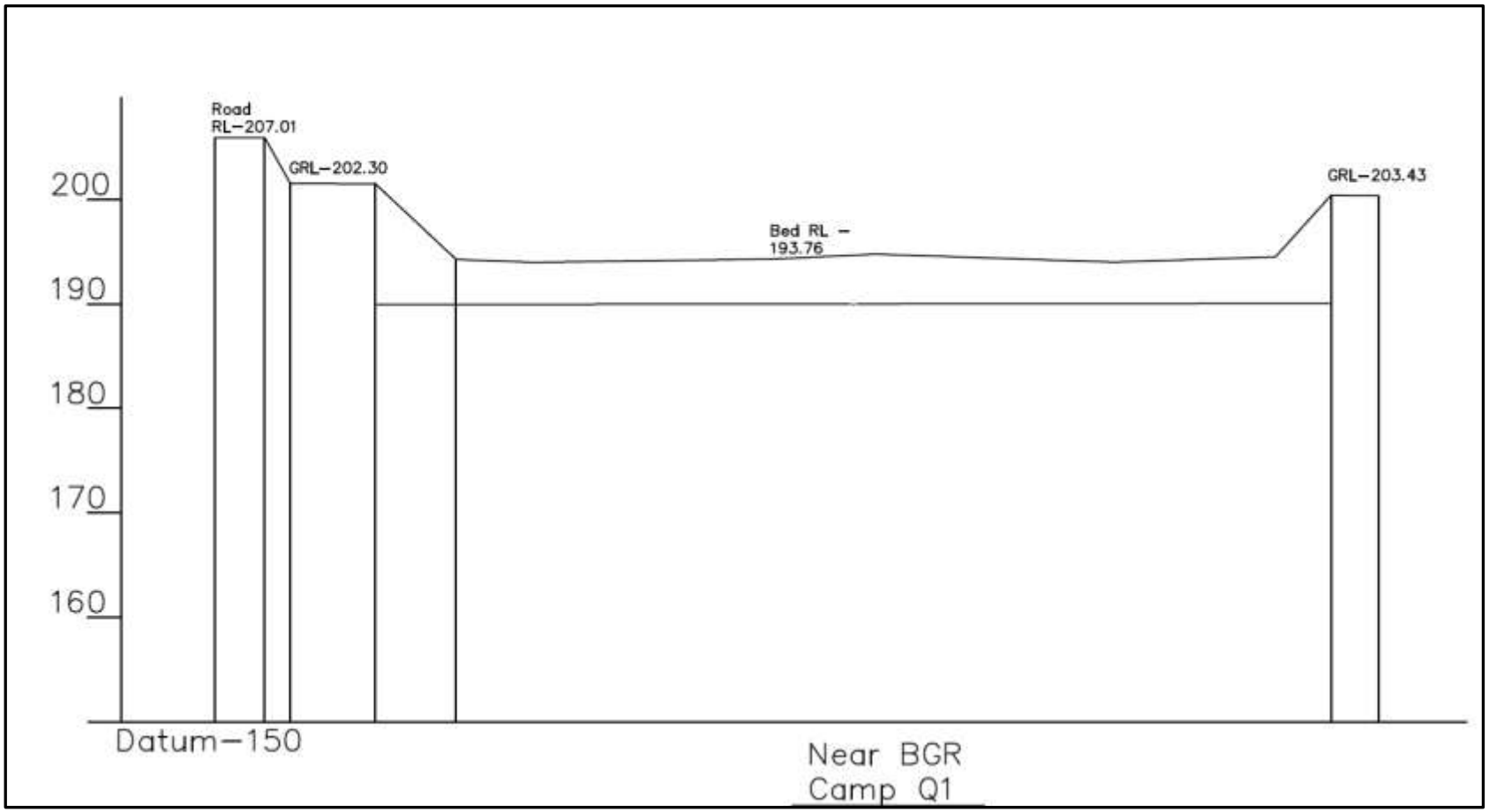


FIGURE-2.12: CROSS-SECTION OF LILARI NALLAH NEAR BGR CAMP

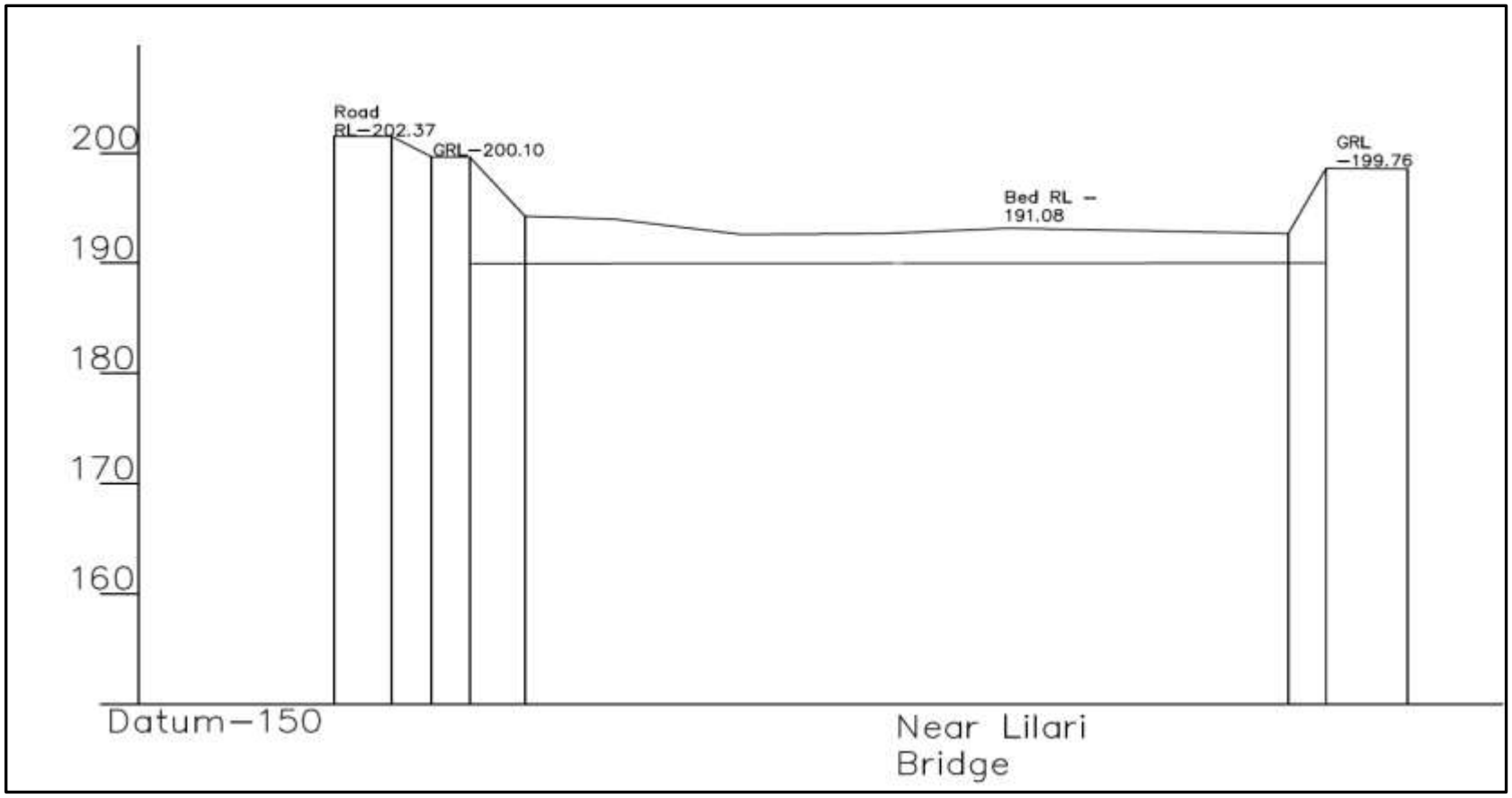


FIGURE-2.13: CROSS-SECTION OF NALLAH NEAR LILARI BRIDGE

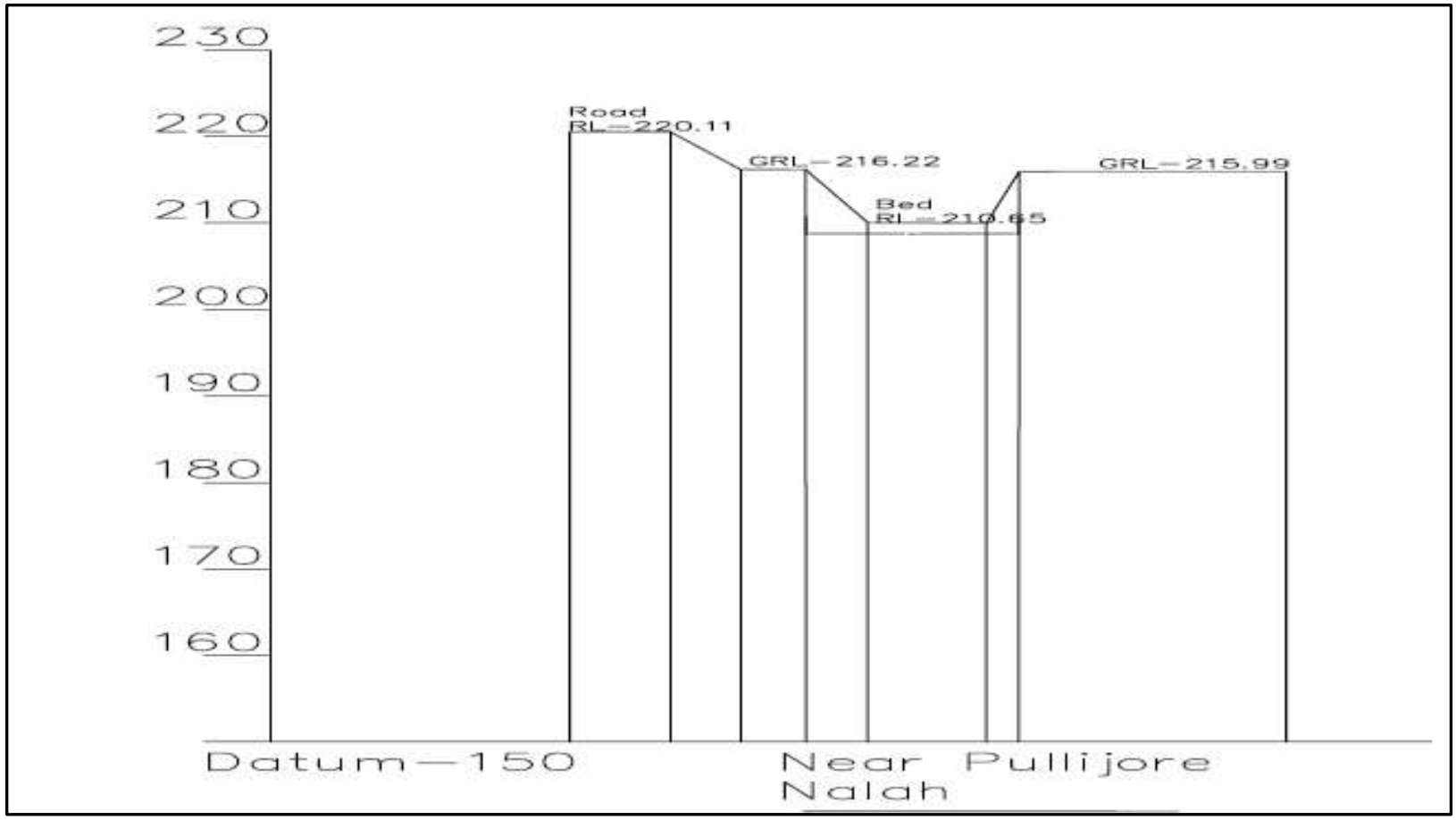


FIGURE-2.14: CROSS-SECTION OF PHULIJHOR NALLAH NEAR VIEW POINT

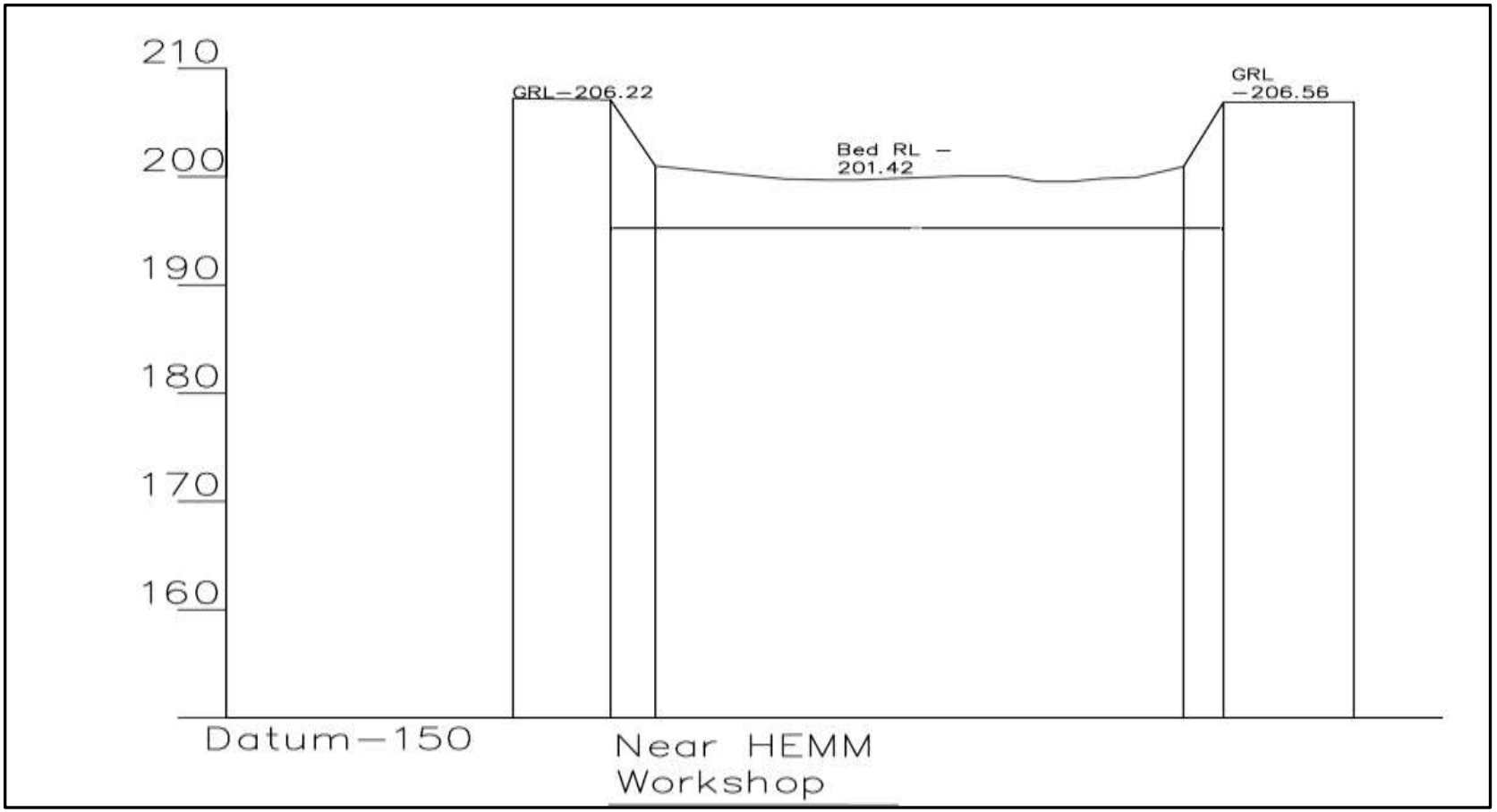


FIGURE-2.15: CROSS-SECTION OF PHULIJHOR NALLAH NEAR HEMM WORKSHOP

➢ METHODOLOGY OF SURFACE WATER ANALYSIS

Sampling Schedule

Present investigation has been conducted on different lentic and lotic aquatic systems of Lakhanpur OCP**.** For completion of the goal the water samples were collected between 9 AM to 12 PM from August-2018 to October-2018 for monthly physico-chemical and biological analysis from all the selected sites which were selected in different areas in the present study area. The physico-chemical parameters were analyzed by following methods as given in Adoni (1985), Trivedi and Goel (1986), APHA (1998) and *NEERI Manual* (1991).

During present study for the collection of water samples were collected directly from the surface of the water body, while plankton net (20 µm) was for filtering of water for the analysis of plankton (Phytoplankton and Zooplankton).

Water sample collection and analysis

Water samples were collected in 1litre plastic cane directly from the surface of the water body from each station. Analysis of some of the physico-chemical parameters such as pH and dissolved oxygen was carried out immediately at the time of sampling in the field itself. Water samples for other physico-chemical parameters were stored and carried to the laboratory for the further analysis.

METHODOLOGY FOR DATA COLLECTION OF AQUATIC FLORA AND FAUNA

For enumeration and quantification of plant biodiversity, in-depth studies were conducted at respective project sites. Considering the potential impact of development on biodiversity, this needs to be assessed from a biodiversity viewpoint to indicate the extent to which the disturbance will have impact on biodiversity. Several field studies were undertaken in order to gather authentic information on enumeration, quantification, and distribution of plant biodiversity in the study region. Standard field and laboratory methods of biodiversity studies were followed for data collection and data analysis. Following methods are used for Biodiversity survey:

Plankton: **Sedgwick Rafter methods for the analysis of Phytoplankton and Zooplankton**

For the qualitative analysis of phytoplankton and zooplankton surface water samples were collected from the different sampling sites the study area. For enumeration of samples, 40 liters of surface water sample was filtered through plankton net (made of bolting silk of mesh size 20µm) and concentrated into 100 ml plastic vials; and preserved with Lugol's iodine solution or 4% formaldehyde simultaneously.

For the qualitative analysis of Phytoplankton and Zooplankton, 1ml of concentrated sample was taken in standard Sedgwick Rafter Cell (Vol. 1ml) and its entire content was analyzed under the inverted light microscope and identification was done with the help of standard taxonomic references viz. Edmondson (1992), Needham and Needham (1962), Batish (1992), Pennak (1978), Ward and Whipple (1966), Michael and Sharma (1988) and Sharma, (1998).

Macro-invertebrates: Random-Qualitative

Ekman Dredge / Peterson Grab method:

After following this method, we collect mud or sediment samples were from a selected site. For qualitative study of benthic fauna mud samples were collected as per random sampling methods. The materials (mud) sieved through metallic sieves of 1mm and 0.5mm pore size. The organisms thus collected on the sieves transferred to white enamel tray and sorted out manually for macro-benthic organisms and preserving the samples with 4% formaldehyde solution.

The identification of macro-invertebrates carried up to the species level for their taxonomic and various morphometric characters with the help of standard taxonomic references (Needham and Needham, 1962; Pennak, 1978; Edmondson, 1992; Tonapi, 1980; Terrence and Edward 1999; Subba Rao, 1989; Plaziat and Younis, 2005 and Birmingham *et al*., 2005).

Fishes: Local survey at landing sites, Verbal communication with local fisherman's, and Information from respective Fishery Department. Fish identification was done by using various morphometric and meristic characters. The identification was made up to the species level, with the help of standard taxonomic references (viz. Day, F. (1967 &78):, Qureshi, T.A. and Qureshi, N.A. (1983), Srivastava, G. L. (1986), Datta Munshi J. S. and Srivastava M. P.(1988), Talwar, P.K. and Jhingaran, A. (1991), and Jayaram, K.C. (1999). and with the help of local people for local names.

Macrophytes (Aquatic weeds): Local survey nearby the selected sampling sites, Verbal communication with local people and others, information available related to it. The identification of fishes was done with the help of standard taxonomic references (viz. Cook, 1996; Gamble, 1935; Mishra, K.C., 1974; Ghosh, 2005) and with the help of local people for local names.

1. Simpson's Diversity Index

In ecology, Simpson's Diversity Index is often used to quantify the biodiversity of a habitat. Simpson's diversity index is a measure of diversity which takes into account the number of species present, as well as the relative abundance of each species.

$$D = 1 - \left(\frac{\Sigma\, n(n-1)}{N(N-1)} \right)$$

n = the total number of organisms of a particular species
N = the total number of organisms of all species

The value of D ranges between 0 and 1. With this index, 1 represents infinite diversity and 0, no diversity.

CHAPTER-III: HYDRO-GEOLOGICAL SETUP

3. HYDRO-GEOLOGY

The Hydrogeological Unit of CMPDI, Ranchi had conducted the hydrogeological studies in Orient colliery, Ib Valley Coalfield in 2005.

Further hydrogeological investigation has been carried out by CGWB for estimation of Ground Water Resources and Development Potential of Jharsuguda district. The salient features of the study are given below to give an idea about the hydrogeological regime of the sedimentary deposit as the sedimentary deposits are of contemporaneous in origin.

- Sandstone between Lajkura and Parkhani seams form an aquifer with depth ranges between 30 to 150 mbgl. The aquifer is semi-confined to confined in nature.
- Disintegrated formation above Parkhani seam or sandstone formation above Lajkura seam upto the land surface with a semi-pervious layer of limited thickness at a depth of 25 to 30 mbgl are encountered. The nature of aquifer is unconfined.
- The general movement of ground water in the ground water table aquifer is from north-west to south-east direction.
- The ground water level in this area ranges from less than 1.30 m bgl to about 4.12 m bgl in post-monsoon and less than 2.80 to about 7.62 m bgl in pre-monsoon period.
- The water level fluctuation annually varies from 1.64 to 12.05 m in this area.
- The specific yield of the phreatic aquifer is 0.05 or 5%.
- The aquifer characteristics of shallow (unconfined) aquifers are estimated by conducting pumping tests on representative open wells tapping different litho units. The litho unit wise aquifer characteristics are given below:

TABLE-3.1: AQUIFER CHARACTERISTICS

Sl. No.	Hydrogeological Unit	Specific capacity (lpm/m)	Permeability (m/day)	Yield (m3/day)
1.	Talcher sand stone	7.148	0.983	20.56
2.	Barakar sand stone	0.720 - 39.880	0.250 - 8.040	24.28 - 239.85
3.	Kamthi sand stone	3.135 - 6.336	0.517 - 1.155	24.28 - 034.56

The hydrogeological data of test wells are summarized given in the next page.

TABLE-3.2: HYDROGEOLOGICAL DATA OF TEST TUBE WELLS IN RAMPUR TRACT OF IB VALLEY COALFIELD

Sl. No.	Location	Well depth (m bgl)	Dia (mm)	Zones tapped	SWL (m bgl)	Disch-arge (LPS)	Draw down (m)	Duration of pumping (Min)	Trans-missivity (m^2/day)	Storage coefficient	Remarks
1.	Lajkura Test Well Orient Colliery Field-1.	142	305/ 152	59-63, 69-76, 83-89, 93-100, 115-118, 120-123, 126-136	13.41	9.5	21.250	1000	44	--	Drilled by CMPDIL in Ib Valley Coalfield in Gondwana sand stone
2.	Lajkura Obs. Well (64.50 m away from Test Well)	142	150	73-77, 85-88, 102-108, 113-116, 130-136	10.56	--	6.375	--	60	--	
3.	Abandoned Air Shaft-1 Test Well.	76	5300	30-75	26.50	20.0	23.095	2200	68.79	5.3×10^{-5}	
4.	Abandoned Air Shaft-1 Test Well. (O.W)	76	5300	30-75	26.51	--	4.280	--	59.99	5.46×10^{-5}	
5.	Lajkura Test Well, Orient Colliery Field-2	68	203/ 152	45-50, 54-66	33.60	3.3	10.685	4300	--	--	
6.	Lajkura Obs. Well (O.W-1) 30 m. away from Test Well	65	152	41.5-48, 50-63	33.33	--	1.070	--	81.90	5.0×10^{-5}	
7.	Lajkura Obs. Well (O.W-2) 60m away from Test Well	68	152	52.0 to 68.0	32.38	--	0.831	--	114.65	6.0×10^{-4}	
8.	Parkhari Test Well	36.8	203	18-24, 29-35	3.69	1.9	29.427	15	0.4	--	

3.1 HYDRO-GEOLOGY OF IB-VALLEY COALFIELD

CMPDI has conducted the hydro-geological investigation for the Ib-Valley Coalfield in the year 2017.

3.2 HYDROLOGY

Two major basins which traverses Ib valley coalfield are Basundhara nalla basin and Lilari nalla basin. All these channels are 5th order streams in the study area of IB coalfields.

3.2.1 SITE INVESTIGATION PROGRAMME

A network of one hundred and fifty (150) open dug wells spread over the Ib valley coalfield were established to monitor the water table variation and to assess the hydraulic head of the water table in the phreatic aquifer.

In order to delineate the aquifer properties and to record proper groundwater levels for the deeper aquifers in Ib valley coalfield, 17 numbers of piezometers were installed and tested.

To evaluate the present state of water quality in Ib valley coalfield, 20 tubewells, 17 piezoometers, 11 surface water stations and 8 mine water stations were identified for the study. Water samples collected and analyzed both in pre-monsoon season and post monsoon season.

3.3 HYDROGEOLOGY

3.3.1 AQUIFER DISPOSITION

The aquifers in Ib valley coalfield have been broadly classified as shallow & deep aquifer and have been referred as unconfined and confined aquifers respectively representing their mode of occurrence. The division between confined and unconfined is entirely gradational. The term semi-confined is used for the intermediate condition.

3.3.2 ESTIMATION OF HYDRAULIC PROPERTIES

Hydraulic conductivity signifies the dominant role of secondary porosity in the aquifer development. The hydraulic conductivity of tested piezometers ranges from 0.001 m/day to 0.228 m/day.

PRESENT GROUNDWATER LEVELS IN PHREATIC AQUIFER

One hundred and fifty (150) dug wells were monitored across various villages in Ib valley coalfield. The water level contour coincides with the topography of the study area.

3.4 ANNUAL WATER LEVEL FLUCTUATION

The annual fluctuation water level for during May 2007 and May 2015 shows an increasing trends in Ib valley coalfield. As the fluctuation in water levels during 8 years period was observed to vary from - 6.10 m to + 6.22 m and which is very close to the natural fluctuation observed in villages located far away from mine areas. At the same time the fluctuation trend also shows negligible change in water level

fluctuation throughout the time period of 8 years. These variations may be attributed to the local utilization and recharge conditions only. Thus, the influence of mining on these water levels may be considered as marginal.

The annual fluctuation water level for during August 2007 and August 2015 shows an increasing trends in Ib valley coalfield. As the fluctuation in water levels during 8 years period was observed to vary from – 1.23 m to + 1.54 m and which is very close to the natural fluctuation observed in villages located far away from mine areas. At the same time the fluctuation trend also shows negligible change in water level fluctuation throughout the time period of 8 years. These variations may be attributed to the local utilization and recharge conditions only. Thus, the influence of mining on these water levels may be considered as marginal.

The annual fluctuation water level for during November 2007 and November 2015 shows an increasing trends in Ib valley coalfield. As the fluctuation in water levels during 8 years period was observed to vary from – 0.90 m to + 1.17 m and which is very close to the natural fluctuation observed in villages located far away from mine areas. At the same time the fluctuation trend also shows negligible change in water level fluctuation throughout the time period of 8 years. These variations may be attributed to the local utilization and recharge conditions only. Thus, the influence of mining on these water levels may be considered as marginal.

The annual fluctuation water level for during January 2008 – January 2016 shows an increasing trends in Ib valley coalfield. As the fluctuation in water levels during 8 years period was observed to vary from – 0.50 m to + 2.45 m and which is very close to the natural fluctuation observed in villages located far away from mine areas. At the same time the fluctuation trend also shows negligible change in water level fluctuation throughout the time period of 8 years. These variations may be attributed to the local utilization and recharge conditions only. Thus, the influence of mining on these water levels may be considered as marginal.

3.5 HISTORICAL GROUNDWATER LEVEL TRENDS

To evaluate the behaviour of long term groundwater level trends, long term water level data from the permanent observation CGWB wells has been referred in this report. To study the long term water level trends, hydrograph of all the above CGWB observation wells has been drawn. Long term water level trends signifies that the groundwater is not affected by mining.

3.6 WATER BALANCE

Total Annual recharge estimated in Ib valley coalfield is 209.85 Mm3. Net groundwater availability for industrial or any other purpose is estimated to be 147.99 Mm3.

3.7 HYDROCHEMISTRY

3.7.1 SAMPLE ANALYSIS PROGRAMME

Water sampling together with laboratory analysis was undertaken to determine the presence of surface and subsurface water contamination. Chemical analysis of ground water, surface water, and mine water includes the determination of the concentrations of inorganic constituents including heavy metals.

3.7.2 ANALYTICAL RESULTS AND INTERPRETATION

It is clearly interpreted that all the parameters analysed in surface water samples are within permissible limits except Biological oxygen demand and dissolved oxygen.

All the parameters analysed in mine water samples are within permissible limits except Manganese. Manganese is seen marginally exceeding permissible limits in premonsoon season only. The increase in Manganese may be geogenic.

All the parameters analysed in piezometer's water samples are within limits except Manganese. Manganese is seen marginally exceeding limits in both pre monsoon ((MIP 07, 11, 12, 15, 16, 17) and post monsoon season (MIP 15, 16, 17). The increase in manganese may be geogenic.

All the parameters analysed in tube well water samples are within limits except Manganese and total hardness Manganese is seen marginally exceeding limits in premonsoon season only in well no. MIBTW 2, 6, 15. Total hardness is seen marginally exceeding limits in post monsoon season (MTTW 02) only. The increase in manganese may be geogenic.

` **ANNUAL WATER LEVEL FLUCTUATION**

I. Annual water level fluctuation (May 2007 – May 2015)

A comparison of depth to water level during May 2007 and May 2015 reveals that 76.16% of the total wells shows rise in water level and 23.84% of well shows decline in water level. Annual water level fluctuation chart for May 2006 – May 2015 has been prepared and presented in figure 5.

The annual fluctuation water level for during May 2007 and May 2015 shows an increasing trends in Ib valley coalfield. As the fluctuation in water levels during 8 years period was observed to vary from - 6.10 m to + 6.22 m and which is very close to the natural fluctuation observed in villages located far away from mine areas. At the same time the fluctuation trend also shows negligible change in water level fluctuation throughout the time period of 8 years. These variations may be attributed to the local utilization and recharge conditions only. Thus, the influence of mining on these water levels may be considered as marginal.

II. Annual water level fluctuation (August 2007 and August 2015)

A comparison of depth to water level during August 2007 and August 2015 reveals that 70.86% of the total wells shows rise in water level and 29.14% of well shows decline in water level. Annual water level fluctuation chart for August 2007 and August 2015has been prepared and presented in figure 6.

The annual fluctuation water level for during August 2007 and August 2015 shows an increasing trends in Ib valley coalfield. As the fluctuation in water levels during 8 years period was observed to vary from – 1.23 m to + 1.54 m and which is very close to the natural fluctuation observed in villages located far away from mine areas. At the same time the fluctuation trend also shows negligible change in water level fluctuation throughout the time period of 8 years. These variations may be attributed to the local utilization and recharge

conditions only. Thus, the influence of mining on these water levels may be considered as marginal.

III. Annual water level fluctuation (November 2007 – November 2015)

A comparison of depth to water level during November 2007 and November 2015 reveals that 80.13% of the total wells shows rise in water level and 19.87% of well shows decline in water level. Annual water level fluctuation chart for August 2007 and August 2015has been prepared and presented in figure 7.

The annual fluctuation water level for during November 2007 and November 2015 shows an increasing trends in Ib valley coalfield. As the fluctuation in water levels during 8 years period was observed to vary from – 0.90 m to + 1.17 m and which is very close to the natural fluctuation observed in villages located far away from mine areas. At the same time the fluctuation trend also shows negligible change in water level fluctuation throughout the time period of 8 years. These variations may be attributed to the local utilization and recharge conditions only. Thus, the influence of mining on these water levels may be considered as marginal.

IV. Annual water level fluctuation (January 2008 – January 2016)

A comparison of depth to water level during January 2008 – January 2016 reveals that 47.68% of the total wells shows rise in water level and 52.32% of well shows decline in water level. Annual water level fluctuation chart for August 2007 and August 2015has been prepared and presented in figure 8.

The annual fluctuation water level for during January 2008 – January 2016 shows an increasing trends in Ib valley coalfield. As the fluctuation in water levels during 8 years period was observed to vary from – 0.50 m to + 2.45 m and which is very close to the natural fluctuation observed in villages located far away from mine areas. At the same time the fluctuation trend also shows negligible change in water level fluctuation throughout the time period of 8 years. These variations may be attributed to the local utilization and recharge conditions only. Thus, the influence of mining on these water levels may be considered as marginal.

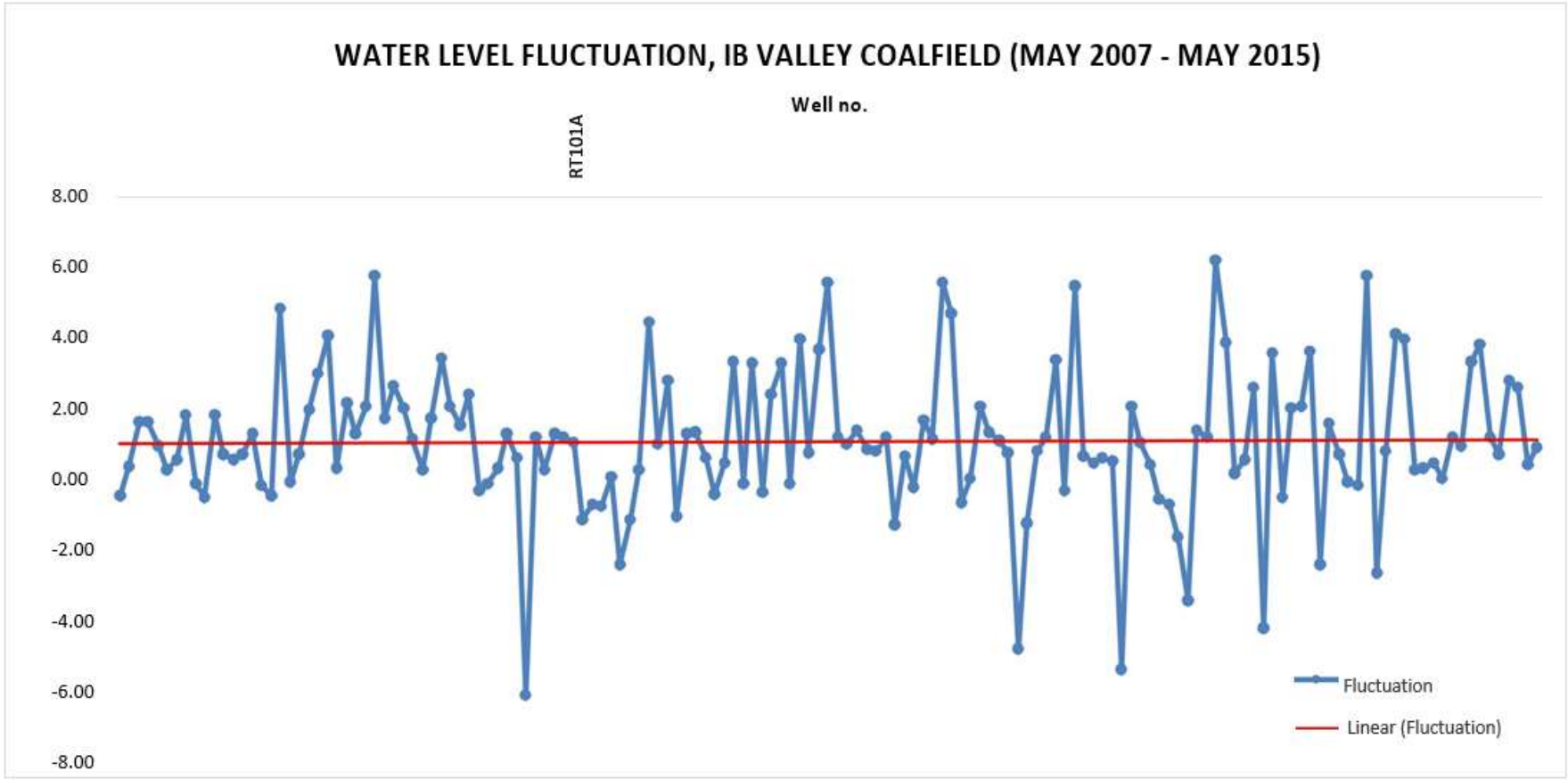


FIGURE-3.1(A): ANNUAL WATER LEVEL FLUCTUATION (MAY 2007 – MAY 2015)

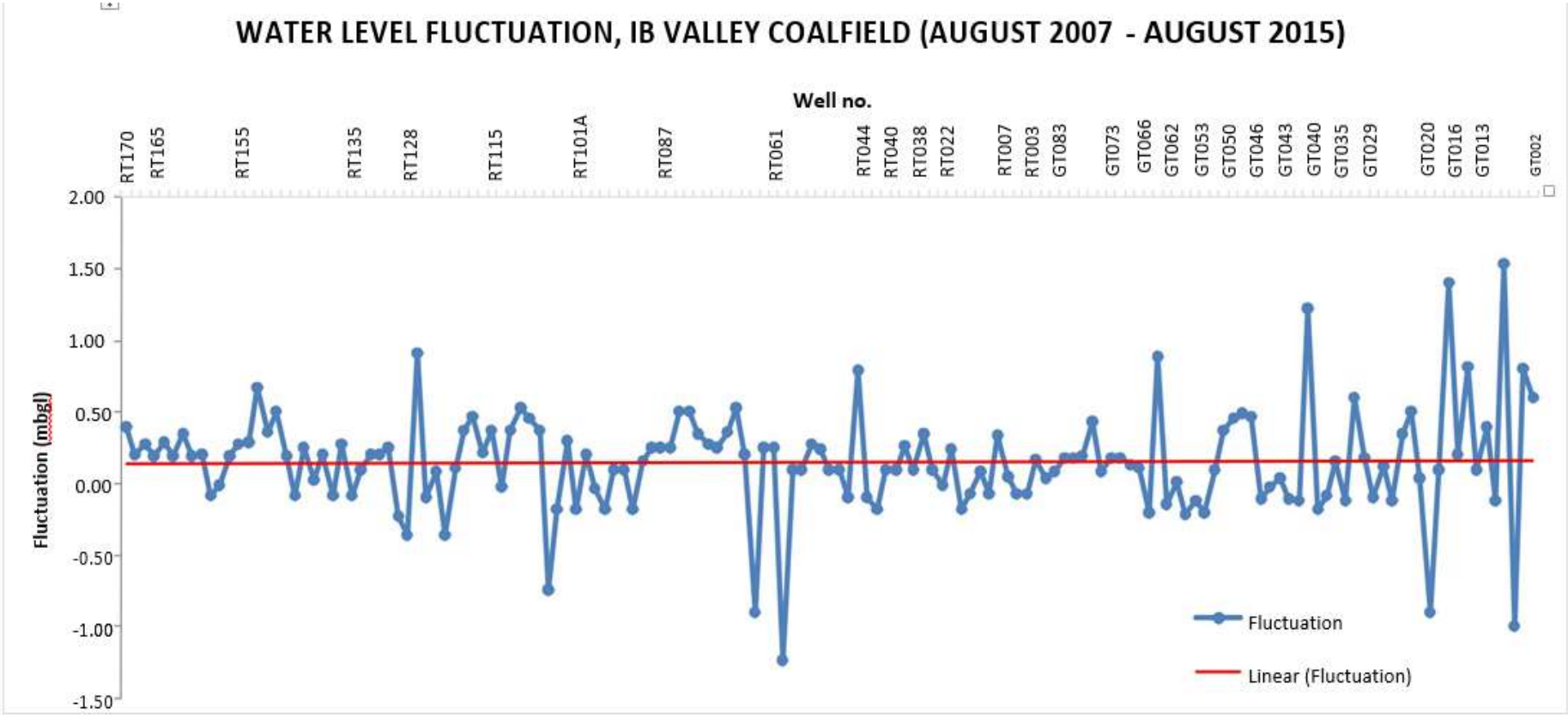


FIGURE-3.1(B): ANNUAL WATER LEVEL FLUCTUATION (MAY 2007 – MAY 2015)

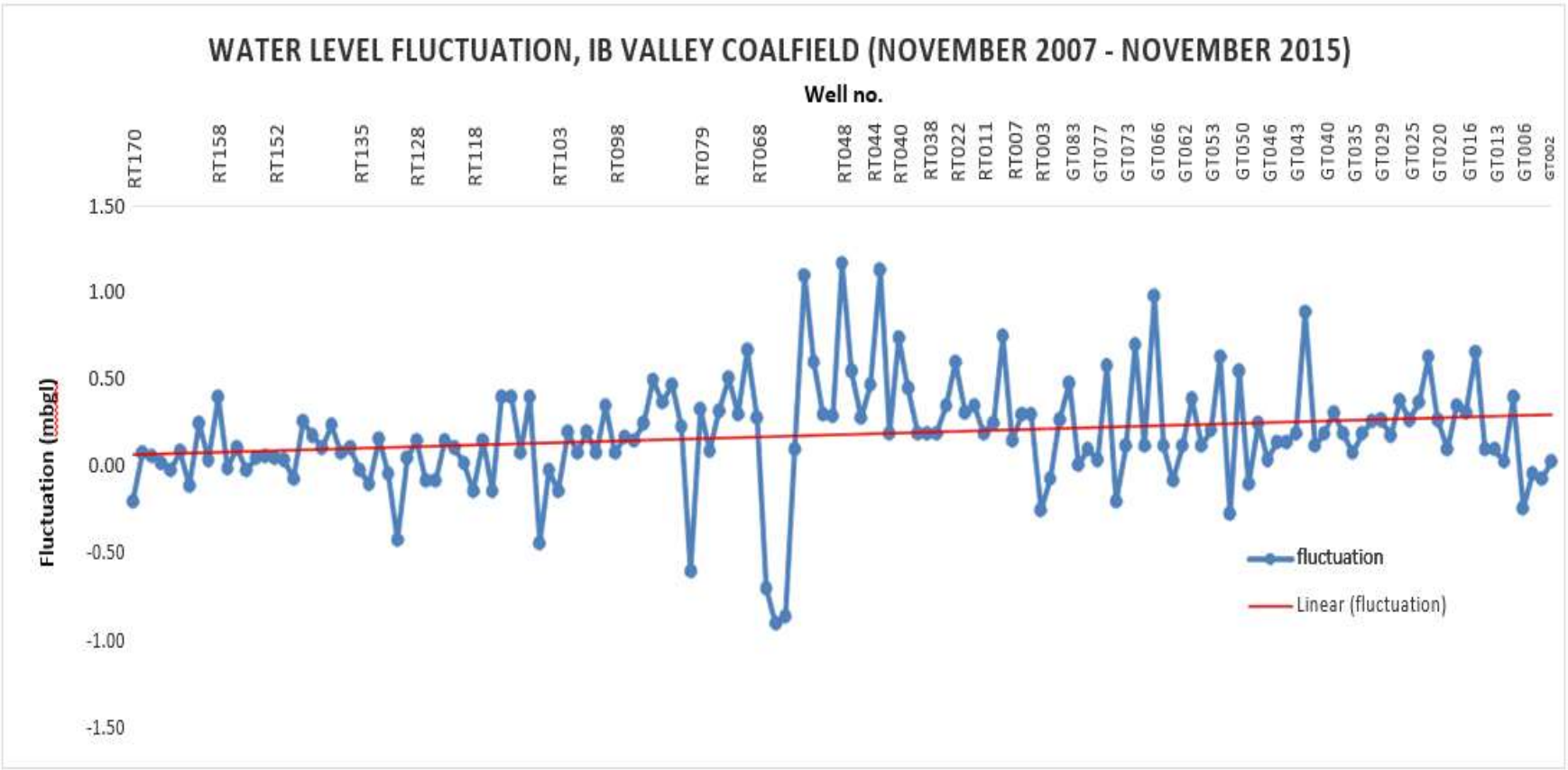


FIGURE-3.1(C): ANNUAL WATER LEVEL FLUCTUATION (MAY 2007 – MAY 2015)

3.8 LONG TERM GROUNDWATER LEVEL TRENDS

As groundwater level data are temporal and dynamic in nature and is mainly controlled by rainfall pattern in relation to the aquifer material. So, long term groundwater level data becomes the principal source of information about hydrologic stresses affecting groundwater recharge, storage and discharge. Ground water levels are controlled by the balance among recharge to, storage in and discharge from an aquifer. Physical properties such as porosity, permeability and thickness of the aquifer affect this balance. When the rate of recharge to an aquifer exceeds the rate of discharge, water levels will rise. Conversely, when the rate of groundwater withdrawal or discharge is greater than the rate of groundwater recharge, the water stored in the aquifer becomes depleted and water levels will decline. Water levels in many aquifer follow a cyclic pattern of season fluctuation, typically rising during post monsoon season due to precipitation and recharge and declining during pre-monsoon season owing to less recharge.

3.9 GROUND WATER BALANCE

There is an intricate relationship between surface water and ground water. In the monsoon time, till the aquifer attains its original ground water level, the surface water bodies like stream flow, ponds & lakes recharge the aquifer. As soon as the ground water recoups and attains its level, the groundwater contributes water to the surface water bodies. After post-monsoon period, this process is reversed again as the ground water level gets lowered from the original level. This recharge and discharge system of the area brings surface water and ground water relationship complicated. The water balance studies of this area untie the above referred intricate relationship of surface and ground water. Water balance study was carried out on the basis of land use details and the information from the report of the Ground Water Resource Estimation Committee (June, 1997). Water balance study is given in the following paragraphs:

3.9.1 ESTIMATE FOR GROUND WATER AVAILABILITY (BY RAINFALL INFILTRATION METHOD)

Demographic & geographic details

i	Geographical area of buffer zone (Gb)	=	1186.60 km^2
ii	Forest area (Fa)	=	800.86 km^2
iii	Total cultivable area (Cv)	=	222.54 km^2
iv	Irrigated agricultural land	=	17.35 km^2
v	Unirrigated area (Cu)	=	205.19 km^2
vi	Cultivable wasteland (Cw)	=	80.88 4km^2
vii	Water spread area (Ws)	=	15.76 km^2

	River	=	12.60 km^2
	Ponds	=	3.09 km^2
viii	Total population in Ib valley coalfield [Based on census of India 2001]	=	3,05,414
ix	Total cattle population (@ of 10.11 per family)	=	6,17,547
	[District statistical handbook of 2001, Sundergarh dist.		

Hydro-geological parameters

i	Average annual rainfall (A) (groundwater information bullet of Jharsuguda dist. By CGWB)	:	1.232 m
ii	Infiltration index of the area (Ii) [based on report of the Ground Water Resource Estimation Committee, June 1997]		
	# Weathered granite, gneiss and schist with low clay content	:	8 %
	# Barakar formation (semi-consolidated)	:	12 %
	# Talchir and Karharbari formations (consolidated)	:	6 %
iii	Specific yield of the area in the buffer zone (Sy) [based on CMPDI investigation]	:	4 %
iv	Seepage from water spread area (Sws) [based on CGWB & GEC reports]	:	0.210 m/annum
v	Losses due to evapo-transpiration [based on CGWB, GEC report and Circular Memo No. HG 7/1832/78 dated 05/7/1978 from the Office of the CE, PWD, Ground Water, Chennai-17]	:	15 %
vi	Seepage from river, streams, etc. (Srs) [based on CGWB, GEC report and Circular Memo No. HG 7/1832/78 dated 05/7/1978 from the Office of the CE, PWD, Ground Water, Chennai-17]	:	0.0211 m/day
vii	Return flow from irrigated area for wet crop like paddy, etc. (Rf) (Based on GEC report, June, 1997)	:	0.67 / crop

B Hydrologic budget for the buffer zone

- **Estimation of annual ground water recharge through rainfall infiltration (Rarf)**

(a) Recharge through rainfall in semi consolidated formations

Rg = A x R x Ii

Where A = 1090.95 km^2
R = 1.232 m
Ii = 12 %
So, Rg = 161.29 Mm^3

(b) Recharge through rainfall in consolidated formations

Rg = A x R x Ii

Where A = 95.65 km^2
R = 1.232 m
Ii = 6 %
So Rg = 7.07 Mm^3

Total annual recharge through rainfall infiltration (Rarf) [a+b] = 168.36 Mm^3

- **Estimation of ground water recharge through other sources (Raos)**

(a) Recharge through water spread area

Rg = A x Sws

Where A = 3.09 km^2
Sws = 0.210 m/annum
So Rg = 0.65 Mm^3

(b) Recharge through river and streams (Sr)

Rg = A x Sr

Where A = 12.60 km^2
Sr = 1.899 m/annum
So Rg = 23.92 Mm^3

(c) Recharge through irrigated area

Rg = A x Rf

Where A = 17.35 km^2
Rf = 0.67 m/wetcrop

So Rg = 11.62 Mm^3

(d) Recharge through mine discharge

Rg = Ma x Ii

Where Ma : Annual mine discharge from all 11 mines = 26.50 Mm^3
Ii : Infiltration index for mine dewatered discharge = 20%

So Rg = 5.30 Mm^3

Total annual recharge from other sources (Raos) [a+b+c+d] = 41.49 Mm^3

Therefore, total annual recharge in the buffer zone (Rarf+Raos) = 209.85 Mm^3

- **Inventory of ground water utilization**

i.	Ground water required (Di) for irrigating 17.35 km^2 (1735 : ha) of agricultural land @ 10,000 l/day/ha for 120 days (20% goes as seepage)$	1.67 Mm^3
ii.	Ground water required (Dh) for human population of 3,05,414@ 60 l/day/capita for 365 days$$:	6.69 Mm^3
iii.	Ground water required (Df) for forest area of 800.86 km^2 (80086 ha) @ 2000 l/day/ha for 120 days$:	19.24 Mm^3
iv.	Ground water required (Dc) for cattle population of 6,17,547@ 20 l/day for 365 days$:	4.51 Mm^3
v.	Mine pumping as mine seepage :	8.77 Mm^3

vi. Ground water losses (Dso) due to sub-surface out-flow : 20.98 Mm^3 & evapo-transpiration (As per GEC norms)

Total water discharge (losses)	: 61.86 Mm^3

$ Source : Forest Research Institute, Madhya Pradesh $$ As per GEC Norms

- **Net ground water availability for industrial or any other purposes**

Net ground water available for industrial or any other purposes
= Total annual average ground water recharge - (total water utilization + total net draft from the surrounding area) = 209.85 – 61.86 = 147.99 Mm^3

3.10 ANALYTICAL RESULTS AND INTERPRETATIONS

3.10.1 SURFACE WATER ANALYTICAL RESULTS

Eleven (11) surface water samples collected and analysed from eleven locations in both the seasons, i.e. pre-monsoon as well as post-monsoon season. The results are discussed below:

i. Dissolved oxygen

Dissolved Oxygen varies between 4.70 mg/L to 6.60 mg/L in the pre-monsoon season and between 4.40 mg/L to 5.40 mg/L during post-monsoon season. The minimum concentration of DO as per IS:2296 Inland Surface water class C is 4.00 mg/L.

ii. Biological Oxygen Demand (BOD)

BOD ranges between 2.70 mg/L to 3.80 mg/L in the pre-monsoon season and between 2.70 mg/L to 3.80 mg/L during post-monsoon season. The maximum permissible concentration of DO as per IS:2296 Inland Surface water class C is 3.00 mg/L.

iii. pH

pH ranges between 6.80 to 8.28 in pre-monsoon season and between 6.72 to 8.45 in post-monsoon season. The maximum permissible concentration as per IS:2296 Inland Surface water class C is 6.50-8.50.

iv. Total suspended solids (TSS)

Total suspended solids ranges between 14 mg/L to 44 mg/L in the pre-monsoon season and between 12 mg/L to 48 mg/L during post-monsoon season.

v. Total dissolved solids (TDS)

Total dissolved solids ranges between 104 mg/L to 880 mg/L in the pre-monsoon season and between 64 mg/L to 368 mg/L during post-monsoon season. The maximum permissible concentration as per IS:2296 Inland Surface water class C is 1500 mg/L.

vi. Total hardness

Total hardness ranges between 28 mg/L to 488 mg/L in the pre-monsoon season and between 24 mg/L to 192 mg/L during post-monsoon season.

vii. Chloride

Chloride ranges between 10 mg/L to 58 mg/L in the pre-monsoon season and between 8 mg/L to 28 mg/L during post-monsoon season. The maximum permissible concentration as per IS:2296 Inland Surface water class C is 600 mg/L.

viii. Sulphate

Sulphate ranges between 6 mg/L to 276 mg/L in the pre-monsoon season and between 4 mg/L to 116 mg/L during post-monsoon season. The maximum permissible concentration as per IS:2296 Inland Surface water class C is 400 mg/L.

ix. Nitrate

Nitrate ranges between 2.07 mg/L to 7.47 mg/L in the pre-monsoon season and between 1.01 mg/L to 4.76 mg/L during post-monsoon season. The maximum permissible concentration as per IS:2296 Inland Surface water class C is 50 mg/L.

x. Fluoride

Fluoride ranges between 0.36 mg/L to 0.82 mg/L in the pre-monsoon season and between 0.37 mg/L to 0.85 mg/L during post-monsoon season. The maximum permissible concentration as per IS:2296 Inland Surface water class C is 1.5 mg/L.

xi. Arsenic

Arsenic is present in concentration less than 0.002 in pre-monsoon season as well as in post-monsoon season. The maximum permissible concentration as per IS:2296 Inland Surface water class C is 0.2 mg/L.

xii. Lead

Lead is present in concentration ranges between less than 0.005 mg/L to 0.024 mg/L in pre-monsoon season and is less than 0.005 mg/L to 0.01 mg/L post-

monsoon season. The maximum permissible concentration as per IS:2296 Inland Surface water class C 0.1 mg/L.

xiii. Hexavalent chromium

Hexavalent chromium is present in concentration less than 0.01 mg/L in both pre-monsoon season and post-monsoon season. The maximum permissible concentration as per IS:2296 Inland Surface water class C 0.05 mg/L.

xiv. Zinc

Zinc ranges between 0.07 mg/L to 2.07 mg/L in the pre-monsoon season and between less than 0.02 mg/L to 0.08 mg/L during post-monsoon season. The maximum permissible concentration as per IS:2296 Inland Surface water class C 15.00 mg/L.

xv. Iron

Iron ranges between 0.13 mg/L to 2.40 mg/L in the pre-monsoon season and less than 0.06 mg/L during post-monsoon season. The maximum permissible concentration as per IS:2296 Inland Surface water class C 50.00 mg/L.

xvi. Cadmium

Cadmium is present in concentration less than 0.0005 mg/L in both pre-monsoon season and post-monsoon season. The maximum permissible concentration as per IS:2296 Inland Surface water class C 0.01 mg/L.

xvii. Selenium

Selenium is present in concentration less than 0.002 mg/L in both pre-monsoon season and post-monsoon season. The maximum permissible concentration as per IS:2296 Inland Surface water class C 0.05 mg/L.

xviii. Copper

Copper ranges between less than 0.04 mg/L to 0.07 mg/L in the pre-monsoon season and between less than 0.03 mg/L during post-monsoon season. The maximum permissible concentration as per IS:2296 Inland Surface water class C 1.50 mg/L.

xix. Phenolic compound

Phenolic compound is present in concentration less than 0.001 mg/L in both pre-monsoon season and post-monsoon season. The maximum permissible concentration as per IS:2296 Inland Surface water class C 0.005 mg/L.

3.10.2 INTERPRETATIONS OF SURFACE WATER ANALYTICAL RESULTS

It is clearly interpreted that all the parameters analysed in surface water samples are within permissible limits except Biological oxygen demand and dissolved oxygen. As Dissolved Oxygen is the amount of gaseous oxygen (O2) dissolved in

the water and necessary for aquatic living organism, hence, it is a positive sign for all the surface water sample as they cross the limits. Marginally increased BOD in surface water samples indicates the influence of population, dead plants, leaves, grass clippings, manure, sewage, or even food waste is present in a water supply.

3.10.3 MINE WATER ANALYTICAL RESULTS

Eight (08) mine water samples that were collected and analyzed from thirteen on-site mine water discharge locations in both pre-monsoon and post-monsoon season. The results are discussed below.

i. Biological Oxygen Demand (BOD)

BOD ranges between 2.20 mg/L to 3.20 mg/L for pre-monsoon and between 8.30 mg/L to 14.00 mg/L post-monsoon season. The maximum permissible concentration as per MOEF-Schedule VI Standard is 30.00 mg/L.

ii. Total Kjeldahl Nitrogen (TKN as NH3)

TKN is present in concentration between 0.53 mg/L to 4.91 mg/L in pre-monsoon season and between 1.32 mg/L to 2.44 mg/L in post-monsoon season. The maximum permissible concentration as per MOEF-Schedule VI Standard is 100.00 mg/L.

iii. Ammonical Nitrogen

Ammonical Nitrogen is present in concentration between 0.25 mg/L to 2.10 mg/L in pre- monsoon season and between 0.20 mg/L to 0.38 mg/L in post-monsoon season. The maximum permissible concentration as per MOEF-Schedule VI Standard is 50.00 mg/L..

iv. Fluoride

Fluoride is present in concentration between 0.44 mg/L to 0.87 mg/L in pre-monsoon season and between 0.12 mg/L to 0.91 mg/L in post-monsoon season. The maximum permissible concentration as per MOEF&CC-Schedule VI Standard is 2.00 mg/L.

v. Dissolved phosphate

Dissolved Phosphate is present in concentration between 0.10 mg/L to 0.24 mg/L in pre- monsoon season and between less than 0.01 mg/L to 1.86 mg/L in post-monsoon season. The maximum permissible concentration as per MOEF-Schedule VI Standard is 5.00 mg/L.

vi. Manganese (Mn)

Manganese (Mn) is present in concentration ranging between less than 0.02 mg/L to 9.01 mg/L in pre-monsoon season and between less than

0.02 mg/L to 6.32 mg/L in post-monsoon season. The maximum permissible concentration as per MOEF-Schedule VI Standard is 2.00 mg/L.

vii. Nitrate Nitrogen

Nitrate Nitrogen is present in concentration between 1.80 mg/L to 3.20 mg/L in pre- monsoon season and between 1.80 mg/L to 2.20 mg/L in post-monsoon season. The maximum permissible concentration as per MOEF-Schedule VI Standard is 10.00 mg/L.

viii. Zinc

Zinc is present in concentration ranging between less than 0.02 mg/L to 0.42 mg/L in pre-monsoon season and between less than 0.02 mg/L to 0.17 mg/L in post-monsoon season.. The maximum permissible concentration as per MOEF-Schedule VI Standard is 5.00 mg/L.

ix. Sulphide

Sulphide is present in concentration between ranging between 0.006 mg/L to 0.062 mg/L in pre-monsoon season and between 0.003 mg/L to 0.009 mg/L in post-monsoon season. The maximum permissible concentration as per MOEF-Schedule VI Standard is 2.00 mg/L.

x. Nickel

Nickel is present in concentration between ranging between less than 0.1 mg/L to 0.56 mg/L in pre-monsoon season and between less than 0.1 mg/L to 0.36 mg/L in post-monsoon season. The maximum permissible concentration as per MOEF-Schedule VI Standard is 3.00 mg/L.

xi. Arsenic

Arsenic is present in concentration less than 0.002 in pre-monsoon season and between less than 0.002 mg/L to 0.012 mg/L post-monsoon season. The maximum permissible concentration as per MOEF-Schedule VI Standard is 0.2 mg/L.

xii. Lead

Lead is present in concentration less than 0.005 mg/L in pre-monsoon season and varies between less than 0.005 mg/L to 0.0058 mg/L in post-monsoon season.. The maximum permissible concentration as per MOEF-Schedule VI Standard is 0.1 mg/L.

xiii. Hexavalent chromium

Hexavalent chromium is present in concentration less than 0.01 mg/L in both pre-monsoon season and post-monsoon season. The maximum permissible concentration as per MOEF-Schedule VI Standard is 0.10 mg/L.

xiv. Total Chromium

Total chromium is present in concentration less than 0.10 mg/L in both pre-monsoon season and post-monsoon season. The maximum permissible concentration as per MOEF-Schedule VI Standard is 2.00 mg/L.

xv. Copper

Copper is present in concentration less than 0.03 mg/L in both pre-monsoon season and post-monsoon season. The maximum permissible concentration as per MOEF-Schedule VI Standard is 3.00 mg/L.

xvi. Selenium

Selenium is present in concentration less than 0.002 mg/L in both pre-monsoon season and post-monsoon season. The maximum permissible concentration as per MOEF-Schedule VI Standard is 0.05 mg/L.

xvii. Cadmium

Cadmium is present in concentration less than 0.0005 mg/L in both pre-monsoon season and post-monsoon season. The maximum permissible concentration as per MOEF-Schedule VI Standard is 2.00 mg/L.

xviii. Iron

Iron is present in concentration ranging between less than 0.06 mg/L to 0.01 mg/L pre-monsoon season and in post-monsoon season the concentration of iron is less than 0.06 mg/L. The maximum permissible concentration as per MOEF-Schedule VI Standard is 3.00 mg/L.

xix. Phenolic compound

Phenolic compound is present in concentration less than 0.001 mg/L in both pre-monsoon season and post-monsoon season. The maximum permissible concentration as per MOEF-Schedule VI Standard is 1.00 mg/L.

3.10.4 INTERPRETATIONS OF MINE WATER ANALYTICAL RESULTS

It is clearly interpreted that all the parameters analysed in mine water samples are within permissible limits except Manganese. Manganese is seen marginally exceeding permissible limits in pre-monsoon season only. The increase in Manganese may be geogenic.

3.10.5 GROUNDWATER ANALYTICAL RESULTS AND INTERPRETATION FROM TUBE WELLS

Twenty (20) groundwater samples from tube wells/dug wells were collected and analyzed from twenty locations in both the seasons i.e pre-monsoon as well as post-monsoon season. The results are discussed below.

i. pH

pH varies between 7.08 to 8.03 in the pre-monsoon season and between 6.54 to 7.16 during post-monsoon season. The acceptable concentration as per Indian Drinking Standards (IS-10500):2012 is 6.5 – 8.5.

ii. Total dissolved solids (TDS)

Total dissolved solids ranges between 54 mg/L to 1528 mg/L in the pre-monsoon season and between 106 mg/L to 1792 mg/L during post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 2000 mg/L.

iii. Total alkalinity

Total alkalinity ranges between 8 mg/L to 36 mg/L in the pre-monsoon season and between 12 mg/L to 32 mg/L during post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 600 mg/L.

iv. Total Hardness

Total hardness ranges between 20 mg/L to 540 mg/L in the pre-monsoon season and between 20 mg/L to 1000 mg/L during post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 600 mg/L.

v. Fluoride

Fluoride ranges between 0.32 mg/L to 0.70 mg/L in the pre-monsoon season and between 0.26 mg/L to 0.69 mg/L during post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 1.5 mg/L.

vi. Nitrate

Nitrate ranges between 1.47 mg/L to 3.47 mg/L in the pre-monsoon season and between 1.86 mg/L to 13.76 mg/L during post-monsoon season. The maximum acceptable concentration as per Indian Drinking Standards (IS-10500):2012 is 45 mg/L.

vii. Calcium

Calcium ranges between 3.20 mg/L to 131.20 mg/L in the pre-monsoon season and between 4.80 mg/L to 166.40 mg/L during post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 200 mg/L.

viii. Sulphate

Sulphate ranges between 4.00 mg/L to 328.00 mg/L in the pre-monsoon season and between 6.00 mg/L to 208.00 mg/L during post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 400 mg/L.

ix. Chloride

Chloride ranges between 8.00 mg/L to 294.00 mg/L in the pre-monsoon season and between 12.00 mg/L to 542.00 mg/L during post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 1000 mg/L.

x. Manganese (Mn)

Manganese (Mn) is present in concentration ranging between less than 0.02 mg/L to 0.40 mg/L in pre-monsoon season and between less than 0.02 mg/L to 0.156 mg/L in post-monsoon season.. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 0.30 mg/L

xi. Residual free chlorine

Residual free chlorine is present in concentration less than 1.00 mg/L in pre-monsoon season and post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 1.00 mg/L

xii. Zinc

Zinc is present in concentration ranging between less than 0.02 mg/L to 1.23 mg/L in pre-monsoon season and between less than 0.02 mg/L to 5.41 mg/L in post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 15 mg/L

xiii. Boron

Boron is present in concentration less than 0.02 mg/L in both pre-monsoon season and post-monsoon season.. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 1 mg/L.

xiv. Arsenic

Arsenic is present in concentration less than 0.002 in both pre-monsoon season post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 0.05 mg/L.

xv. Lead

Lead is present in concentration less than 0.005 mg/L in both pre-monsoon season and post-monsoon season.. The maximum acceptable concentration as per Indian Drinking Standards (IS-10500):2012 is 0.01 mg/L.

xvi. Hexavalent chromium

Hexavalent chromium is present in concentration less than 0.01 mg/L in both pre-monsoon season and post-monsoon season. The maximum acceptable concentration as per Indian Drinking Standards (IS-10500):1991 is 0.05 mg/L.

xvii. Copper

Copper is present in concentration less than 0.03 mg/L in both pre-monsoon season and post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 1.50 mg/L.

xviii. Selenium

Selenium is present in concentration less than 0.002 mg/L in both pre-monsoon season and post-monsoon season. The maximum acceptable concentration as per Indian Drinking Standards (IS-10500):2012 is 0.01 mg/L.

xix. Cadmium

Cadmium is present in concentration less than 0.0005 mg/L in both pre-monsoon season and post-monsoon season. The maximum acceptable concentration as per Indian Drinking Standards (IS-10500):2012 is 0.003 mg/L.

xx. Iron

Iron is present in concentration ranging between less than 0.06 mg/L to 0.47 mg/L in pre-monsoon season and in post-monsoon season the concentration of iron is ranges from less than 0.06 mg/L to 0.123 mg/L. The maximum acceptable concentration as per Indian Drinking Standards (IS-10500):2012 is 0.30 mg/L.

3.10.6 INTERPRETATIONS OF DRINKING WATER ANALYTICAL RESULTS FROM TUBE WELL

It is clearly interpreted that all the parameters analysed in tube well water samples are within limits except Manganese, and total hardness. Manganese is seen marginally exceeding limits in premonsoon season only in well no. MIBTW 2, 6, 15. Total hardness is seen marginally exceeding limits in post monsoon season (MTTW 02) only. The increase in manganese may be geogenic.

3.10.7 GROUNDWATER ANALYTICAL RESULTS AND INTERPRETATION FROM PIEZOMETERS

Seventeen (17) groundwater samples from piezometers were collected and analyzed from seventeen locations in both the seasons i.e pre-monsoon as well as post-monsoon season. The results are discussed below.

i. pH

pH varies between 6.72 to 7.80 in the pre-monsoon season and between 6.59 to 8.25 during post-monsoon season. The acceptable concentration as per Indian Drinking Standards (IS-10500):2012 is 6.5 – 8.5.

ii. Total dissolved solids (TDS)

Total dissolved solids ranges between 106 mg/L to 492 mg/L in the pre-monsoon season and between 88 mg/L to 330 mg/L during post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 2000 mg/L.

iii. Total alkalinity

Total alkalinity ranges between 8 mg/L to 28 mg/L in the pre-monsoon season and between 12 mg/L to 32 mg/L during post-monsoon season. The maximum

permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 600 mg/L.

iv. Total Hardness

Total hardness ranges between 44 mg/L to 336 mg/L in the pre-monsoon season and between 36 mg/L to 240 mg/L during post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 600 mg/L.

v. Fluoride

Fluoride ranges between 0.36 mg/L to 0.63 mg/L in the pre-monsoon season and between 0.35 mg/L to 0.63 mg/L during post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 1.5 mg/L.

vi. Nitrate

Nitrate ranges between 1.76 mg/L to 5.87 mg/L in the pre-monsoon season and between 2.23 mg/L to 5.87 mg/L during post-monsoon season. The maximum acceptable concentration as per Indian Drinking Standards (IS-10500):2012 is 45 mg/L.

vii. Calcium

Calcium ranges between 6.40 mg/L to 49.60 mg/L in the pre-monsoon season and between 8.00 mg/L to 67.20 mg/L during post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 200 mg/L.

viii. Sulphate

Sulphate ranges between 4.00 mg/L to 50.00 mg/L in the pre-monsoon season and between 7.00 mg/L to 12.00 mg/L during post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 400 mg/L.

ix. Chloride

Chloride ranges between 14.00 mg/L to 104.00 mg/L in the pre-monsoon season and between 12.00 mg/L to 84.00 mg/L during post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 1000 mg/L.

x. Manganese (Mn)

Manganese (Mn) is present in concentration ranging between less than 0.02 mg/L to 1.44 mg/L n pre-monsoon season and between 0.02 mg/L to 1.97 mg/L in post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 0.30 mg/L.

xi. Residual free chlorine

Residual free chlorine is present in concentration less than 1.00 mg/L in pre-monsoon season and post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 1.00 mg/L

xii. Zinc

Zinc is present in concentration ranging between less than 0.02 mg/L to 2.67 mg/L in pre-monsoon season and between less than 0.02 mg/L to 2.09 mg/L in post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 15 mg/L

xiii. Boron

Boron is present in concentration less than 0.02 mg/L in both pre-monsoon season and post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 1 mg/L

xiv. Arsenic

Arsenic is present in concentration less than 0.002 mg/L in pre-monsoon season and between less than 0.002 mg/L to 0.003 mg/L in post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 0.05 mg/L.

xv. Lead

Lead is present in concentration less than 0.005 mg/L in pre-monsoon season and between less than 0.005 mg/L to 0.008 mg/L in post-monsoon season. The maximum acceptable concentration as per Indian Drinking Standards (IS-10500):2012 is 0.01 mg/L.

xvi. Hexavalent chromium

Hexavalent chromium is present in concentration less than 0.01 mg/L in both pre-monsoon season and post-monsoon season. The maximum acceptable concentration as per Indian Drinking Standards (IS-10500):1991 is 0.05 mg/L.

xvii. Copper

Copper is present in concentration less than 0.03 mg/L in both pre-monsoon season and post-monsoon season. The maximum permissible concentration as per Indian Drinking Standards (IS-10500):2012 is 1.50 mg/L.

xviii. Selenium

Selenium is present in concentration less than 0.002 mg/L in both pre-monsoon season and post-monsoon season. The maximum acceptable concentration as per Indian Drinking Standards (IS-10500):2012 is 0.01 mg/L.

xix. Cadmium

Cadmium is present in concentration less than 0.0005 mg/L in both pre-monsoon and post monsoon season. The maximum acceptable concentration as per Indian Drinking Standards (IS-10500):2012 is 0.003 mg/L.

xx. xl. Iron

Iron is present in concentration is less than less than 0.06 mg/L in both pre-monsoon and post monsoon season.. The maximum acceptable concentration as per Indian Drinking Standards (IS-10500):2012 is 0.30 mg/L.

3.10.8 INTERPRETATIONS OF DRINKING WATER ANALYTICAL RESULTS FROM PIEZOMETERS

It is clearly interpreted that all the parameters analysed in piezometer's water samples are within limits except Manganese. Manganese is seen marginally exceeding limits in both pre monsoon ((MIP 07, 11, 12, 15, 16, 17) and post monsoon season (MIP 15, 16, 17). The increase in manganese may be geogenic.

- The drainage of the study area is controlled by two major streams namely Basundhara nala, and Lilari nala, that drains to the Ib river.
- The coalfield area is represented by low irregular upland of undulating topography
- The study shows very low hydraulic conductivity in Ib valley coalfield which ranges from 0.001 m/day to 0.228 m/day. The permeability of the aquifer in the study area is influenced by the geological structural disturbance and compactness of the geological strata.
- Hydraulic conductivity signifies the dominant role of secondary porosity in aquifer development.
- Total Annual recharge estimated for Talcher coalfield is 209.85 Mm^3. Total calculated draft for Talcher coalfield is 61.86 Mm^3. Net groundwater availability for industrial or any other purpose is calculated to be 147.99 Mm^3.
- From water balance studies, it is estimated that there is surplus water available per annum from ground water annual recharge after catering to the existing demographic settlements and industrial demand. The surplus annual rainfall recharge replenishes existing annual groundwater draft every year.
- The water level contour coincides with the topography of the study area.
- The annual fluctuation water level for during May 2007 and May 2015 shows an increasing trends in Ib valley coalfield. As the fluctuation in water levels during 8 years period was observed to vary from - 6.10 m to + 6.22 m and which is very close to the natural fluctuation observed in villages located far away from mine areas. At the same time the fluctuation trend also shows negligible change in water level fluctuation throughout the time period of 8 years. These variations may be attributed to the local utilization and recharge conditions only. Thus, the influence of mining on these water levels may be considered as marginal.
- The annual fluctuation water level for during August 2007 and August 2015 shows an increasing trends in Ib valley coalfield. As the fluctuation in water levels during 8 years period was observed to vary from – 1.23 m to + 1.54 m and which is very close to the natural fluctuation observed in villages located far away from mine

areas. At the same time the fluctuation trend also shows negligible change in water level fluctuation throughout the time period of 8 years. These variations may be attributed to the local utilization and recharge conditions only. Thus, the influence of mining on these water levels may be considered as marginal.

- The annual fluctuation water level for during November 2007 and November 2015 shows an increasing trends in Ib valley coalfield. As the fluctuation in water levels during 8 years period was observed to vary from – 0.90 m to + 1.17 m and which is very close to the natural fluctuation observed in villages located far away from mine areas. At the same time the fluctuation trend also shows negligible change in water level fluctuation throughout the time period of 8 years. These variations may be attributed to the local utilization and recharge conditions only. Thus, the influence of mining on these water levels may be considered as marginal.
- The annual fluctuation water level for during January 2008 – January 2016 shows an increasing trends in Ib valley coalfield. As the fluctuation in water levels during 8 years period was observed to vary from – 0.50 m to + 2.45 m and which is very close to the natural fluctuation observed in villages located far away from mine areas. At the same time the fluctuation trend also shows negligible change in water level fluctuation throughout the time period of 8 years. These variations may be attributed to the local utilization and recharge conditions only. Thus, the influence of mining on these water levels may be considered as marginal.
- Mining operation has created voids or depression which are inducing or accelerating rainfall recharge or rainfall runoff in the area.
- The impact of mining on the groundwater regime is limited in aerial extent from the mining zone. The lowering of water level around the shallow depth of mine is more prominent than the deeper depth on the down dip horizon due to multilayered sedimentary formation.
- The cumulative impact study reveals that the water level variation or fluctuation shows normal trend and it signifies that the mining impact on ground water is insignificant out the radius of influence to groundwater.
- It is clearly interpreted that all the parameters analysed in surface water samples are within permissible limits except Biological oxygen demand and dissolved oxygen. As, Dissolved Oxygen is the amount of gaseous oxygen(O2) dissolved in the water and necessary for aquatic living organism, hence, it is a positive sign for all the surface water sample as they cross the limits. Marginally increased BOD in surface water samples indicates the influence of population, dead plants, leaves, grass clippings, manure, sewage, or even food waste is present in a water supply.
- It is clearly interpreted that all the parameters analysed in mine water samples are within permissible limits except Manganese. Manganese is seen marginally exceeding permissible limits in premonsoon season only. The increase in Manganese may be geogenic.
- It is clearly interpreted that all the parameters analysed in tube well water samples are within limits except Manganese, and total hardness. Manganese is seen marginally exceeding limits in pre-monsoon season only in well no. MIBTW 2, 6, 15. Total hardness is seen marginally exceeding limits in post monsoon season (MTTW 02) only. The increase in manganese may be geogenic.

- It is clearly interpreted that all the parameters analysed in piezometer's water samples are within limits except Manganese. Manganese is seen marginally exceeding limits in both pre monsoon ((MIP 07, 11, 12, 15, 16, 17) and post monsoon season (MIP 15, 16, 17). The increase in manganese may be geogenic.

CHAPTER-IV: ASSESSMENT OF RIVERINE ECO-SYSTEM

4.0 ASSESSMENT OF RIVERINE ECO-SYSTEM

The assessment of riverine eco-system of Lakhanpur Phase-II OCP, MCL has been undertaken and the results are tabulated below:

TABLE-4.1: MONTHLY VARIATION IN PHYSICO-CHEMICAL CHARACTERISTICS OF SURFACE WATER COLLECTED FROM DIFFERENT LOCATION OF THE STUDY AREA (LAKHANPUR)

Parameters	S4			S2			S3			S1			S5			S6		
	Aug.	Sep.	Oct.	Aug.	Sep.	Oct.	Aug.	Sep.	Oct.	Aug.	Sep.	Oct.	Aug.	Sep.	Oct.	Aug.	Sep.	Oct.
pH (Units)	6.5	6.8	6.5	6.4	6.5	7.1	6.8	7.1	6.9	6.7	7.1	7.2	6.8	6.9	7.4	7.0	7.2	7.3
Dissolved Oxygen (mg/l)	7.3	8	8.2	6.8	6.2	5.8	6	6.2	6.8	6.8	6.4	7.2	5.6	5.6	5.2	8.1	8.4	8.4
TDS (ppm)	139	124	80	194	65	78	302	310	452	168	70	82	70	72	75	95	78	102
Total Solids (ppm)	146	176	106	301	165	168	512	525	621	237	142	96	107	112	98	256	252	240
Total Alkalinity (mg/l)	24	22	36	16	18	32	46	47	56	28	22	20	20	18	28	28	38	56
Total Hardness (mg/l)	28	52	48	16	38	40	194	152	308	32	42	48	28	27	40	38	57	74
Calcium Hardness (mg/l)	18	21	24	22	20	20	136	142	144	20	18	12	17	19	16	22	20	36
Chloride (mg/l)	14	12	16	10	11	17	24	21	28	22	17	18	18	13	16	9	8	11
Nitrate (mg/l)	0.6	0.8	0.7	1.2	1	0.9	15	12	11	3.2	1.2	1.1	7.5	3.8	1.2	1.3	1	0.9

TABLE-4.2: WATER SAMPLING LOCATIONS

S. No.	Name of the sites
S1	Tingismal Pond
S2	Phulijhor Nala near Viewpoint
S3	Phulijhor Nala near Sel parking
S4	Picnic Spot (Lilari U/s)
S5	Confluence of Phullijhor and Lillari Nalla (near Darlipali Village)
S6	Confluence of Lilari Nalla and IB river

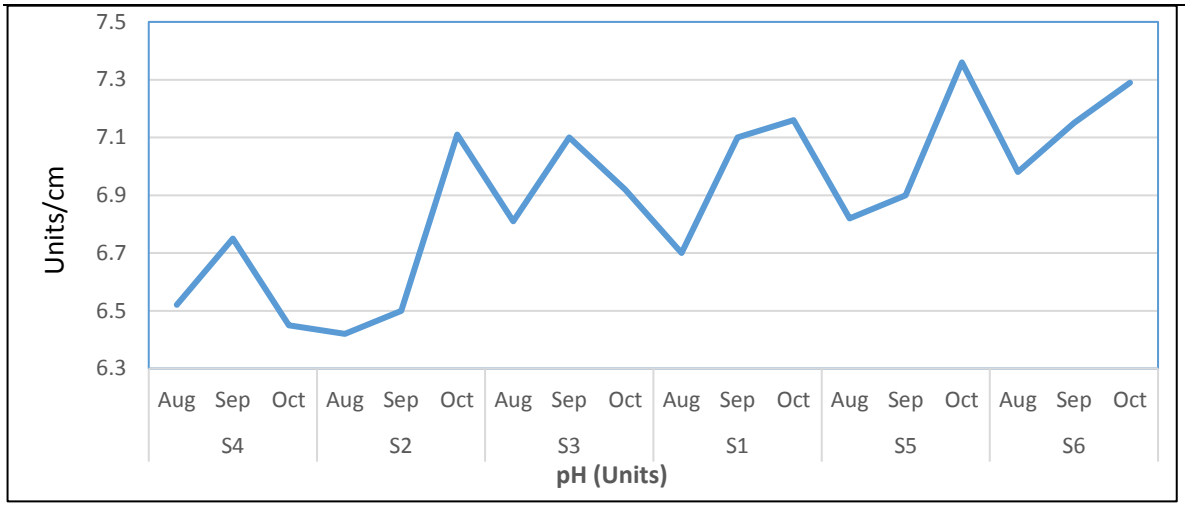


FIGURE-4.1: MONTHLY VARIATION IN pH AT DIFFERENT SAMPLING SITES

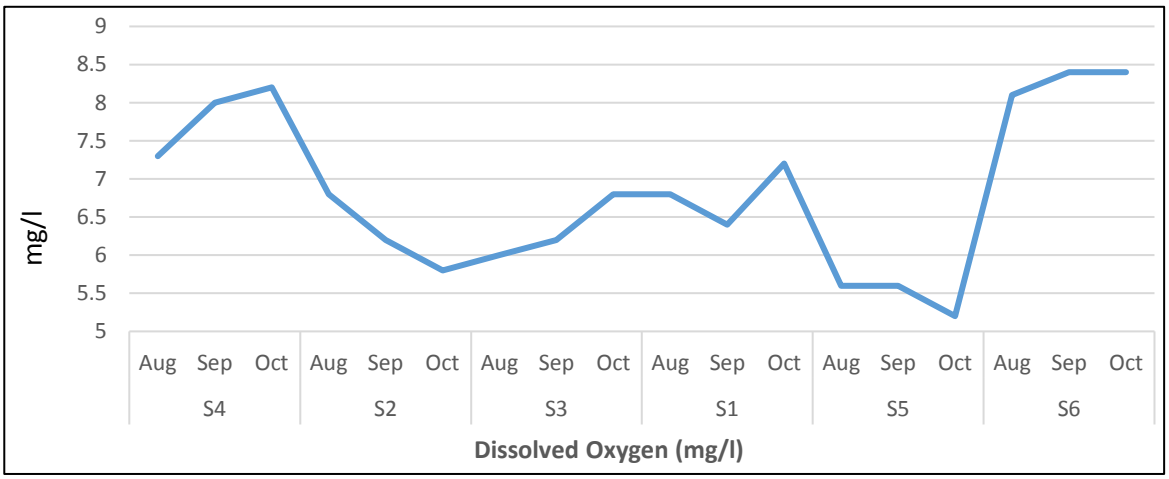


FIGURE-4.2: MONTHLY VARIATION IN D.O. AT DIFFERENT SAMPLING SITES

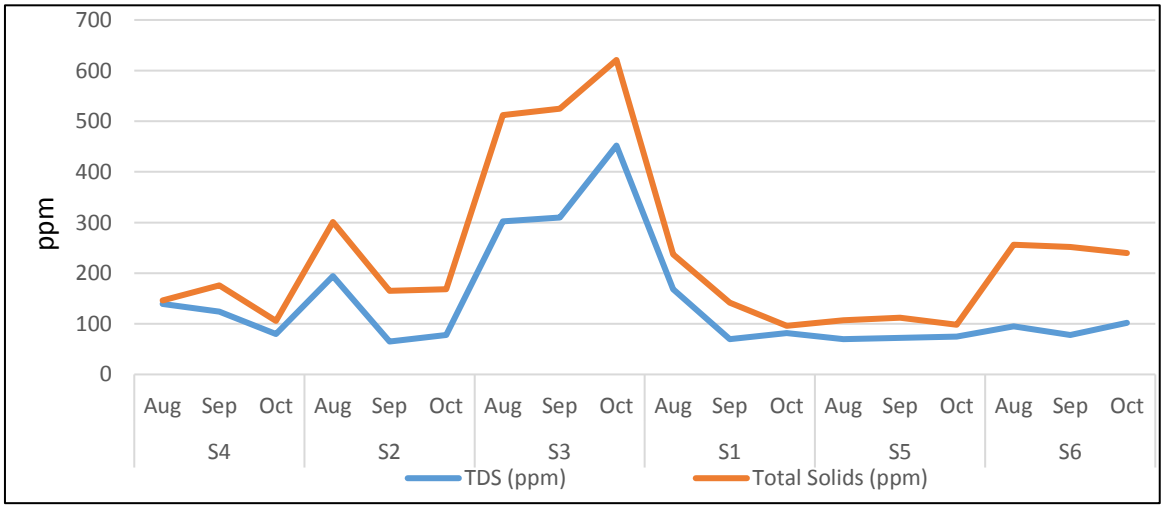


FIGURE-4.3: MONTHLY VARIATION IN TDS AND TOTAL SOLIDS AT DIFFERENT SAMPLING SITES

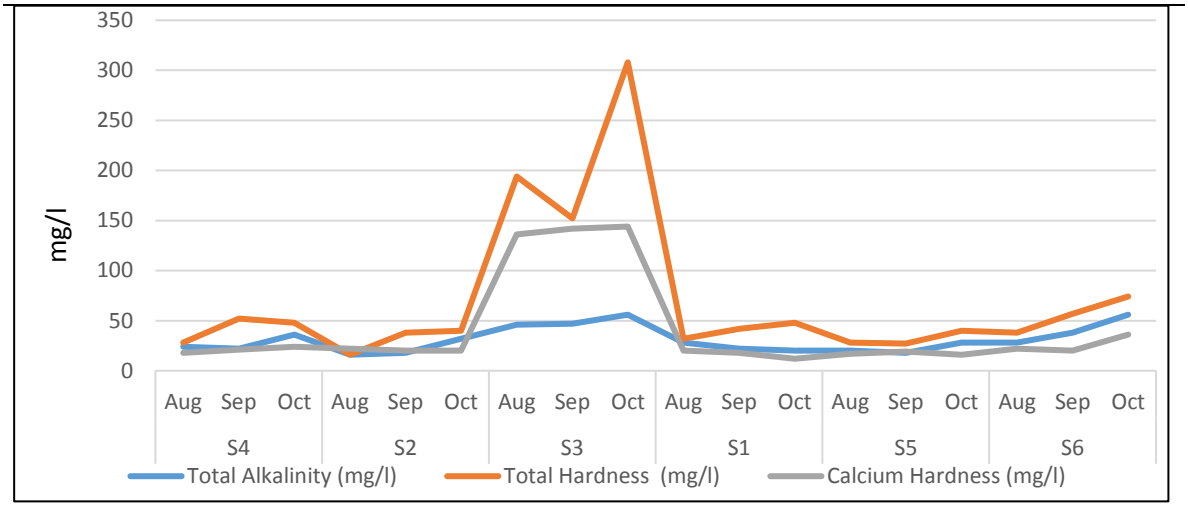


FIGURE-4.4: MONTHLY VARIATION IN T. ALKALINITY, T. HARDNESS AND C. HARDNESS AT DIFFERENT SAMPLING SITES

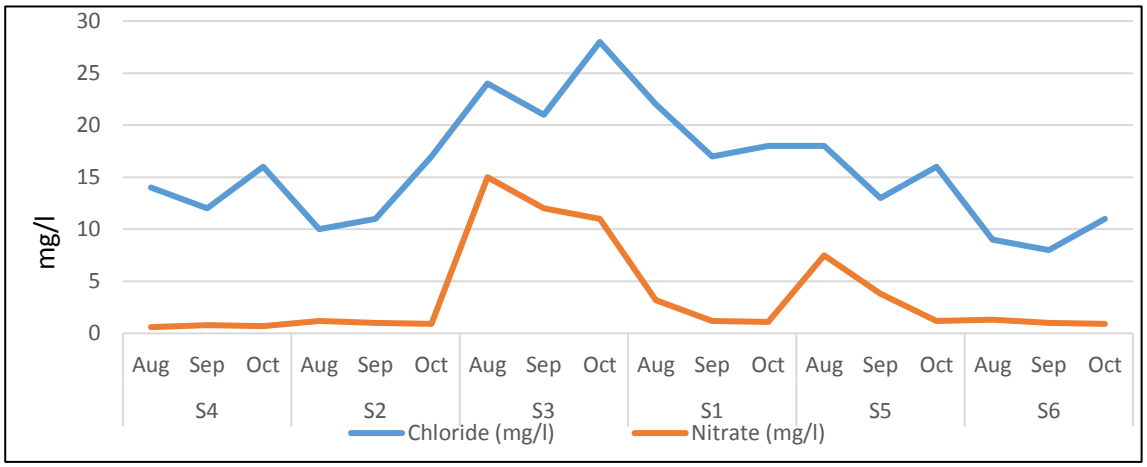


FIGURE-4.5: MONTHLY VARIATION IN CHLORIDE AND NITRATE AT DIFFERENT SAMPLING SITES

TABLE 4.3: VARIATION IN PHYSICO-CHEMICAL CHARACTERISTICS OF SURFACE WATER AT DIFFERENT SELECTED SITES OF THE STUDY AREA (LAKHANPUR OCP) (ON AVERAGE BASIS)

Parameters	S4	S2	S3	S1	S5	S6
pH (Units)	6.6	6.7	6.9	7.0	7.0	7.1
Dissolved Oxygen (mg/l)	7.83	6.27	6.33	6.8	5.47	8.3
TDS (ppm)	114	112	355	107	72.3	91.7
Total Solids (ppm)	143	211	553	158	106	249
Total Alkalinity (mg/l)	27.3	22	49.7	23.3	22	40.7
Total Hardness (mg/l)	42.7	31.3	218	40.7	31.7	56.3
Calcium Hardness (mg/l)	21	20.7	141	16.7	17.3	26
Chloride (mg/l)	14	12.7	24.3	19	15.7	9.33
Nitrate (mg/l)	0.7	1.03	2.87	1.83	4.17	1.07

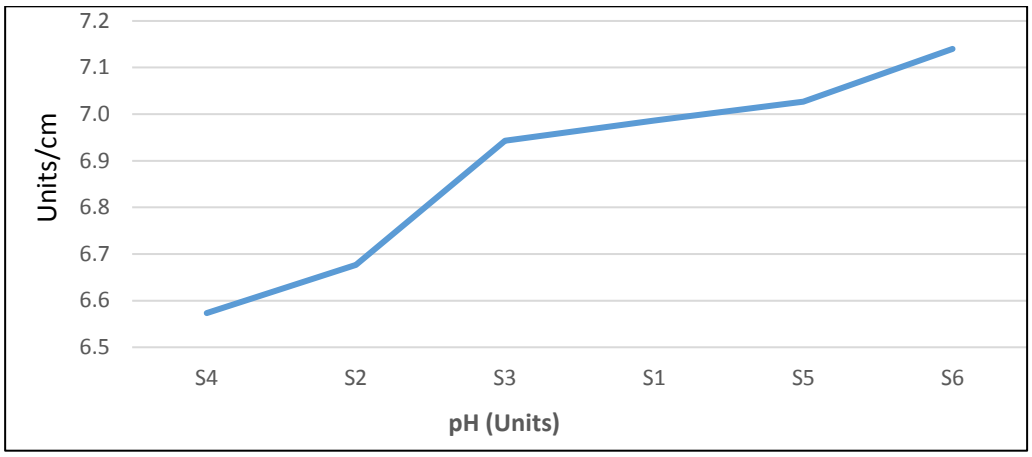


FIGURE-4.6: VARIATION IN pH AT DIFFERENT SAMPLING SITES

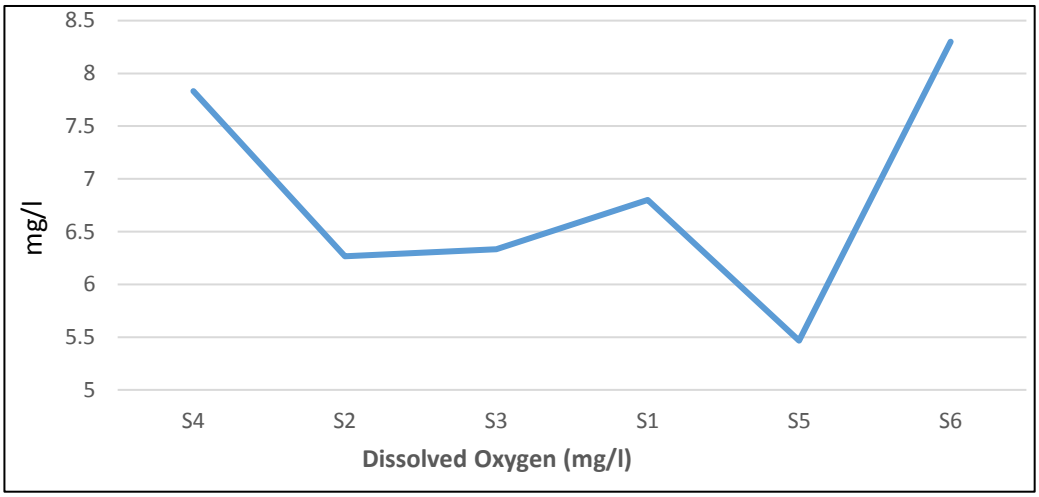


FIGURE-4.7: VARIATION IN D.O. AT DIFFERENT SAMPLING SITES

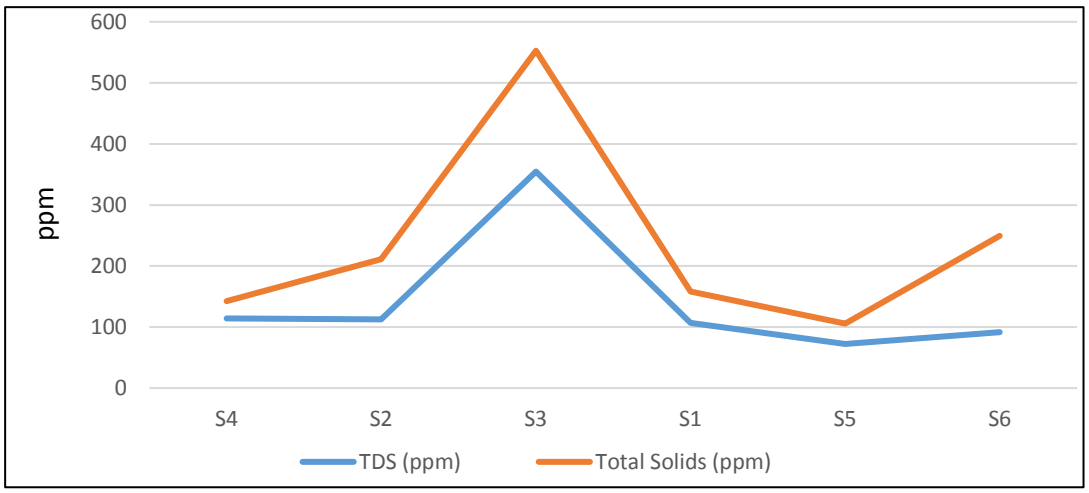


FIGURE-4.8: VARIATION IN TDS AND TOTAL SOLIDS TOTAL SOLIDS AT DIFFERENT SAMPLING SITES

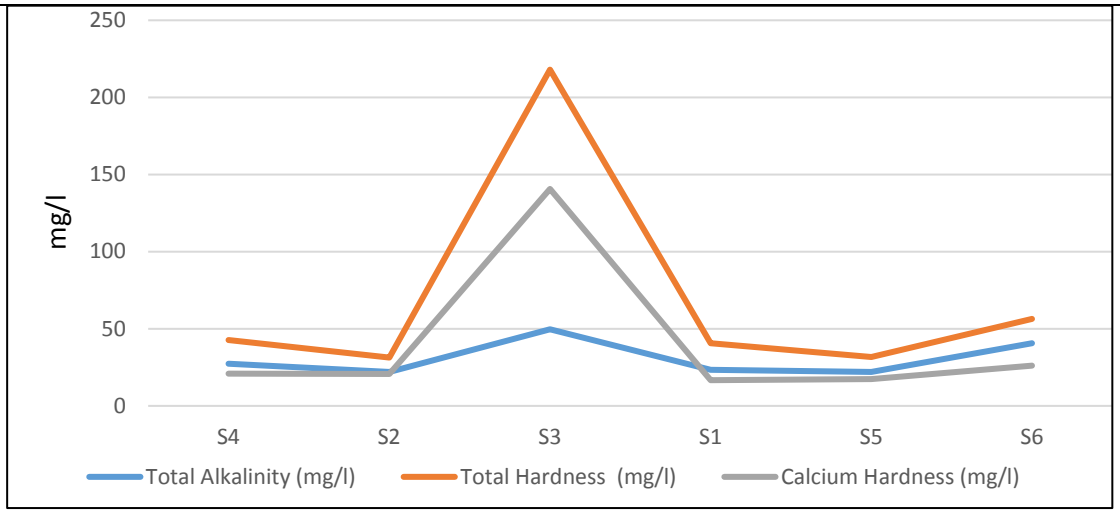


FIGURE-4.9: VARIATION IN T. ALKALINITY, T. HARDNESS AND CALCIUM HARDNESS AT DIFFERENT SAMPLING SITES

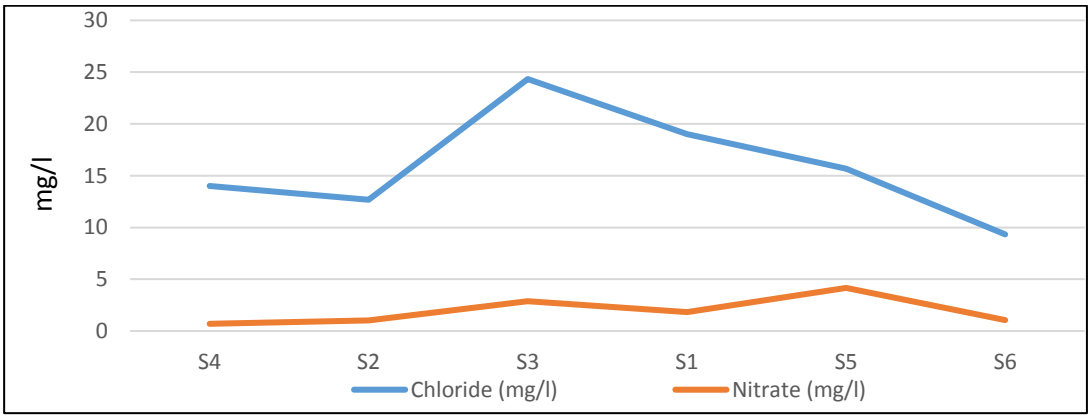


FIGURE-4.10: VARIATION IN CHLORIDE AND NITRATE AT DIFFERENT SAMPLING SITES

4.1 STATUS OF AQUATIC ECOLOGY

(A) Phytoplankton

Plankton abundance and distribution are strongly dependent on factors such as ambient nutrients concentration, the physical state of the water column, and the abundance of other plankton. Phytoplankton are minute organisms and is essential links in food chain in aquatic system. Phytoplankton are the major group of plankton. Phytoplankton play a phenomenal role in the biosynthesis of organic material while zooplankton forms important components of secondary production. Phytoplankton provide food to macro-invertebrates, fishes and aquatic birds etc. They also play an important role in the primary productivity. Phytoplankton has immense value as the natural purification of polluted waters.

Phytoplankton recorded during the present study **(Lakhanpur OCP)** at different sampling locations are listed in the table below.

TABLE-4.4: MONTHLY DISTRIBUTION OF PHYTOPLANKTON SPECIES AT DIFFERENT SITES

Name of the Taxa	Aug-18						Sep-18						Oct-18					
CHLOROPHYCEAE	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6
Ankistrodesmus sp.	+					+	+					+	+	+	+			
Ankistrodesmus falcatus		+	+	+			+		+	+	+		+	+	+		+	+
Arthrodesmus sp.	+		+		+	+		+	+							+		+
Chlorella sp.						+	+					+	+					
Chlorella vulgaris					+	+	+				+		+			+		
Chlorococcum sp.							+						+					+
Closteriopsis sp.	+			+						+								
Closterium quadratulum	+		+	+	+	+	+			+	+	+	+		+	+		+
Coelastrum sp.						+					+	+					+	
Cosmarium sp.							+					+	+					
Cosmarium aequale		+			+	+			+		+					+		+
Cosmarium formii				+			+			+		+	+					
Cosmarium margaritatum						+						+			+	+	+	
Crucigenia sp.						+				+			+			+		+
Crucigenia crucifera		+						+				+	+	+			+	
Desimidium sp.						+	+					+	+		+	+		
Gloeocystis gigas						+	+			+						+	+	
Gloeocystis sp.		+	+	+					+	+	+	+	+	+	+		+	+
Gonium sp.	+		+		+			+	+			+				+		+
Oocystis crassa				+	+	+	+				+		+			+		
Oocystis lacustris						+						+	+					
Pediastrum duplex	+	+	+		+		+	+	+		+	+	+	+	+		+	+
Pediastrum ovatum						+						+	+					
Pediastrum simplex		+		+	+		+		+		+					+		+
Scenedesmus armatus						+	+					+						
Scenedesmus bijugatus						+							+					
Spirogyra sp.		+	+		+		+		+		+		+			+		+
Stigeoclonium sp.						+	+					+				+		
Tetraedron sp.				+	+						+		+	+	+			
Tetraedron trigonum						+	+			+		+				+	+	
Tetrastrum sp.			+										+					+
Treubaria sp.						+						+						
Treubaria triappendiculata					+	+	+		+			+	+			+		
Ulothrix sp.	+		+	+						+		+						+
Ulothrix zonata				+				+		+			+			+	+	
Volvox sp.						+	+					+	+					
Zygnema sp.	+		+	+	+	+	+			+	+		+		+	+		
BACILLARIOPHYCEAE																		
Achnanthes sp.	+	+			+			+		+	+	+	+					+
Amphora alata	+	+			+	+		+	+			+	+		+	+	+	+
Amphora ovalis	+			+		+		+		+	+		+	+	+			
Amphora sp.			+	+	+	+			+		+	+				+		
Anomoeoneis sp.	+		+		+					+			+	+			+	+
Cocooneis sp.	+				+	+	+	+		+		+	+		+	+		

Name of the Taxa	Aug-18						Sep-18						Oct-18					
CHLOROPHYCEAE	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6
Cyclotella sp.						+	+			+		+		+		+		
Cymbella affinis	+	+	+		+		+	+	+		+		+			+	+	+
Eunotia sp.					+	+	+					+	+	+	+			+
Eunotia major	+	+			+			+	+			+			+			
Fragillaria pinnata	+	+	+			+	+			+			+			+		+
Gomphonema sp.	+				+	+		+				+		+	+		+	+
Gomphonema lanceolatum	+	+	+				+			+		+			+	+		+
Gyrosigma sp.	+					+						+	+	+				
Melosira sp.						+			+	+			+		+	+	+	
Melosira granulata	+	+	+	+	+			+		+	+	+				+		+
Navicula cincta	+	+	+			+		+	+	+			+	+	+			
Navicula pupila						+	+	+			+		+				+	
Navicula similis	+					+						+	+		+	+		+
Navicula subrhyncocephala		+	+	+	+	+	+			+			+	+		+		+
Nitzschia capitellata	+			+			+	+			+	+	+				+	
Nitzschia palea	+	+			+	+				+			+	+		+	+	+
Pinnularia sp.	+			+		+	+	+	+		+	+	+			+		
Pleurosigma sp.			+	+	+					+								
Synedra sp.	+			+	+	+		+	+	+						+	+	+
Synedra acus			+			+	+		+	+			+	+		+	+	+
Synedra ulna	+			+					+		+		+			+		+
Synedra ulna var. biceps	+			+	+	+	+						+					
Synedra ulna var. subaequalis	+	+	+			+					+		+	+	+	+		
Tabellaria sp.			+	+	+	+				+		+	+			+		
CYANOPHYCEAE																		
Anabaena sp.			+		+	+						+	+					+
Anabaena circinalis				+			+			+	+					+		
Anabaena flosaque	+	+		+		+		+	+	+		+	+	+			+	+
Anacystis sp.	+			+		+	+					+	+		+			
Aphanocapsa sp.	+	+	+		+		+	+		+	+							
Aphanothece elasticha	+					+			+				+	+			+	+
Aphanothece sp.		+	+			+	+		+	+		+	+		+	+	+	+
Arthrospira sp.	+			+			+				+	+	+		+	+	+	
Chroococcus sp.		+				+		+	+	+	+			+	+	+		
Cylindrospermum sp.	+			+		+	+		+			+	+		+			+
Gloeocapsa rupestris							+			+		+						+
Gloeocapsa sp.			+	+					+		+		+		+	+	+	
Lyngbya sp.		+		+	+	+	+					+		+				+
Lyngbya ventricosa		+	+	+			+		+	+	+		+		+	+	+	+
Merismopedia sp.	+	+			+		+				+							
Merismopedia glauca						+			+	+		+	+	+		+	+	+
Merismopedia tenuissima	+			+			+	+				+					+	
Microcystis sp.	+	+			+	+			+	+	+		+		+	+	+	+
Microcystis aeruginosa				+				+			+		+	+	+			
Nostoc sp.	+	+	+	+	+	+	+			+		+	+					+
Oscillatoria subbrevis	+					+			+						+	+	+	

Name of the Taxa	Aug-18						Sep-18						Oct-18					
CHLOROPHYCEAE	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6
Spirulina sp.			+		+		+	+				+		+	+	+		
Spirulina laxissima						+			+		+	+	+	+			+	
Synechocystis sp.	+		+	+		+	+	+		+		+	+		+	+		
EUGLENOPHYCEAE																		
Euglena acus							+			+		+	+					+
Euglena sp.	+		+	+					+		+		+		+	+	+	
Euglepha sp.		+		+	+	+	+	+				+		+				+
Lepocinclis sp.	+		+	+		+	+		+	+	+		+		+	+	+	+
Phacus sp.	+	+			+		+				+							
Phacus acuminatus	+					+		+	+	+		+	+	+		+	+	+
Phacus caudatus	+			+			+	+				+					+	
Trachelomonas sp.	+	+			+	+			+	+	+		+		+	+	+	+
Trachelomonas volvocina		+		+				+				+	+	+			+	

TABLE-4.5: QUALITATIVE DISTRIBUTION OF PHYTOPLANKTON SPECIES AT DIFFERENT SITES ON MONTHLY BASIS

Group	Aug-18						Sep-18						Oct-18					
	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6
Chlorophyceae	8	7	10	11	12	22	20	5	9	11	12	21	24	6	9	17	9	13
Bacillariophyceae	21	11	12	11	16	21	12	13	10	16	10	15	22	11	11	18	10	15
Cyanophyceae	12	9	8	12	7	14	14	7	11	11	10	14	15	8	12	11	11	10
Euglenophyceae	6	4	3	4	3	4	5	4	4	4	4	5	6	3	3	4	6	5
Total	**47**	**31**	**33**	**38**	**38**	**61**	**51**	**29**	**34**	**42**	**36**	**55**	**67**	**28**	**35**	**50**	**36**	**43**

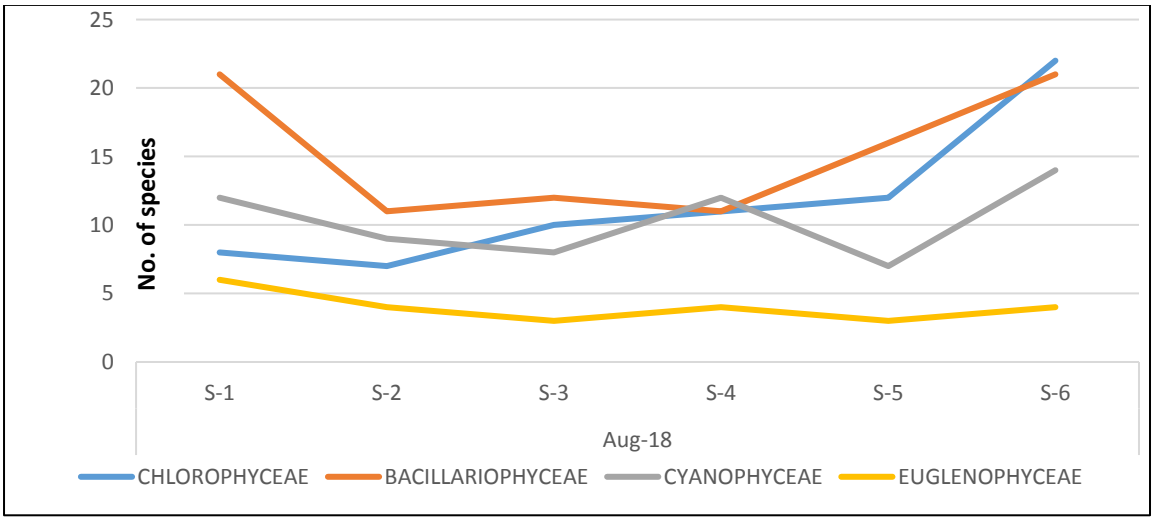


FIGURE-4.11: DISTRIBUTION OF PHYTOPLANKTON SPECIES AT DIFFERENT SITES DURING THE MONTH OF AUGUST, 2018

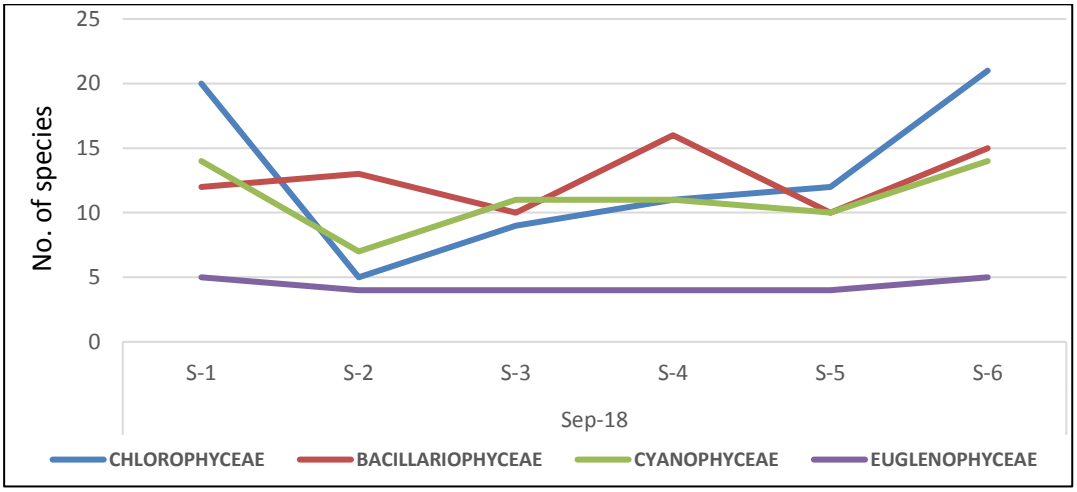


FIGURE-4.12: DISTRIBUTION OF PHYTOPLANKTON SPECIES AT DIFFERENT SITES DURING THE MONTH OF SEPTEMBER, 2018

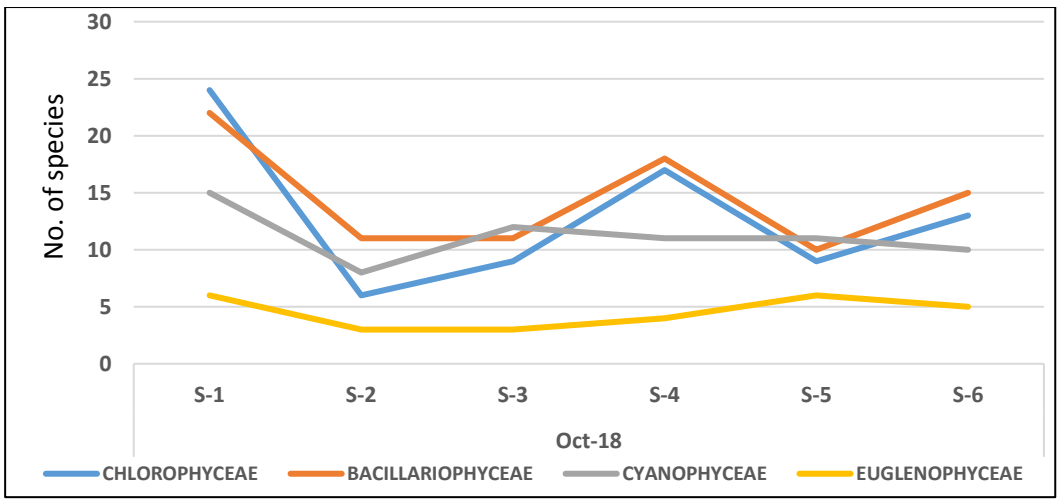


FIGURE-4.13: DISTRIBUTION OF PHYTOPLANKTON SPECIES AT DIFFERENT SITES DURING THE MONTH OF OCTOBER, 2018

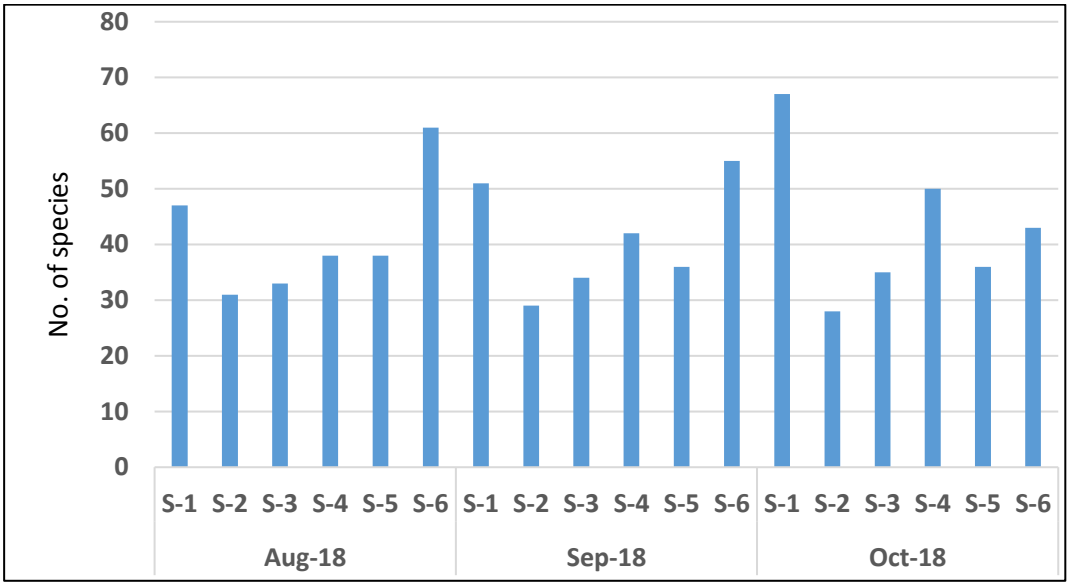


FIGURE-4.14: QUANTITATIVE DISTRIBUTION OF PHYTOPLANKTON SPECIES AT DIFFERENT SITES DURING AUG. TO OCT., 2018

(B) Zooplankton

Zooplankton are microscopic, planktonic animalcules ranging from a few microns to a millimeter or more and are highly variable in nature from one water body to another. Among all freshwater aquatic habitats, zooplankton are mainly constituted by: *Protozoa, Rotifer, Cladocera, Copepod* and *Ostrachoda*. Zooplankton by their heterotrophic activity play a key role in the cycling of organic materials in aquatic ecosystems. The species assemblage of zooplankton has long been used as indicators of water quality of different trophic status. Most of the zooplankton occupy an intermediate second or the third trophic level of aquatic food webs feeding on algae and bacteria and in turn are being eaten up by numerous invertebrates and fishes. Therefore, any adverse effect to them will be indicated in the health of the fish populations.

Zooplankton species (a major element at secondary level) are cosmopolitan in nature and they inhabit all freshwater habitats of the world, including polluted, industrial and municipal wastewater. They often exhibit dramatic changes in response to change in the *limno-chemical* and *limno-biological* characteristics of an aquatic environment and thus have great significance as pollution indicators, besides assessing the trophic status of water body. Since they form the stable diet of fish, therefore, their study for understanding the energy flow is of paramount importance.

Zooplankton, the secondary producers play an integral role in riverine ecosystem. They affect phytoplankton diversity and succession and also help in nutrient cycling. Zooplankton are not only useful as bio-indicators to help us detect

pollution load, but are also helpful for ameliorating polluted waters. Comparisons of size, structure, fecundity, and reproductive strategies of zooplankters can indicate the nature and extent of pollutant loads.

Zooplankton species recorded during the present study **(Lakhanpur OCP)** at different sampling locations are listed below in the table below.

TABLE-4.6: MONTHLY DISTRIBUTION OF ZOOPLANKTON SPECIES AT DIFFERENT SITES

Name of the Taxa	Aug-18						Sep-18						Oct-18					
	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6
Protozoa																		
Arcella sp.	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+
Arcella discoides	+											+	+	+	+			
Arcella vulgaris						+	+			+							+	+
Centropyxis sp.		+	+	+					+	+	+			+	+	+	+	
Centropyxis ecornis						+	+					+	+					
Difflugia sp.	+		+		+			+	+							+		+
Difflugia cuminata					+					+	+	+	+				+	
Euglypha sp.														+				+
Hypostomata sp.										+					+		+	
Lacrymaria sp.						+	+											+
Metopus sp.							+					+	+					
Opercularia sp.					+		+				+							+
Rotifera																		
Anuraeopsissp.					+	+	+					+	+					+
Anuraeopsis fissa	+			+						+								
Asplanchna sp.				+				+		+							+	+
Asplanchna brightwelli						+	+											
Brachionus sp.	+	+	+		+			+	+		+	+	+	+	+	+	+	
Brachionus angularis	+		+	+	+	+	+			+	+	+	+		+			+
Brachionus bidentata									+									
Brachionus calyciflorus						+	+			+				+				+
Brachionus caudatus											+						+	
Brachionus quadridentata												+	+					
Brachionus falcatus		+			+				+		+					+		+
Brachionus forficula						+	+						+					
Brachioeceles gammari																		
Brachionus rubens Ehrenberg										+		+	+					
Cephaloodella sp.															+		+	+
Cephlodella gibba																		+
Filinia sp.	+		+						+			+	+			+		
Filinia longiseta					+						+			+	+			
Gastropus sp.										+								+

Name of the Taxa	Aug-18						Sep-18						Oct-18					
	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6
Keratella sp.		+						+				+	+	+			+	
Keratella Cochlearis			+			+	+		+		+				+	+		+
Keratella quadrata																		
Keratella Tropica						+	+					+	+		+			+
Lepadella sp.													+		+			
Lecane sp.	+		+	+	+	+	+		+	+	+			+				+
Lecane bulla								+	+			+	+			+	+	
Lecane luna																		
Monostyla quadridentatus										+								
Monostyla sp.	+		+		+				+	+	+					+		+
Mytilina sp.			+						+							+		
Polyarthra vulgaris						+	+					+	+					
Scaridium sp.											+							
Testudinella patina																	+	
Trichocera multricrinis										+			+					+
Trichocerca sp.					+								+		+			
Cladocera																		
Alona sp.													+		+			
Alona intermediate																		+
Bosmina sp.	+		+	+					+	+				+		+	+	+
Bosmina longirostris	+					+	+	+				+	+					+
Ceriodaphnia sp.					+	+	+		+		+	+	+	+	+	+		
Chydorus sp.										+					+		+	
Chydorus sphaericus	+													+				
Daphnia sp.			+			+	+		+			+	+		+	+		+
Daphnia pulex																		+
Daphnia similis																		
Diaphnosoma sp.	+	+		+	+			+		+	+	+	+				+	
Diaphnosoma excisum						+	+			+				+	+		+	+
Leydgia sp.																		
Moina sp.													+					
Moina daphnia																		
Pleuroxus sp.													+					+
Sida sp.																+		
Simocephalus sp.					+						+	+	+		+			+
Copepoda																		
Cyclops sp.	+			+	+	+	+			+	+	+	+		+		+	+
Diaptomus sp.		+	+			+		+	+							+		
Eucyclops sp.														+			+	+
Heleodiaptomus viduus																		
Mesocyclops sp.	+						+			+	+	+	+	+			+	

Name of the Taxa	Aug-18						Sep-18						Oct-18					
	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6
Nauplius larvae	+	+	+	+	+		+	+	+		+				+	+		+
Neodiaptomus sp.																		
Nitzii amphibia													+					+
Paradiaptomus sp.							+					+						
Thermocyclops sp.							+	+	+	+	+	+	+	+		+		+
Thermocyclops crassus						+	+					+	+		+			+
Ostracoda																		
Cyprinotus sp.																		
Cypris sp.				+			+	+		+			+					+
Stenocypris sp.					+		+		+		+	+	+		+	+	+	
Stenocypris malcolmsoni													+					+

TABLE-4.7: QUALITATIVE DISTRIBUTION OF ZOOPLANKTON SPECIES AT DIFFERENT SITES ON MONTHLY BASIS

Group	Aug-18						Sep-18						Oct-18					
	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6
Protozoa	3	2	3	2	4	3	6	2	3	5	4	4	4	3	4	3	5	6
Rotifera	6	3	7	4	8	9	9	4	9	10	8	10	14	5	8	7	7	13
Cladocera	5	1	2	2	2	4	4	2	3	4	3	5	8	4	6	4	4	7
Copepoda	3	2	2	2	2	7	6	3	3	3	4	5	5	3	3	3	3	6
Ostrachoda	0	0	0	1	1	0	2	1	1	1	1	1	3	0	1	2	1	2
Total	**17**	**8**	**14**	**11**	**17**	**23**	**27**	**12**	**19**	**23**	**20**	**25**	**34**	**15**	**22**	**19**	**20**	**34**

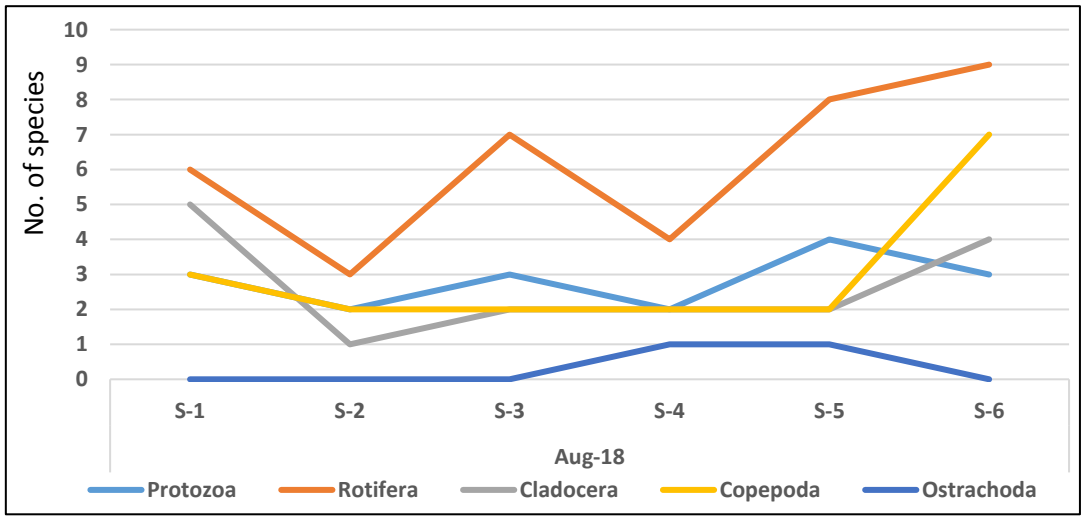


FIGURE-4.15: DISTRIBUTION OF ZOOPLANKTON SPECIES AT DIFFERENT SITES DURING THE MONTH OF AUGUST, 2018

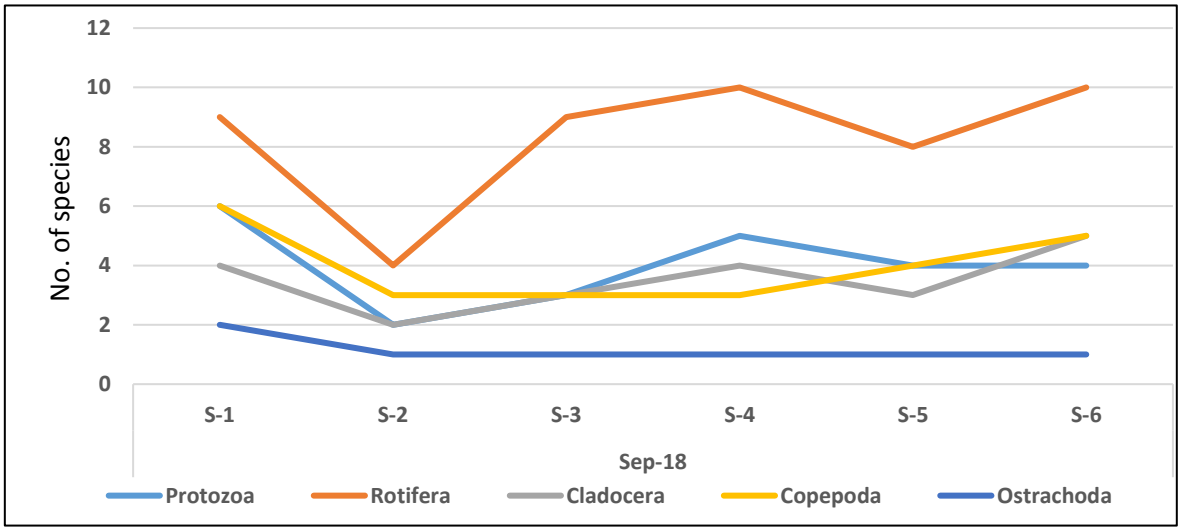


FIGURE-4.16: DISTRIBUTION OF ZOOPLANKTON SPECIES AT DIFFERENT SITES DURING THE MONTH OF SEPTEMBER, 2018

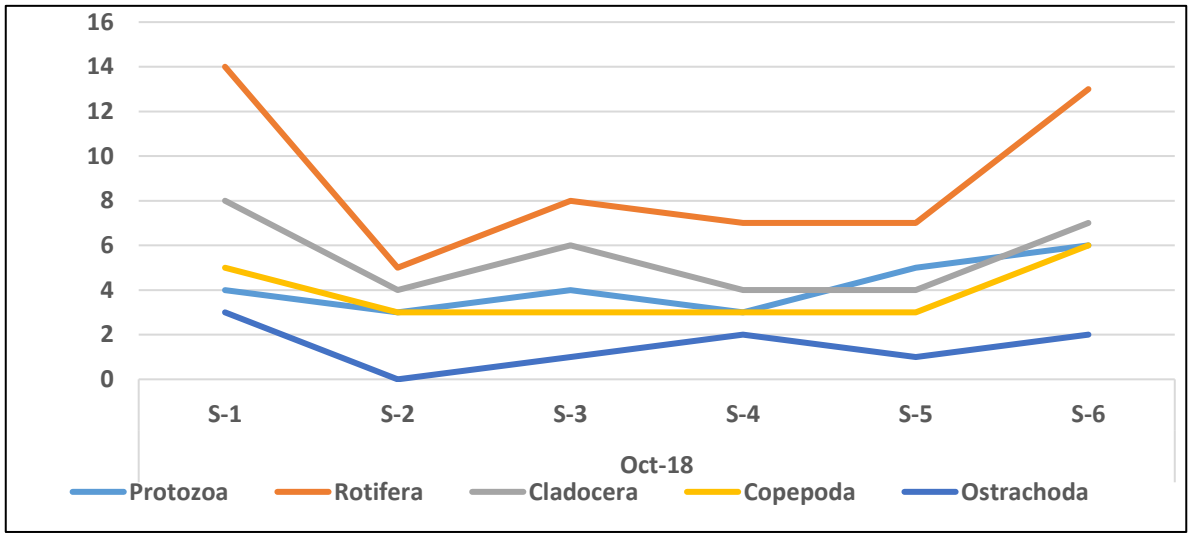


FIGURE-4.17: DISTRIBUTION OF ZOOPLANKTON SPECIES AT DIFFERENT SITES DURING THE MONTH OF OCTOBER, 2018

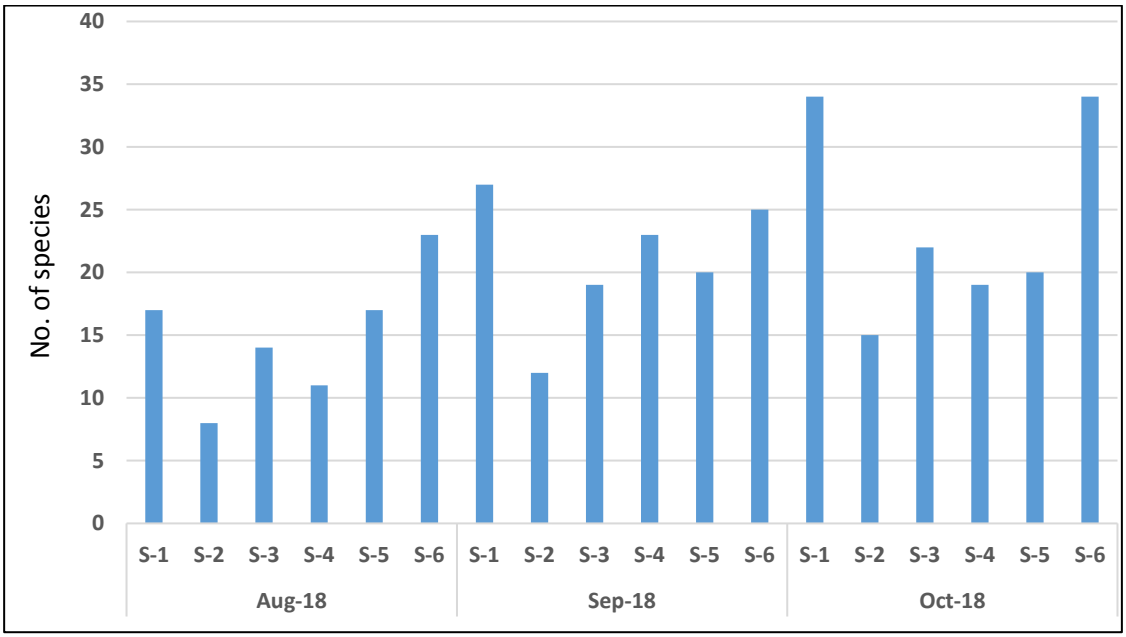


FIGURE-4.18: QUALITATIVE DISTRIBUTION OF ZOOPLANKTON SPECIES AT DIFFERENT SITES DURING AUG. TO OCT., 2018

(C) Macro-invertebrates

Freshwater ecosystems are inhabited by great variety of organisms. Aquatic macro-invertebrates have been identified as excellent tool for biomonitoring studies as they respond rapidly to the environmental changes. Their abundance, diversity and short life cycle makes them ideal subjects for the assessment of ecological conditions of rivers and lakes. Benthic population is an essential part of riverine ecosystems, exerting a considerable impact upon their functioning.

The study on benthic fauna in an aquatic ecosystem gives better idea of trophic conditions. Microbenthic communities occupy the bottom of water body and play an important role in the trophic dynamics of all aquatic ecosystems. They are an important part of aquatic ecosystem and respond to changes in the physical and chemical environment. Being efficient energy converters, they constitute an important link in the aquatic food chain as well as food web. Benthic fauna support the economically important fish population especially bottom feeders and also facilitates the recycling of nutrients. Their quantitative distribution indicates the potential of water body and also serves as good indicator of trophic status.

Macro-invertebrates species recorded during the present study **(Lakhanpur OCP)** at different sampling locations are listed below in the table below.

TABLE-4.8: MONTHLY DISTRIBUTION OF MACRO-INVERTEBRATES AT DIFFERENT SITES

Name of the Taxa	Aug., 2018						Sept., 2018						Octob., 2018					
Insecta	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6
Amphiops sp.	+		+	+	+		+		+	+	+	+	+		+	+	+	+
Baetis nymph		+									+		+					+
Berosus nitricepa					+		+			+								+
Berosus pulchellus			+	+					+	+		+		+	+	+		+
Chaoborus sp.														+				+
Chironomus plumosus	+	+		+		+				+	+	+	+					+
Chironomus sp.					+		+	+		+				+	+		+	+
Cybister confuscus					+		+				+		+					
Cybister limbatus	+		+	+	+	+	+			+	+	+	+		+		+	
Damsel flies nymphs										+	+		+					
Ephydra larvae						+					+	+	+		+		+	
Glossosoma sp.						+	+		+		+	+	+		+	+		+
Haliplida sp.	+			+						+								
Hirudineria glossophonia	+				+					+			+		+		+	+
Hirudineria sp.											+		+					
Hydropsyche sp.		+				+			+			+				+	+	
Laccotrephes ruber	+		+	+	+	+	+		+	+		+		+			+	
Limnodrillus hoffmeisteri	+				+		+		+		+		+			+	+	+
Limnophora larvae													+				+	
Mayflies nymphs	+			+	+	+	+			+	+	+	+		+		+	+
Mosquitos larvae	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Pheretima sp.	+				+		+				+		+				+	
Ranatra elongata	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Ranatra filliformis																		
Stone flies nymphs							+				+							
Tubifex sp.										+				+				
Tubifex tubifex	+			+	+	+	+			+	+	+	+			+	+	+
Mollusca																		
Bellamya bengalensis							+			+					+		+	+
Bellamya dissimilis			+		+	+												
Corbicula fluminalis	+								+			+						
Corbicula sp.					+						+		+					
Gyraulus convexiculus									+		+	+	+				+	
Gyraulus sp.				+	+	+	+			+	+		+		+		+	+
Indoplnorbis exustus																+		
Lymnaea acuminata			+	+	+													
Lymnaea sp.	+												+				+	
Melanoides lineatus	+			+	+	+	+		+			+			+	+	+	

Name of the Taxa	Aug., 2018						Sept., 2018						Octob., 2018					
Insecta	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6
Melanoides tuberculatus	+						+				+							
Pila globosa(apple snail)							+		+	+	+	+	+			+	+	
Pila sp.					+		+				+		+		+		+	
Thira sp.						+	+		+		+	+	+		+	+		+
Thira tuberculata	+			+	+	+	+			+	+	+	+		+		+	+
Unio tigridis			+		+				+							+		
Vivipara bengalensis																	+	+

TABLE-4.9: QUALITATIVE DISTRIBUTION OF MACRO-INVERTEBRATES AT DIFFERENT SITES ON MONTHLY BASIS

Group	Aug., 2018						Sept., 2018						Oct., 2018					
	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6
Insecta	12	5	6	10	13	10	14	3	8	15	16	12	17	7	10	8	14	14
Mollusca	5	0	3	4	8	5	8	0	6	4	8	6	8	0	6	5	9	5
Total	17	5	9	14	21	15	22	3	14	19	24	18	25	7	16	13	23	19

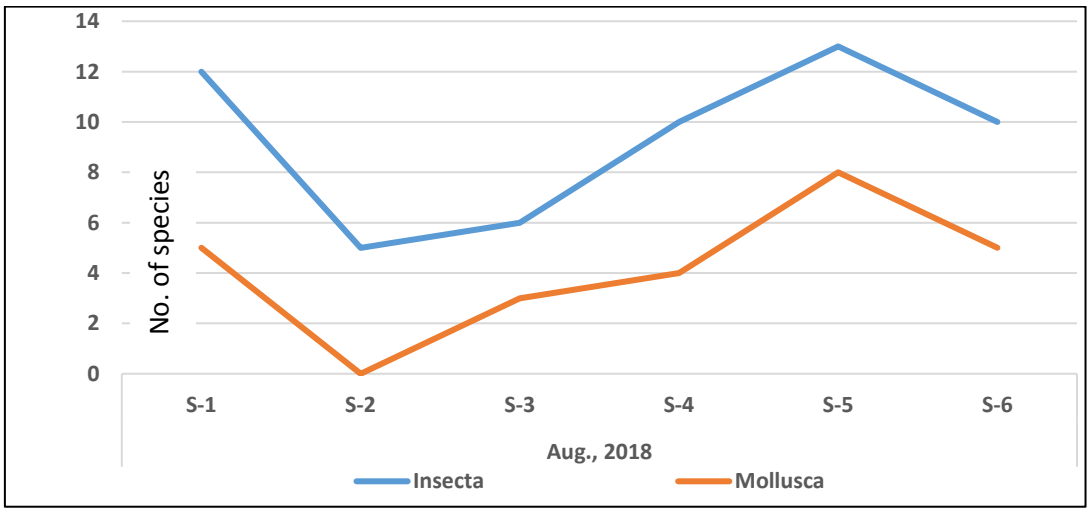


FIGURE-4.19: DISTRIBUTION OF MACRO-INVERTEBRATES AT DIFFERENT SITES DURING THE MONTH OF AUGUST, 2018

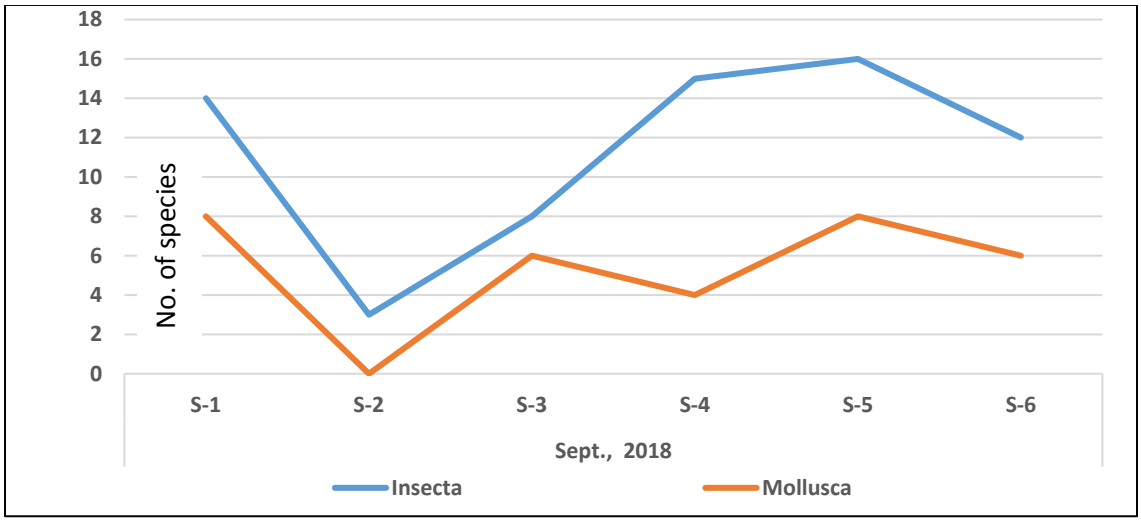


FIGURE-4.20: DISTRIBUTION OF MACRO-INVERTEBRATES AT DIFFERENT SITES DURING THE MONTH OF SEPTEMBER, 2018

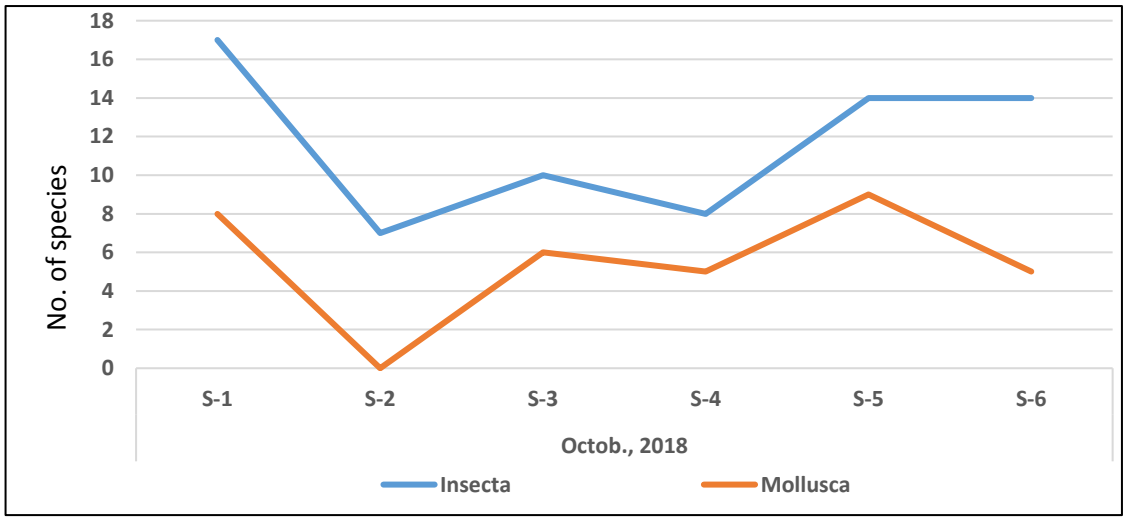


FIGURE-4.21: DISTRIBUTION OF MACRO-INVERTEBRATES AT DIFFERENT SITES DURING THE MONTH OF OCTOBER, 2018

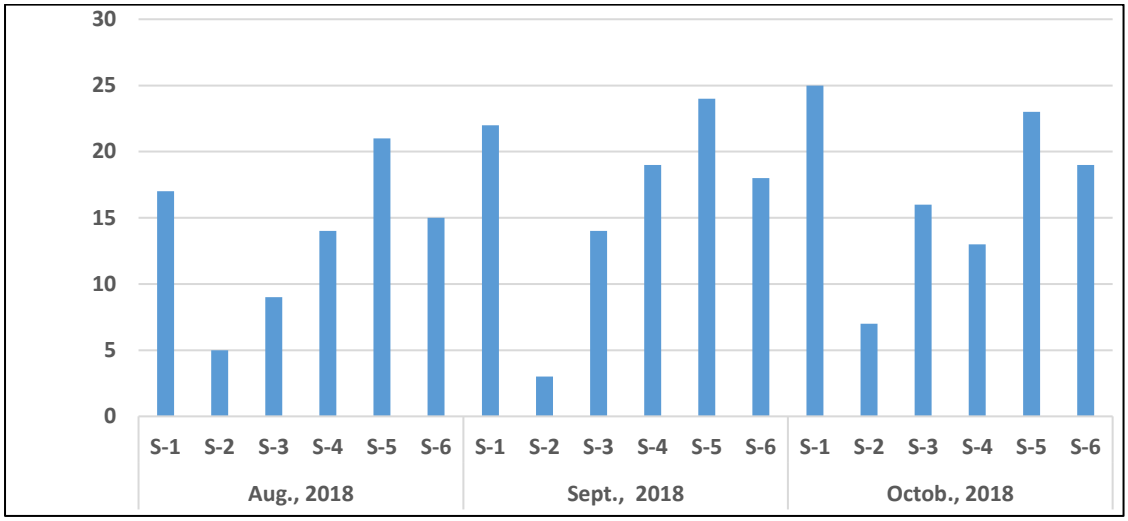


FIGURE-4.22: QUALITATIVE DISTRIBUTION OF MACRO-INVERTEBRATES AT DIFFERENT SITES DURING AUG. TO OCT., 2018

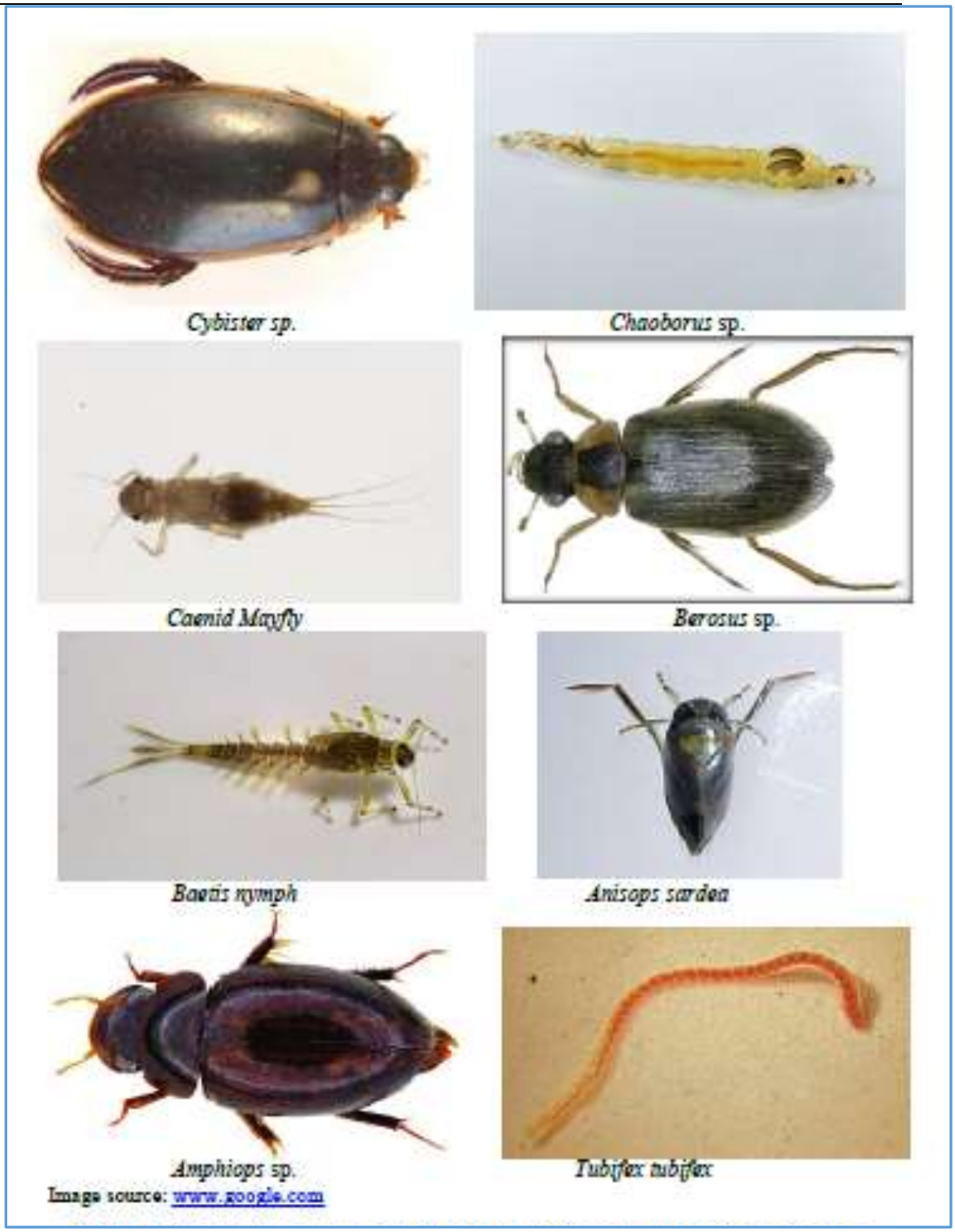


FIGURE-4.23: SOME INSECTS RECORDED FROM DIFFERENT SITES OF STUDY AREA

FIGURE-4.24: SOME INSECTS RECORDED FROM DIFFERENT SITES OF STUDY AREA

FIGURE-4.25: SOME MOLLUSCS RECORDED FROM DIFFERENT SITES OF STUDY AREA

FIGURE-4.26: SOME MOLLUSCS RECORDED FROM DIFFERENT SITES OF STUDY AREA

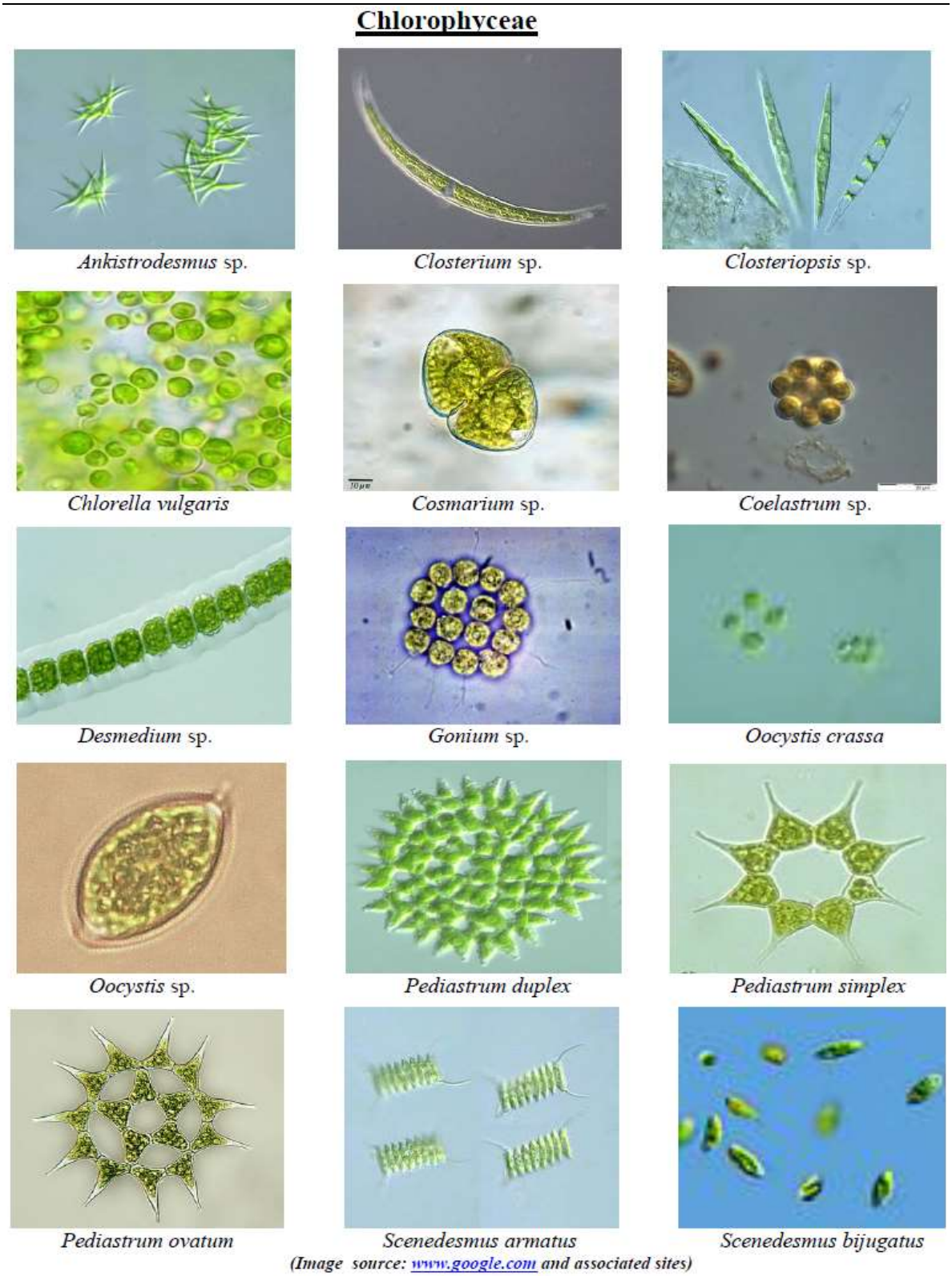
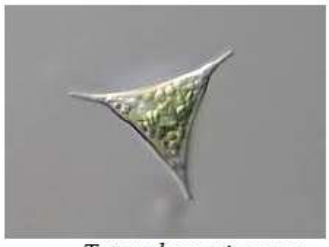


FIGURE-4.27: SOME PHYTOPLANKTON SPECIES COLLECTED FROM THE STUDY AREA OF LAKHANPUR OCP

Spirogyra sp.

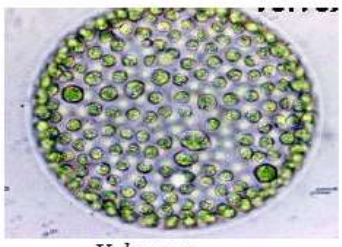
Stigeoclonium sp

Treubaria sp.

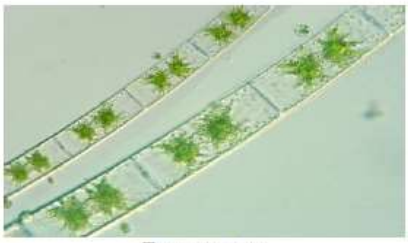


Tetraedron trigonum

Ulothrix zonata

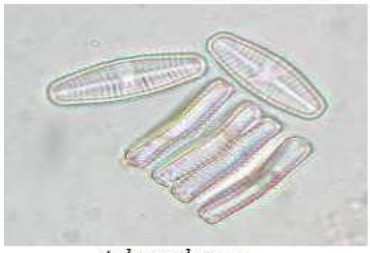


Volvox sp.



Zygnema sp.

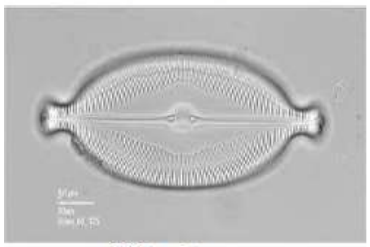
Bacillariophyceae



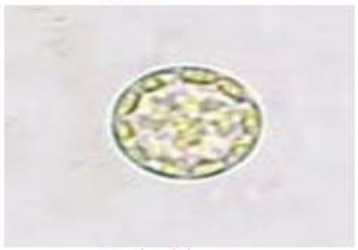
Achnanthes sp.

Amphora ovalis

Amphora sp.



Caloneis sp.



Cyclotella sp.

Cocconeis sp.

(Image source: www.google.com and associated sites)

FIGURE-4.28: SOME PHYTOPLANKTON SPECIES COLLECTED FROM THE STUDY AREA OF LAKHANPUR OCP

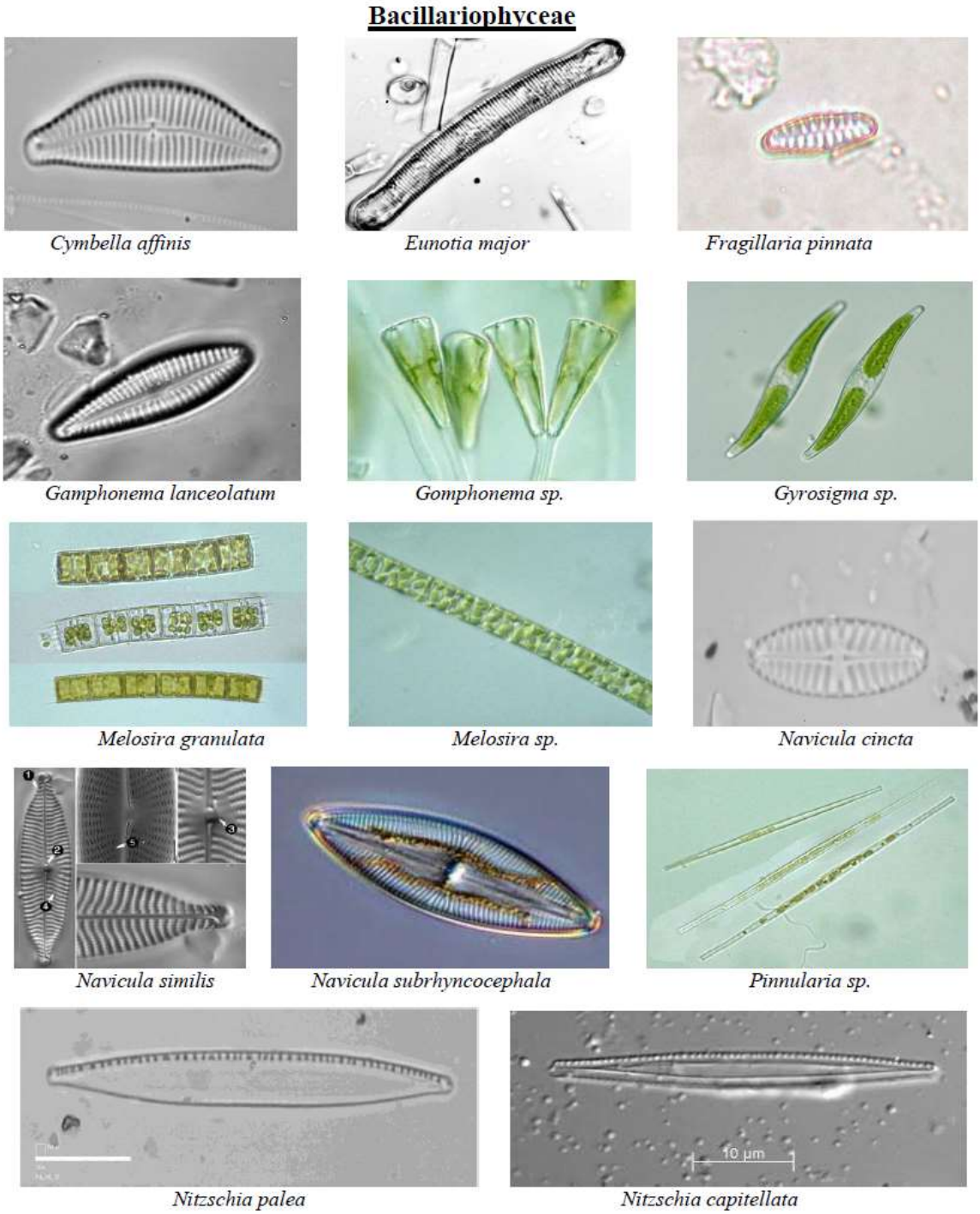
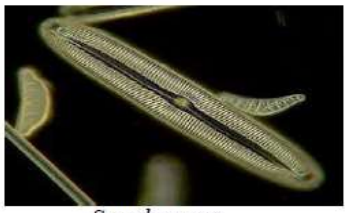
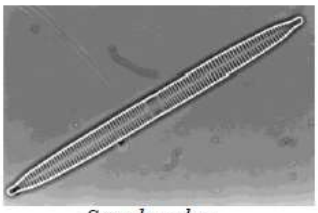


FIGURE-4.29: SOME PHYTOPLANKTON SPECIES COLLECTED FROM THE STUDY AREA OF LAKHANPUR OCP


Synedra acus

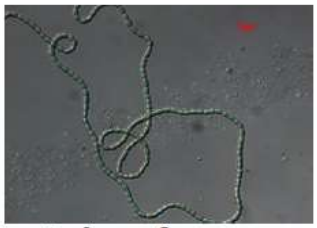

Synedra ulna


Tabellaria sp.

Cyanophyceae

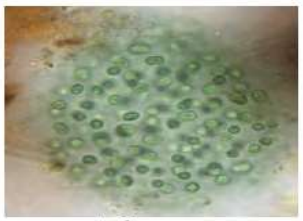

Anabaena circinalis


Anabaena sp.


Anabaena flos-aque

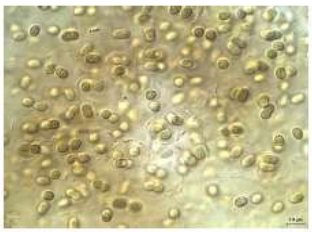

Anacystis sp.


Aphanocapsa sp.

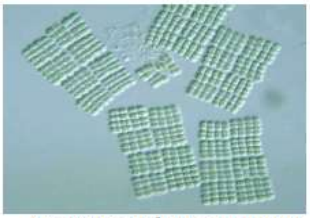

Arthrospira sp.


Chroococcus sp.


Cylindrospermum sp.


Gloeocapsa rupestris

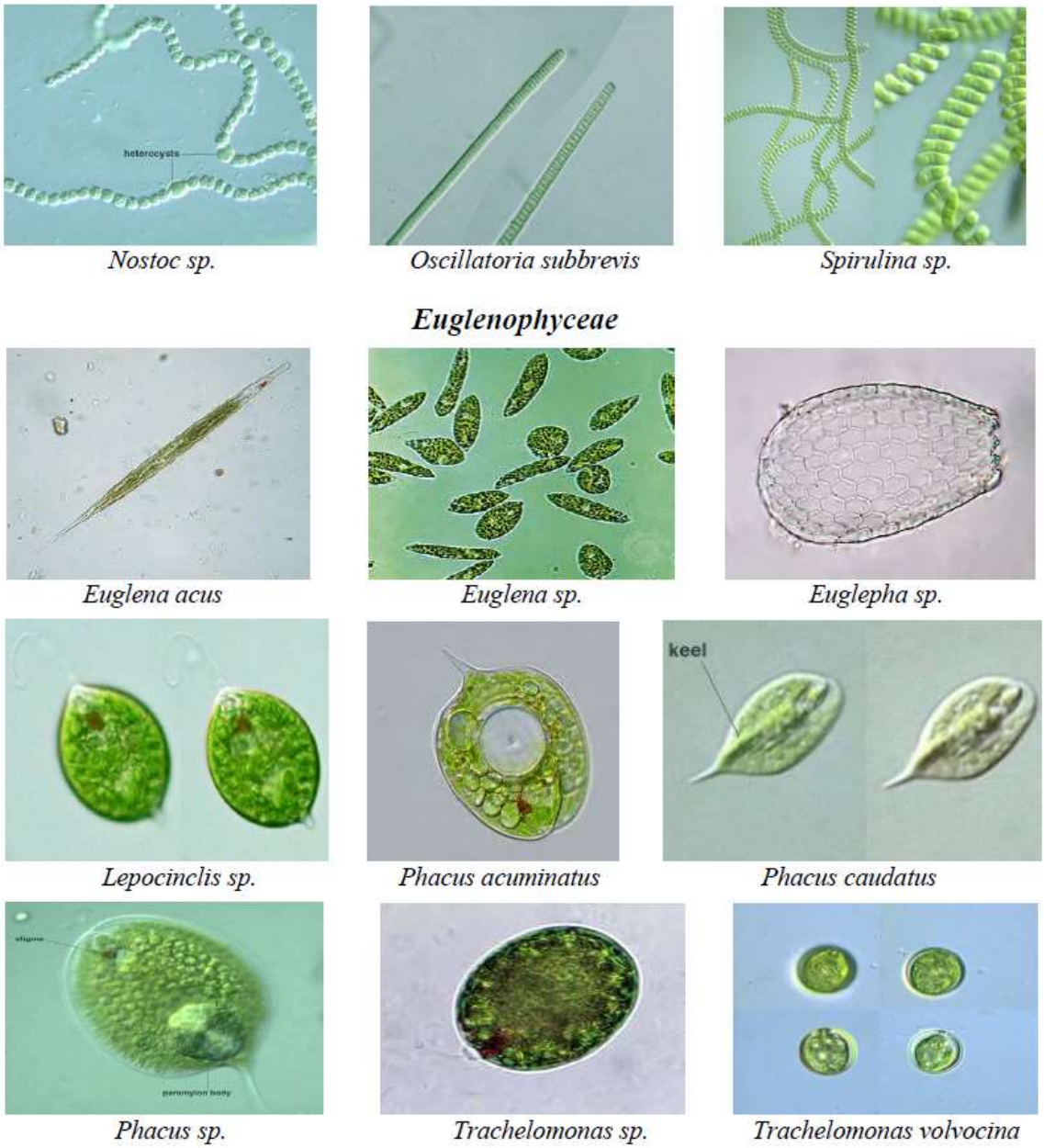

Merismopidia glauca


Merismopidia tenuissima


Microcystis aeruginosa

(Image source: www.google.com and associated sites)

FIGURE-4.30: SOME PHYTOPLANKTON SPECIES COLLECTED FROM THE STUDY AREA OF LAKHANPUR OCP



Nostoc sp. *Oscillatoria subbrevis* *Spirulina sp.*

Euglenophyceae

Euglena acus *Euglena sp.* *Euglepha sp.*

Lepocinclis sp. *Phacus acuminatus* *Phacus caudatus*

Phacus sp. *Trachelomonas sp.* *Trachelomonas volvocina*

(Image source: www.google.com and associated sites)

FIGURE-4.31: SOME PHYTOPLANKTON SPECIES COLLECTED FROM THE STUDY AREA OF LAKHANPUR OCP

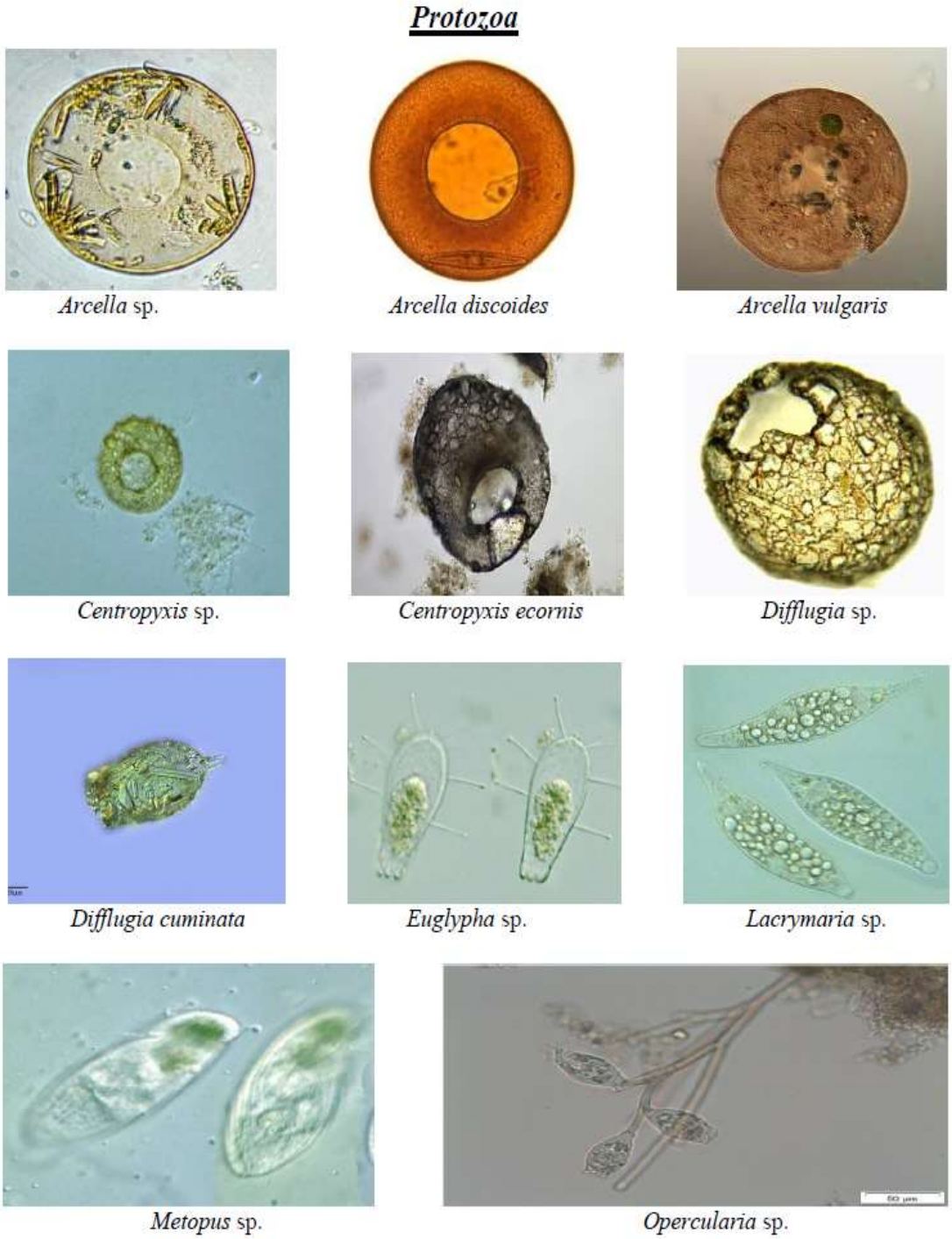


FIGURE-4.32: SOME PROTOZOAN SPECIES COLLECTED FROM THE STUDY AREA OF LAKHANPUR OCP

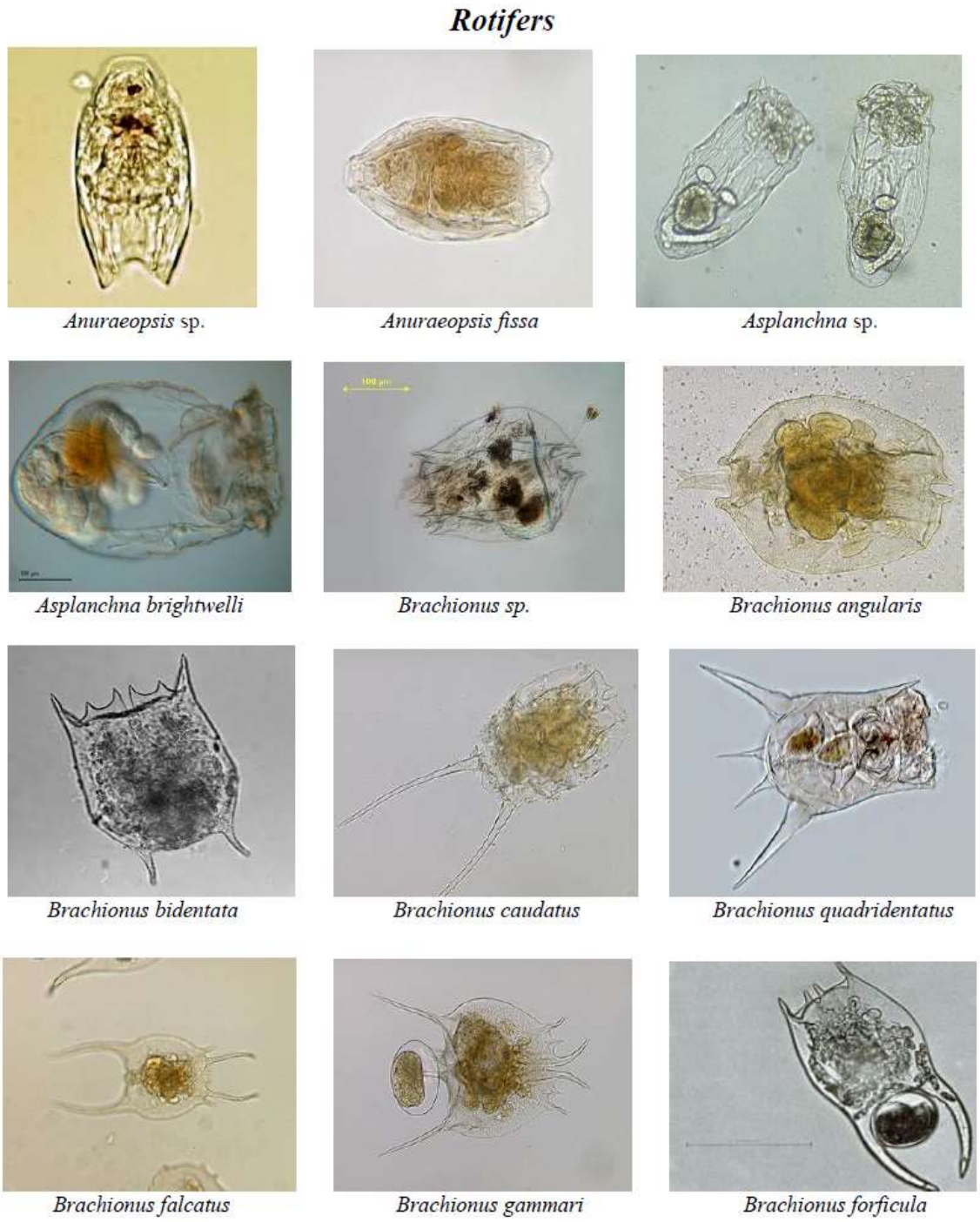
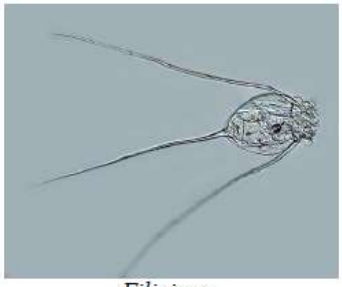


FIGURE-4.33: SOME ROTIFERS SPECIES COLLECTED FROM THE STUDY AREA OF LAKHANPUR OCP

Brachionus rubens

Cephaloodella sp.

Cephlodella gibba

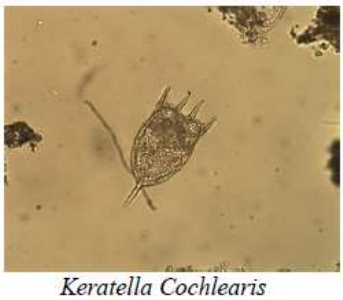


Filinia sp.

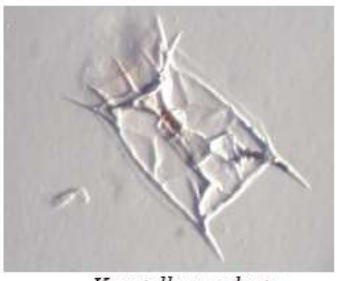
Filinia longiseta

Gastropus sp.

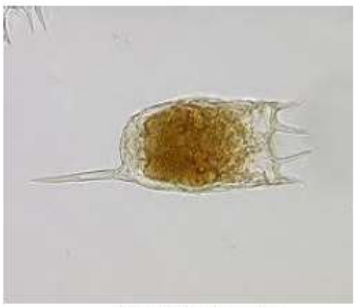
Keratella sp.



Keratella Cochlearis

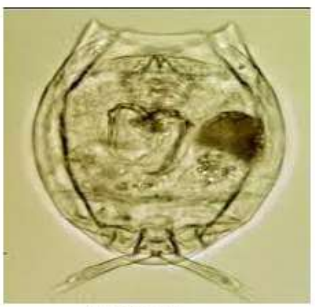


Keratella quadrata



Keratella tropica

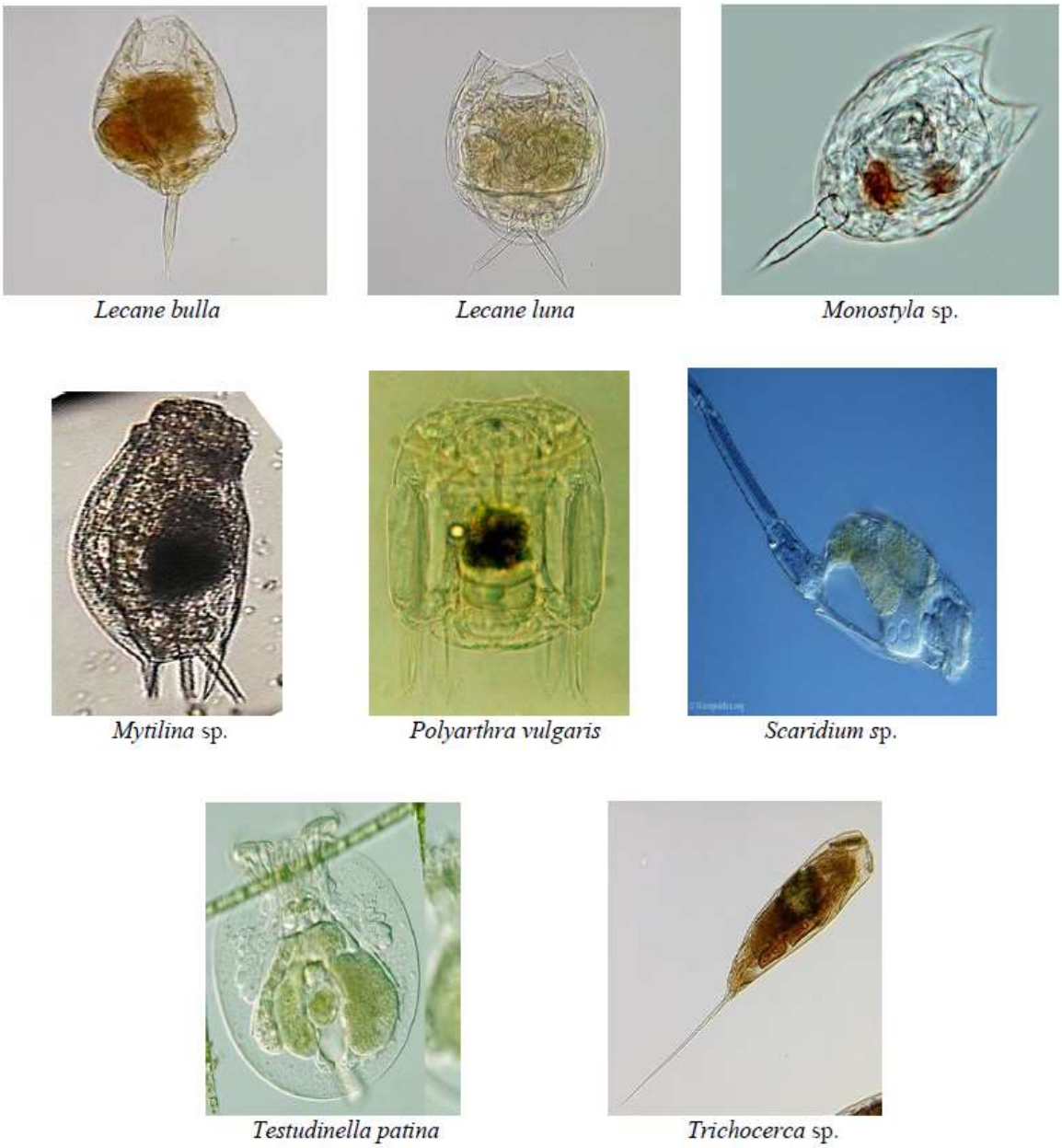
Lepadella sp.



Lecane sp.

(Image source: www.google.com and associated sites)

FIGURE-4.34: SOME ROTIFERS SPECIES COLLECTED FROM THE STUDY AREA OF LAKHANPUR OCP



(Image source: www.google.com and associated sites)

FIGURE-4.35: SOME ROTIFERS SPECIES COLLECTED FROM THE STUDY AREA OF LAKHANPUR OCP

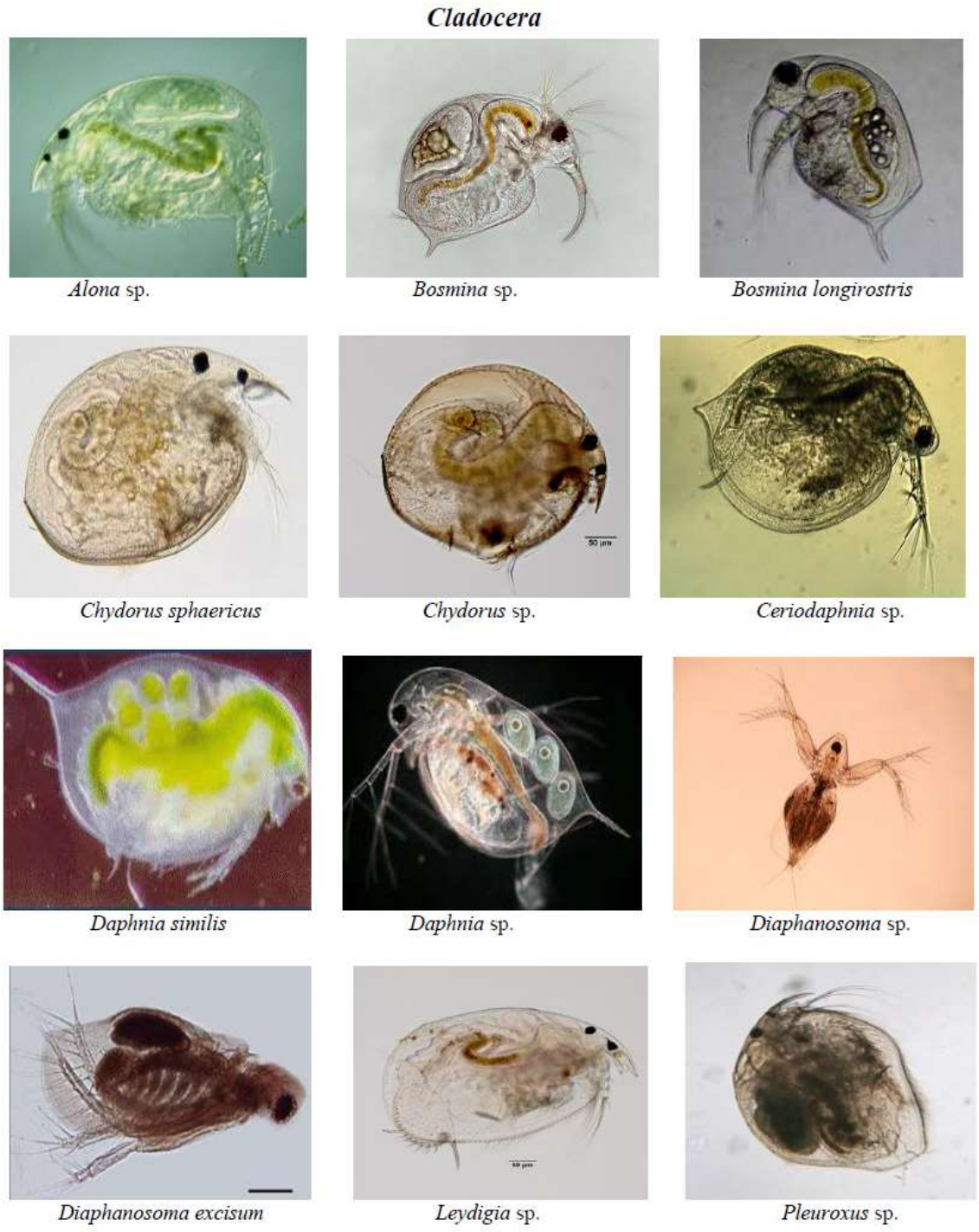


FIGURE-4.36: SOME CLADOCERAN SPECIES COLLECTED FROM THE STUDY AREA OF LAKHANPUR OCP

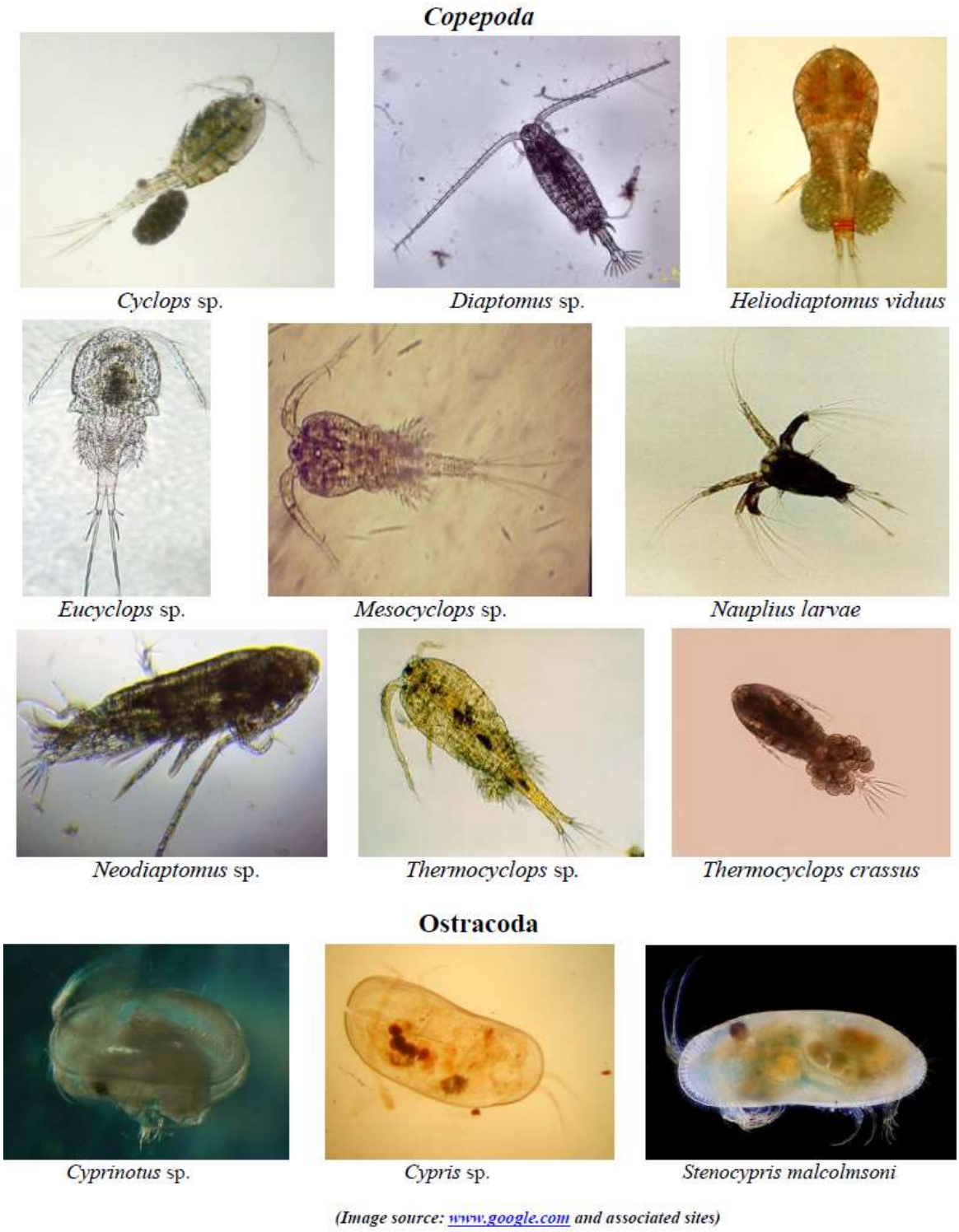


FIGURE-4.37: SOME CLADOCERAN AND OSTRACODS COLLECTED FROM THE STUDY AREA OF LAKHANPUR OCP

(D) Macrophytes (Aquatic Weeds)

Aquatic plants are essential parts of natural aquatic systems and form the basis of a water body's health and productivity. The presence of excessive aquatic vegetation influences the management of water in natural waterways; man made canals and reservoirs which amount to millions of kilometers of such water bodies. They pose serious threat to fish and fisheries. Considering the losses caused by aquatic weeds, their management is of utmost importance to improve the availability of water from the source to its end users. Growth of aquatic weeds interferes with the storage and delivery systems of irrigation water, maintenance of canals, drains, barrages, lakes, ponds *etc.* Aquatic plants play an important role in to maintain the carrying of any water bodies while absorbing the excessive nutrients form the water. Besides these, they also improve the quality of soil the water bodies.

Aquatic plants recoded during the present study **(Lakhanpur OCP)** at different sampling locations are listed below:

TABLE-4.10: QUALITATIVE DISTRIBUTION OF MACROPHYTES AT DIFFERENT SITES OF STUDY AREA (LAKHANPUR OCP)

Particulars	Sampling Sites of Lakhanpur OCP					
	S-1	S-2	S-3	S-4	S-5	S-6
Azolla imbricate	+			+		
Azolla pinnata	+	+	+	+	+	+
Ceratophyllum demersum	+					+
Commelina benghalensis						
Cyperus alopecuroides	+	+	+	+	+	+
Cyperus difformis	+	+	+	+	+	+
Eichhornia crassipes	+			+	+	+
Hydrilla verticillata	+			+		+
Hydrocotyle umbrella						
Ipomea aquatica	+	+	+	+		+
Ipomea carnea	+	+	+	+	+	+
Ipomea hederacea	+					+
Jussiaea repens	+					
Lemna aequinoctialis	+					
Lemna minor	+	+	+	+	+	+
Limnophila indica						
Ludwigia parviflora	+		+	+		+
Ludwigia sp.	+	+	+	+	+	+
Myriophyllum spicatum						
Najas graminea	+					
Nelumbo nucifera	+					

Nelumbo sp.	+			+		+
Nymphoides aquatica						+
Nymphoides indica	+	+	+	+	+	+
Ottelia alismoids	+					
Phragmites communis	+		+	+	+	+
Phragmites karka						+
Pistia stratiotes	+				+	+
Polygonum amphibium	+					+
Polygonum barbatum	+		+	+		+
Polygonum glabrum	+	+	+	+	+	+
Potamogeton nodosus	+					+
Sagittaria guayanensis				+		+
Spirodela polyrhiza	+					
Typha latifolia	+		+	+		+
Typha orientalis	+				+	+
Utricularia aurea	+					+
Total	**30**	**9**	**13**	**18**	**12**	**26**

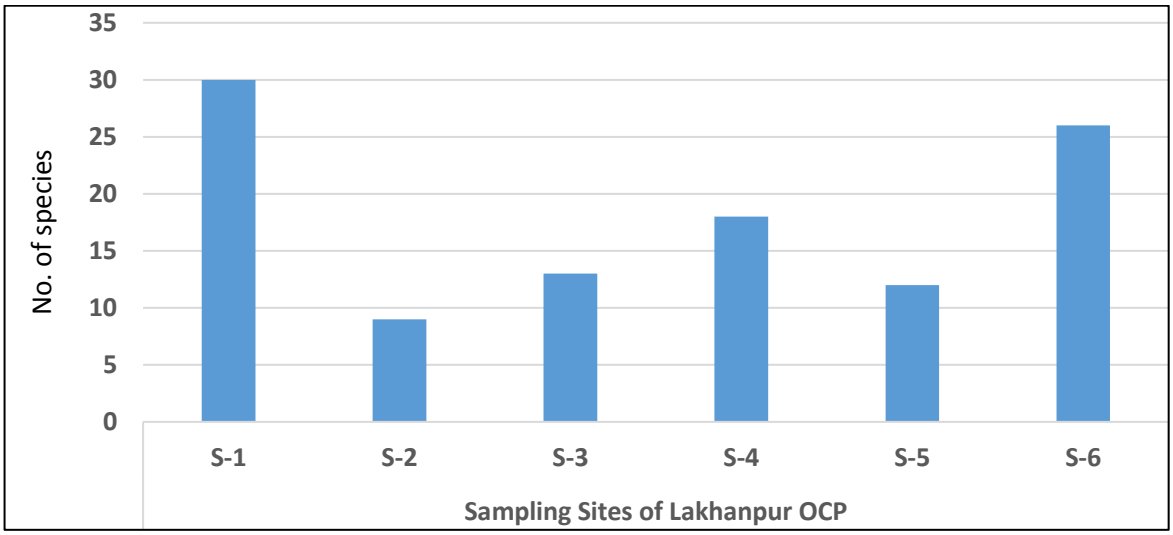


FIGURE-4.38: QUALITATIVE DISTRIBUTION OF MACROPHYTES AT DIFFERENT SITES OF THE STUDY AREA (LAKHANPUR OCP)

(E) Fishes

TABLE-4.11: LIST OF FISHES OBSERVED AT DIFFERENT SITES OF THE STUDY AREA (LAKHANPUR OCP)

Name of the Taxa	Sampling sites of Lakhanpur OCP					
	S-1	S-2	S-3	S-4	S-5	S-6
Catla catla	+					+

Name of the Taxa	Sampling sites of Lakhanpur OCP					
	S-1	S-2	S-3	S-4	S-5	S-6
Channa gachua				+		
Channa punctatus	+					+
Channa stiatus	+	+	+	+	+	+
Cirrhinus carpio	+					+
Cirrhinus mrigala	+					+
Cirrhinus reba	+			+		+
Clarias batrachus						
Labeo bata						
Labeo calbasu	+					+
Labeo rohita	+			+		+
Macrobrachium malcomsoni	+	+	+	+	+	+
Mastacembelus armatus	+					+
Mystus bleekri	+			+		+
Mystus tengara				+	+	
Mystus vitatus						
Nandus nandus	+	+	+			+
Notopterus notopterus					+	
Puntius sarana	+	+	+	+		+
Puntius sophore	+	+	+	+	+	+
Puntius stigma					+	
Puntius ticto				+		
Xenentodon cancila	+				+	+
Total	**15**	**5**	**5**	**10**	**7**	**15**

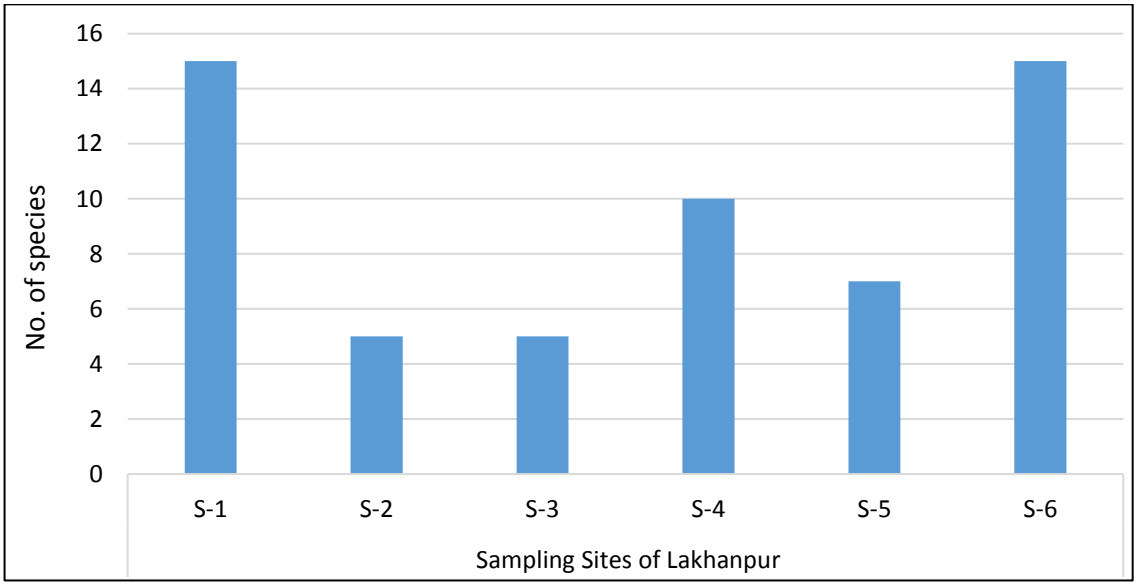


FIGURE-4.39: QUALITATIVE DISTRIBUTION OF MACROPHYTES AT DIFFERENT SITES OF THE STUDY AREA (LAKHANPUR OCP)

Simpson's diversity index

Simpson's diversity index is a measure of diversity which takes into account the number of species present, as well as the relative abundance of each species. The value of D ranges between 0 and 1. With this index, 1 represents infinite diversity and 0, no diversity. During the present study, the Simpson index for Phytoplankton, Zooplankton and Macro-invertebrates has been calculated based on qualitative contribution of different groups.

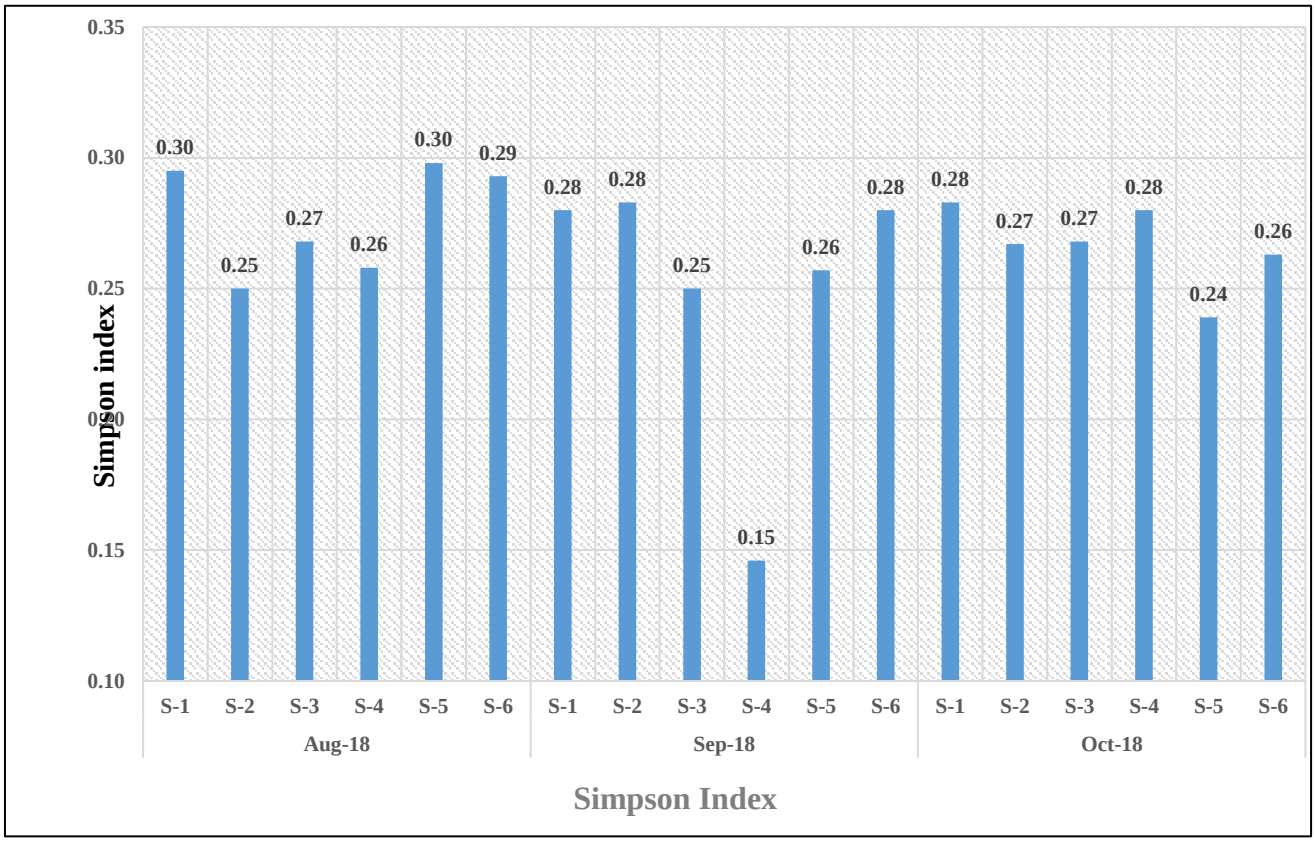


FIGURE-4.40: VARIATION IN SIMPSON INDEX OF PHYTOPLANKTON AT DIFFERENT SITES OF LAKHANPUR

The value of Simpson's diversity index of phytoplankton population at different sites of Lakhanpur OCP ranges between 0.15 to 0.3. The maximum value of Simpson's diversity index value of 0.3 was recorded at site 1 and 5 during the month of August, 2018. Whereas, minimum value (0.15) was observed at site 4 during the month of September, 2018.

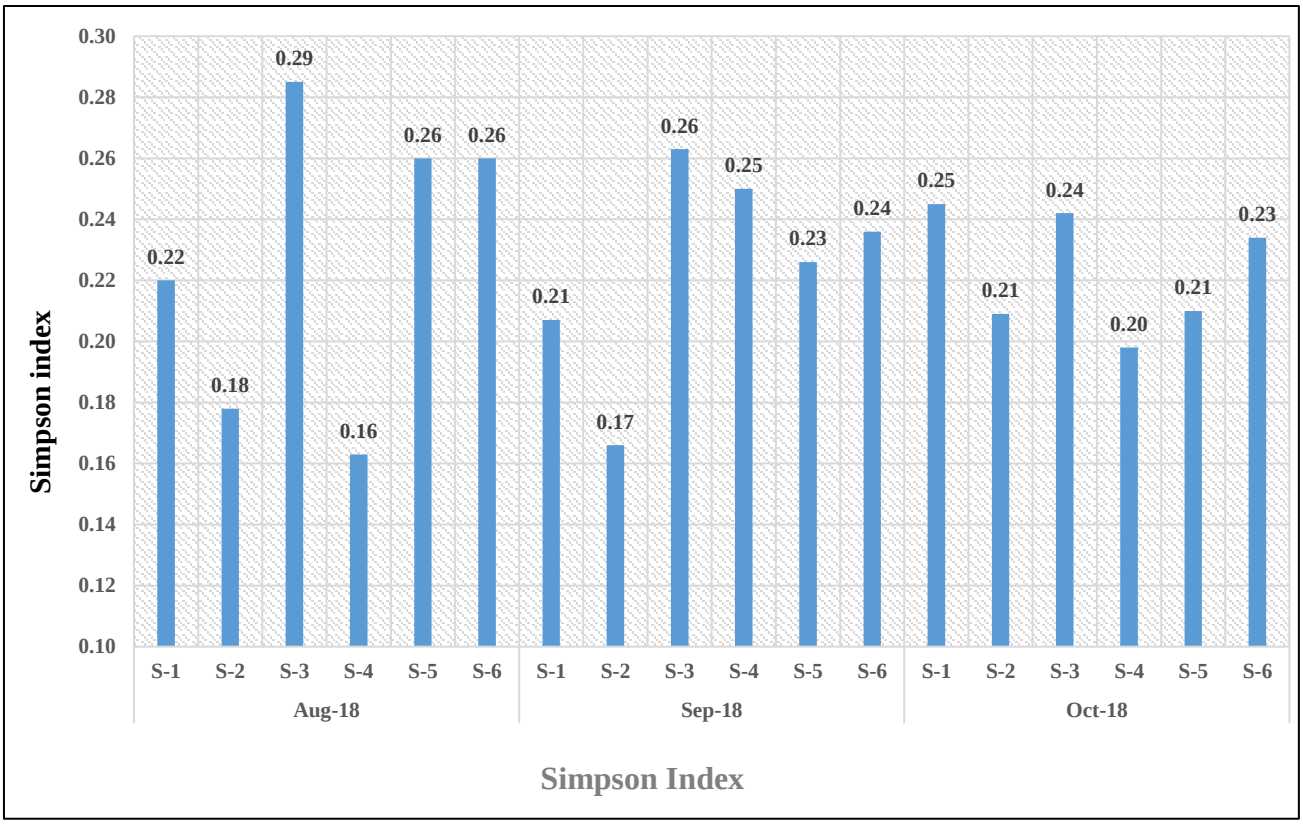


FIGURE-4.41: ARIATION IN SIMPSON INDEX OF ZOOPLANKTON AT DIFFERENT SITES OF LAKHANPUR

The value of Simpson's diversity index of zooplankton population at different sites of Lakhanpur OCP ranges between 0.16 to 0.29. The maximum value of Simpson's diversity index value of 0.29 was recorded at site 3 during the month of August, 2018. On the other hand, minimum value (0.16) was documented at site 4 in the same month.

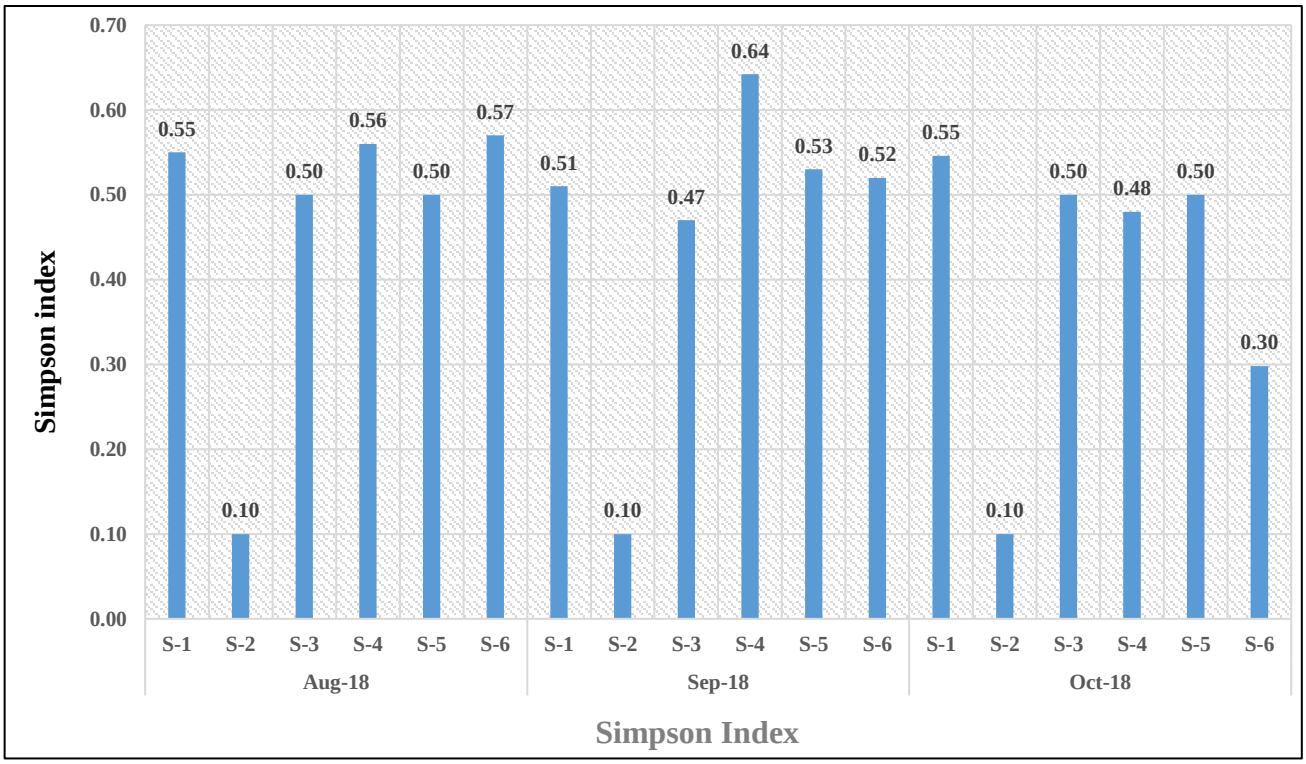


FIGURE-4.42: VARIATION IN SIMPSON INDEX OF MACRO-INVERTEBRATES AT DIFFERENT SITES OF LAKHANPUR

The value of Simpson's diversity index of macro-invertebrates population at different sites of Lakhanpur OCP ranges between 0.1 to 0.64. The maximum value of Simpson's diversity index value of 0.64 was recorded at site 4 during the month of September, 2018. Whereas, minimum value (0.1) was recorded at site 2 during the entire period of the present study.

4.2 WATER QUALITY DATA OF IB RIVER

The Ib River is the major drainage of the study area. The Phulijhor and Lilari nalla ultimately drains into the Ib river. This river is the tributary of Mahanadi River. There is one continuous water quality monitoring station installed near the intake well on the Ib River. The following water quality parameters are being monitored on regular basis through continuous water quality monitoring station:

I. pH
II. TSS
III. BOD, and
IV. COD

The status of the water quality of the river from January, 2018 to March, 2018 is as under:

TABLE-4.12: STATUS OF WATER QUALITY OF IB RIVER

Sl. No.	Period	Value Range			
		pH	COD	BOD	TSS
1	January, 2018	6.61-7.87	27.02-41.82	9.09-10.30	38.26-74.90
2	February, 2018	7.34-8.70	23.65-38.75	7.68-8.49	37.03-72.63
3	March, 2018	7.02-7.31	25.60-28.08	6.03-8.88	45.68-53.62

FIGURE-4.43: LOCATION OF DIFFERENT SAMPLING SITES IN THE STUDY AREA OF LAKHANPUR PROJECT

CHAPTER-V: OUTCOME OF THE STUDY

5.0 GENERAL

The mine leasehold area of Lakhanpur Phase-II OCP encompasses the Phulijhor Nalla. Lilari Nallah traverses the eastern boundary of the project. Both these nallah have their confluence near Darlipalli Village and they ultimately join the Ib River. The length of Phulijhor nallah is approx. 7.3 kms from the origin. This nallah is proposed for diversion to facilitate coal mining. Both these nallah are *seasonal in nature*. The Ib River is the major drainage of the area which ultimately joins River Mahanadi. Within the study area of 10 kms radius from the project, the Phulijhor Nalla, Lilari Nalla and Ib river forms the riverine system the area.

The water requirement for the Lakhanpur Phase-II Mine is primarily being met from the mine water. There is an intake well installed in the Lilari nallah. The water from Lilari Nallah is being supplied for dust suppression of the haul roads in the project. There are two water ponds around the project which is being utilized by nearby villagers for domestic and drinking purposes.

5.1 WATER QUALITY OF THE RIVERINE SYSTEM

The water quality of pond site, Phulijhor, Lilari Nallah and Ib River has been extensively surveyed in terms of pH, Dissolved Oxygen (DO), Total Dissolved Solids (TDS), alkalinity, hardness, chloride and Nitrate. The water quality status of the riverine eco-system reveals that water quality is still endurable and can be utilized after giving moderate treatment. The level of dissolved oxygen is quite good to support aquatic life.

The level of BOD, COD and TSS in the Ib River is moderate. This is the main drainage of the area. Slightly elevated level of BOD and COD is due to surface runoff from the nearby areas. However, the water is being utilized for various uses after giving treatment and is also supportive to aquatic life.

5.2 SUPPORTIVE CAPACITY FOR AQUATIC LIFE

All the water bodies (Lentic & Lotic) have strong self-purification system which controls the entire functioning of the ecosystem. All kinds of aquatic biota, their composition and distribution dependent upon the geomorphological and physico-chemical characteristics of the water bodies. Aquatic biodiversity of any water bodies reflects its potential to carry the external pollution load from the nearby catchment area.

During the present study, physico-chemical and biological characteristics of Phulijhor nalla reflects its alkaline and productive nature of water. Water quality of Phulijhor nalla is very good in comparison to the water quality of Lilari Nalla.

Some anthropogenic activities and direct mixing of domestic waste water has been observed at the site-5 (near confluence point) which may affect the natural conditions of the Lilari Nalla, its natural flow and biological profile. At site 6 (Ib River), a natural wetland consisting of a variety of aquatic vegetation is playing an important role to filter the waters of Lilari Nalla before mixing with the Ib river.

Phulijhor nalla is a seasonal stream. The Phulijhor nalla remains dry except monsoon and early post monsoon period (July to October). All the species of phytoplankton, zooplankton, and macro-invertebrates recorded from Phulijhor nalla are of temporary in nature. Biological components of Lilari Nalla are under stress at site 5 due to anthropogenic pressure from the surrounding areas.

5.3 ASSESSMENT OF IMPACT ON ENVIRONMENTAL COMPONENTS DUE TO PROPOSED PROJECT:

The Lakhanpur Phase-II OCP has been planned to produce 21 MTY of coal for meeting the requirement of various consumers. This project lies in the Ib Valley Coalfields. This coalfield has immense potential of coal reserves that can be exploited through production of coal.

The Lakhanpur Phase-II OCP is an open cast project and consists of mining related operations like drilling, blasting, loading and transportation of coal, *etc*. One of the major factors which impacts the local water eco-system is degradation of land. The land degradation by way of excavation leads to formation of mine voids, wherein, mine water gets accumulated. This accumulated mine water is being utilized for meeting the industrial water requirement of the project and thus, the footprint of the project on the local riverine system is minimized. The project has also undertaken construction of garland drains and catch drains to arrest the silt from the mining areas and prevent run-off into the surrounding water regime. The external OB dumps and back filled areas undergo technical and biological reclamation with the objective to minimize the surface runoff from such areas and to put the post mining land use for gainful utilization. This helps in minimizing the impact on the riverine eco system of the Lakhanpur Phase-II OCP.

As the mining operation progresses, suitable pollution control measures including, technical and biological reclamation of mined out area are undertaken. These efforts ensure that there is minimum impact on the riverine ecosystem. This has also been observed during the field surveys undertaken during the study period. The water quality of the Phulijhor Nallah, Lilari Nallah and Ib river located in the study area was found to have endurance enough to support the naturally prevailing flora and fauna (viz. phytoplankton, zooplankton, macrophytes, molluscs, insects, fishes, etc.) of the region.

It may be mentioned that coal mining in Lakhanpur Phase-II OCP only involves physical activities and there are no chemical processes involved. Hence, the

mining activities do not alter the chemical built-up/attributes of the natural streams.

5.4 RECOMMENDATIONS:

Since the total suspended solids from Lakhanpur Phase II OCP and nearby areas are likely to impact the riverine ecosystem in the study area significantly, it is recommended:

- To strengthen the catch drains and garland drains; this will help to prevent the run-off of suspended solids getting carried over into the surrounding water regime.
- Undertake proper management and reclamation of the mined out areas through plantation; this will help to arrest the erosion due to the mining activity. Plantation activities would also be carried out in additional areas in a phase wise manner, once the mining is completed in the respective stretches.
- As stipulated in the Forest Clearance granted for the project, additional studies pertaining to erosion and its impacts on land and soil will also be conducted and suitable mitigation plan will be implemented.

With respect to maintaining and improving the ecological condition of the Lilari Nalla and its minor adjoining streams, the following measures are recommended:

i. Siltation wetland should be constructed at sewage entering sites at every village located on the river bank.
ii. Desilting and cleaning work should be conducted at the shallow sites of the nallah,
iii. Public awareness program can be organized to create awareness for cleaning, conservation and management of riverine ecosystem.
iv. Plantation can be done at riparian zone of the river to reduce the soil erosion of the river bank, which may enhance the natural habitat of local faunal species.
v. Scientific monitoring survey should be conducted to determine the pollution levels at the source itself so that the exact effect of pollutants from catchment area can be identified beforehand for planning of additional pollution control measures, as required.

****

ANNEXURES

No.J-11015/391/2012-IA.II(M)
Government of India
Ministry of Environment, Forest & Climate Change
IA-II (Coal Mining) Division

Indira Paryavaran Bhawan,
Jorbagh Road, N Delhi - 3
Dated: 28th February, 2018

To,

The Chief General Manager (CP&P)
M/s Mahanadi Coalfields Limited
PO - Jagruti Vihar, Burla,
Sambalpur - 768 020 **(Odisha)**

E-mail: cgmenvt2014@gmail.com; gmenvt_mcl@yahoo.co.in

Sub: Expansion of Lakhanpur Opencast (Phase-II) Coal Mine Project from 18.75 MTPA to 21 MTPA by M/s Mahanadi Coalfields Limited in an area of 2452 ha located in District Jharsuguda (Odisha) - Environmental Clearance-reg.

Sir,

This has reference to your letter No.MCL/HQ/(ENVT)/Lakhanpur OCP/17-18/2783 dated 9th December, 2017 along with online proposal No.IA/OR/CMIN/71528/2017 dated 19.12.2017 and subsequent letters dated 15.12.2017, 20.12.2017, 22.12.2017 and 11.01.2018 on the above mentioned subject.

2. The Ministry of Environment, Forest and Climate Change has considered the proposal is for grant of environmental clearance to the project for expansion of Lakhanpur Opencast (Phase-II) coal mine from 18.75 MTPA to 21 MTPA in a total area of 2452 ha (ML area 2240 ha) by M/s Mahanadi Coalfields Limited located in District Jharsuguda (Odisha).

3. The proposal was considered by the Expert Appraisal Committee (EAC) in the Ministry for Thermal & Coal Mining Sector in its 24th meeting held on 11th January, 2017. The details of the project, as per the documents submitted by the project proponent, and also as informed during the meeting, are reported to be as under:-

(i) The project was earlier accorded environmental clearance vide letter dated 2nd July, 2008 for expansion from 10 MTPA to 15 MTPA and increase in mine lease area from 1467 ha to 2485 ha.
(ii) The project was further issued environmental clearance on 21st May, 2014 for expansion from 15 MTPA to 18.75 MTPA in mine lease area of 2389.60 ha (2485 - 95.40 = 2389.60 ha).
(iii) The latitude and longitude of the project are 21° 47' 32" N to 21° 43'12" N and longitudes 83° 47' 59" E to 83° 51'30" E respectively.
(iv) Joint Venture: No
(v) Coal Linkage : Thermal Power Plant & Basket Linkage
(vi) Employment generated / to be generated: Direct employment already provided to 3110 persons
(vii) Benefits of the project:
  (a) Improvement in Physical Infrastructure
  (b) Improvement in Social Infrastructure
  (c) Increase in employment potential

(d) Contribution to the Exchequer (both State and Central Govt.)
(e) Post mining enhancement of Green Cover
(f) Improvement of Electrical Power Generation and availability of electricity for 24x7 in rural areas
(g) Overall economic growth of the country.

(viii) The land usage of the project will be as follows:

Pre-Mining:

	Type of land	Area (ha)
a.	Agriculture	1182.97
b.	Forest	233.43
c.	Waste Land(Govt. land)	780.98
d.	Grazing	
e.	Surface water Bodies	-
f.	Others (Specify) (Homestead other tenancy land)	42.62
	Total	2240.00

Post- Mining:

S. No.	Land use Category	Land use in ha				
		Left out void/Water body	Afforested or arboriculture/ grass carpeting	Land to be converted for agriculture (Conceptual)	Undistributed/ Built up area	Total area
1.	Quarry Excavation area	38.68	650.32	464.84	160.16	1314.00
2.	Blasting danger Zone	-	245.84	-	492.16	738.00
3.	OB dump (external)	OB area of 38.40 ha falls in safety zone				
4.	Infrastructure	-	42.66	-	145.34	188.00
	Total Lease Area	38.68	938.82	464.84	797.66	2240.00
5.	Residential colony	-	12.00	--	48.00	60.00
6.	Resettlement Site	-	30.40	--	121.60	152.00
	Total	38.68	981.22	464.84	967.26	2452.00

Core area:

S. No.		Land		
	Particulars	Forest	Non-Forest	Total
1.	Quarry excavation	227.10	1086.90	1314.00
2.	Blasting danger Zone (Excluding the part of OB dump)		738.00	738.00
3.	OB dumps (External)	OB area of 38.40 ha falls in Safety Zone		
4.	Railway siding	-		
5.	Infrastructure	6.33	181.67	188.00

6.	**Mine lease Area (Subtotal from 1 to 5)**	**233.43**	**2006.57**	**2240.00***
7.	Residential Colony	--	60	60
8.	Resettlement site	--	152	152
9.	**Outside lease area**	--	**212**	**212**
10.	**Grand Total**	**233.43**	**2218.57**	**2452.00**

*Although, 2389.60 Ha of area has been considered approved mine lease area as per environmental clearance, Phase-I, lease area has been restricted to 2240.00 Ha as mining is not possible in 95.40 Ha of non diverted forest land and part non forest land trapped within and adjacent to this forest land. Phase-II of mining will be implemented after getting approval of forest diversion proposal for remaining 95.40 Ha.

(ix) The total geological reserve of the block is 215.89 MT. The minable reserve for the proposed project is 215.89 and extractable reserve is 215.89 MT (As on 01.04.2017). The percentage extraction would be 100 %.
(x) The coal grade is G-14. The stripping ratio is 2.42/tonne. The seam gradient varies from 3.7° to 5°. There will be one seam with thickness ranging (20.88m to 33.53m) in the full thickness area.
(xi) The total estimated water requirement is 5950 KLD.
(xii) The level of ground water ranges from□2.20 to 8.95 mgbl (Pre-monsoon) and 1.05 to 6.70mbgl (post monsoon)
(xiii) The Method of mining would be Open cast mining (Coal- Surface Miner, OB- Shovel Dumper).
(xiv) There is two external OB dumps with Quantity of 1.94 Mm3 in an area of 38.40 ha with height of 15 meters above the surface level and one internal dump with Quantity of 749.81 Mm3 in an area of 1115.16 ha with height Up to ground level in major part, maximum up to 60 m above ground level at some parts.
(xv) The final mine void would be in 38.68 ha with maximum upto150-155 m depth and the total quarry area is 1314.00 ha. Backfilled quarry area of 1115.16 ha (out of which 650.32 ha will be done plantation/Grass carpeting and rest 464.84 ha will be converted in to agricultural land (Conceptual). The void of 38.68 ha is proposed to be converted in to water body of depth maximum up to 150-155 m.
(xvi) The life of mine is 11 Years as on 01.04.2017
(xvii) Transportation: Coal transportation from face to pit top by trucks, surface to siding by truck (present) by conveyor (proposed) and Siding to loading by pay loader (present) by silo (proposed).
(xviii) There is no additional R & R involved.
(xix) Total capital cost of the project is Rs. 436.79 Crores. CSR Cost According to New CSR policy, the fund for the CSR should be allocated based on 2% of the average net profit of the Company for the three-immediate preceding financial years or Rs. 2.00 per tonne of coal production of previous year whichever is higher. R&R Cost Rs. 56.49 Crores. Environmental Management Cost Rs. 5.36 Cr. for the year 2016-17.
(xx) Phullijhore Nallah passing through the lease whose diversion is proposed. LillariNalla Passing through the mine lease remains undisturbed.
(xxi) Ground water clearance: Not applicable.
(xxii) Mining plan for the 21 MTPA was approved by MCL Board on 07.11.2017 & by MoC Vide letter no. 34011/36/2017-CPAM dated 20-11-2017. Mine closure plan is an integral part of mining plan.
(xxiii) There are no national Parks, wildlife sanctuary, biosphere reserves found in the 10 km buffer zone.

(xxiv) Total forest land involved is 233.43 ha in the mine lease area of 2240 ha. Stage-I Forest clearance for the entire forest land has been obtained vide letter dated 6th October, 1990.
(xxv) Total afforestation plan shall be implemented covering of the mining. This will include green Belt over an area of 207.44 ha. Density of tree plantation 2500 trees/ ha of plants.
(xxvi) There are no court cases/violation pending with the project proponent.
(xxvii) To verify the status of compliance of EC conditions for Lakhanpur opencast expansion project 18.75 MTPA, the Regional Office of MoEF&CC, Bhubaneswar has carried out site inspection on 11th October, 2017. Certified compliance report has been submitted vide letter 101/936/EE.P/510-H dated 6th December, 2017.

4. The Expert Appraisal Committee in its 24th meeting held on 11th January, 2018 has recommended the proposal for grant of environmental clearance for a period of one year. Based on recommendations of the EAC, the Ministry of Environment, Forest and Climate Change hereby accords environmental clearance to the project for expansion of **Lakhanpur Opencast (Phase-II) Coal Mine from 18.75 MTPA to 21 MTPA of M/s Mahanadi Coalfields Ltd in a total area of 2452 ha (ML area 2240 ha) located in Tehsil Lakhanpur, District Jharsuguda (Odisha) for a period of one year**, under the provisions of the Environment Impact Assessment Notification, 2006 and subsequent amendments/circulars thereto subject to the compliance of the terms & conditions and environmental safeguards mentioned below:

(i) Adequate ambient air quality monitoring stations shall be established in consultation with the State Pollution Control Board, and regular monitoring shall be carried out for particulate emissions (both PM_{10} & $PM_{2.5}$), SO_2 & NO_x. The monitoring results for the period during summer season (April-June, 2018) shall be submitted to the State PCB and the Regional Office of this Ministry.
(ii) The EAC shall review compliance of the actions taken on observations of the Regional Office before December, 2018, and make its recommendations for continuance of the project thereafter. Also, based on the monitoring results, the Committee shall examine adequacy and efficacy of the pollution control measures and its impact on ambient air quality.
(iii) To control the dust generation at source, the crusher and inpit belt conveyors shall be provided with mist type sprinklers.
(iv) Mitigative measures to be undertaken to control dust and other fugitive emissions all along the roads by providing sufficient numbers of water sprinklers, preferably mist type mobile sprayers/sprinklers.
(v) Regular monitoring of occupational safety and other health hazards of all employees including outsourced workers and the corrective actions shall be ensured. Report in this regard be submitted to the Regional Office of the Ministry.
(vi) Controlled blasting techniques should be adopted to control ground vibration and fly rocks.
(vii) Persons of nearby villages shall be given training for their livelihood and skill development.
(viii) To ensure health and welfare of nearby villages, regular medical camps shall be organized and report shall be submitted to the Regional Office of the Ministry.
(ix) Wind barrier wall/screen and vertical greenery system, green belt, dust suppression arrangement at railway siding to be installed.
(x) Three tier multi-species green belt of not less than 7.5 m width should be developed all along the project to mitigate/check the dust pollution. Only native species to be used for plantation/greenbelt development.
(xi) In view of the mining potential of the area and the prevailing environmental concerns, carrying capacity of the riverine eco-system shall be studied through some expert agencies to assess impact on the environmental components.

(xii) A mitigation plan based on the study to be submitted to the MOEF&CC Regional Office/SPCB and displayed on company's website.

4.1 The grant of EC is further subject to compliance of the generic conditions as under:

(a) Mining

(i) Mining shall be carried out under strict adherence to provisions of the Mines Act 1952 and subordinate legislations made there-under as applicable.

(ii) No change in mining method i.e OC to UG, calendar programme and scope of work shall be made without obtaining prior approval of the Ministry of Environment, Forest and Climate Change (MoEFCC).

(iii) Mining shall be carried out as per the approved mining plan(including Mine Closure Plan) abiding by mining laws related to coal mining and the relevant circulars issued by Directorate General Mines Safety (DGMS).

(iv) No mining shall be carried out in forest land without obtaining Forestry Clearance as per Forest (Conservation) Act, 1980 and also adhering to The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 read with provisions of Indian Forest Act, 1927.

(b) Land reclamation and water conservation

(i) Digital Survey of entire lease hold area/core zone using Satellite Remote Sensing survey shall be carried out at least once in three years for monitoring land use pattern and report in 1:50,000 scale shall be submitted to Ministry of Environment, Forest and Climate Change/Regional Office (RO).

(ii) The surface drainage plan including surface water conservation plan for the area of influence affected by the said mining operations, considering the presence of river/rivulet/pond/lake etc, shall be prepared and implemented by the project proponent. The surface drainage plan and/or any diversion of natural water courses shall be as per the approved Mining Plan/EIA/EMP report and with due approval of the concerned State/GoI Authority. The construction of embankment to prevent any danger against inrush of surface water into the mine should be as per the approved Mining Plan and as per the permission of DGMS.

(iii) The final mine void depth should preferably be as per the approved Mine Closure Plan, and in case it exceeds 40 m, adequate engineering interventions shall be provided for sustenance of aquatic life therein. The remaining area shall be backfilled and covered with thick and alive top soil. Post-mining land be rendered usable for agricultural/forestry purposes and shall be handed over to the respective state government as specified in the guidelines for Preparation of Mine Closure Plan issued by the Ministry of Coal dated 27th August, 2009 and subsequent amendments.

(iv) The entire excavated area, backfilling, external OB dumping (including top soil) and afforestation plan shall be in conformity with the "during mining"/"post mining" land-use pattern, which is an integral part of the approved Mining Plan and the EIA/EMP submitted to this Ministry. Progressive compliance status vis-a-vis the post mining land use pattern shall be

submitted to the Ministry of Environment, Forest and Climate Change/Regional Office on six monthly basis.

(v) The top soil shall temporarily be stored at earmarked site(s) only and shall not be kept unutilized for long. The top soil shall be used for land reclamation and plantation purposes. Active OB dumps shall be stabilised with native grass species to prevent erosion and surface run off. The other overburden dumps shall be vegetated with native flora species. The excavated area shall be backfilled and afforested in line with the approved Mine Closure Plan. Monitoring and management of rehabilitated areas shall continue until the vegetation becomes self-sustaining. Compliance status shall be submitted to the Ministry of Environment, Forest and Climate Change/ Regional Office on six monthly basis.

(c) Emissions, effluents, and waste disposal

(i) Transportation of coal, to the extent permitted by road, shall be carried out by covered trucks/conveyors. Effective control measures such as regular water/mist sprinkling/rain gun etc shall be carried out in critical areas prone to air pollution (with higher values of $PM_{10}/PM_{2.5}$) such as haul road, loading/unloading and transfer points. Fugitive dust emissions from all sources shall be controlled regularly. It shall be ensured that the Ambient Air Quality parameters conform to the norms prescribed by the Central/State Pollution Control Board.

(ii) Greenbelt consisting of 3-tier plantation of width not less than 7.5 m shall be developed all along the mine lease area in a phased manner. The green belt comprising a mix of native species shall be developed all along the major approach/ coal transportation roads.

(iii) The transportation of coal shall be carried out as per the provisions and route proposed in the approved Mining Plan. Transportation of the coal through the existing road passing through any village shall be avoided. In case, it is proposed to construct a 'bypass' road, it should be so constructed so that the impact of sound, dust and accidents could be appropriately mitigated.

(iv) Vehicular emissions shall be kept under control and regularly monitored. All the vehicles engaged in mining and allied activities shall operate only after obtaining 'PUC' certificate from the authorized pollution testing centres.

(v) Coal stock pile/crusher/feeder and breaker material transfer points shall invariably be provided with dust suppression system. Belt-conveyors shall be fully covered to avoid air borne dust. Side cladding all along the conveyor gantry should be made to avoid air borne dust. Drills shall be wet operated or fitted with dust extractors.

(vi) Coal handling plant shall be operated with effective control measures viz. bag filters/water or mist sprinkling system etc to check fugitive emissions from crushing operations, conveyor system, transfer points, etc.

(vii) Ground water, excluding mine water, shall not be used for mining operations. Rainwater harvesting shall be implemented for conservation and augmentation of ground water resources.

(viii) Catch/garland drains and siltation ponds of appropriate size shall be constructed around the mine working, coal heaps & OB dumps to prevent run off of water and flow of sediments directly into the river and water bodies. Further, dump material shall be properly consolidated/ compacted and accumulation of water over dumps shall be avoided by providing adequate

channels for flow of silt into the drains. The drains/ ponds so constructed shall be regularly de-silted particularly before onset of monsoon and maintained properly. Sump capacity should provide adequate retention period to allow proper settling of silt material. The water so collected in the sump shall be utilised for dust suppression measures and green belt development. Dimension of the retaining wall constructed, if any, at the toe of the OB dumps within the mine to check run-off and siltation should be based on the rainfall data. The plantation of native species to be made between toe of the dump and adjacent field/habitation/water bodies.

(ix) Industrial waste water generated from CHP, workshop and other waste water, shall be properly collected and treated so as to conform to the standards prescribed under the Environment (Protection) Act, 1986 and the Rules made there under, and as amended from time to time. Oil and grease trap shall be installed and maintained fully functional with effluents discharge adhering to the norms. Sewage treatment plant of adequate capacity shall be installed for treatment of domestic waste.

(x) Adequate groundwater recharge measures shall be taken up for augmentation of ground water. The project authorities shall meet water requirement of nearby village(s) in case the village wells go dry due to dewatering of mine.

(d) Illumination, noise & vibration

(i) Adequate illumination shall be ensured in all mine locations (as per DGMS standards) and monitored weekly. The report on the same shall be submitted to this ministry & its RO on six-monthly basis.

(ii) Adequate measures shall be taken for control of noise levels below 85 dB(A) in the work environment. Workers engaged in blasting and drilling operations, operation of HEMM, etc shall be provided with personal protective equipments (PPE) like ear plugs/muffs in conformity with the prescribed norms and guidelines in this regard. Adequate awareness programme for users to be conducted. Progress in usage of such accessories to be monitored.

(iii) Controlled blasting techniques shall be practiced in order to mitigate ground vibrations and fly rocks as per the guidelines prescribed by the DGMS.

(iv) The noise level survey shall be carried out as per the prescribed guidelines to assess noise exposure of the workmen at vulnerable points in the mine premises, and report in this regard shall be submitted to the Ministry/RO on six-monthly basis.

(e) Occupational health & safety

(i) The project proponent shall undertake occupational health survey for initial and periodical medical examination of the workers engaged in the project and maintain records accordingly as per the provisions of the Mines Rules, 1955 and DGMS circulars. Besides regular periodic health check-up, 20% of the workers identified from workforce engaged in active mining operations shall be subjected to health check-up for occupational diseases and hearing impairment, if any.

(ii) Personnel (including outsourcing employees) working in dusty areas shall wear protective respiratory devices and shall also be provided with adequate training and information on safety and health aspects.

(iii) Skill training as per safety norms specified by DGMS shall be provided to all workmen including the outsourcing employees to ensure high safety standards in mines.

(f) Ecosystem and biodiversity conservation

(i) The project proponent shall take all precautionary measures during mining operation for conservation and protection of endangered flora/fauna, if any, spotted/reported in the study area. The Action plan in this regard, if any, shall be prepared and implemented in consultation with the State Forest and Wildlife Department.

(g) Public hearing, R&R and CSR

(i) Implementation of the action plan on the issues raised during the public hearing shall be ensured. The project proponent shall undertake all the tasks/measures as per the action plan submitted with budgetary provisions during the public hearing. Land oustees shall be compensated as per the norms laid down in the R&R policy of the company/State Government/Central Government, as applicable.

(ii) The project proponent shall ensure the expenditure towards socio-economic development in and around the mine, in every financial year in pursuance of the Corporate Social Responsibility Policy as per the provisions under Section 135 of the Companies Act, 2013

(iii) The project proponent shall follow the mitigation measures provided in this Ministry's OM No.Z-11013/5712014-IA.I1 (M) dated 29th October, 2014, titled 'Impact of mining activities on habitations-issues related to the mining projects wherein habitations and villages are the part of mine lease areas or habitations and villages are surrounded by the mine lease area'.

(iv) The project proponent shall make necessary alternative arrangements, if grazing land is involved in core zone, in consultation with the State government to provide alternate areas for livestock grazing, if any. In this context, the project proponent shall implement the directions of Hon'ble Supreme Court with regard to acquiring grazing land.

(h) Corporate environment responsibility

(i) The Company shall have a well laid down environment policy duly approved by Board of Directors. The environment policy should prescribe for standard operating procedures to have proper checks and balances and to bring into focus any infringements/deviation/violation of the environmental or forest norms/conditions. Also, the company shall have a defined system of reporting of non-compliances/violations of environmental norms to the Board of Directors and/or shareholders/stakeholders.

(ii) The hierarchical system or Administrative Order of the company to deal with environmental issues and for ensuring compliance with the environmental clearance conditions should be displayed on website of the Company.

(iii) A separate environmental management cell both at the project and company headquarter level, with suitable qualified personnel shall be set-up under the control of a Senior Executive, who will report directly to the Head of the Organization.

(iv) Action plan for implementing EMP and environmental conditions shall be prepared and shall be duly approved by competent authority. The year wise funds earmarked for environmental protection measures shall be kept in separate account and not to be diverted for any other purpose. Year wise progress of implementation of action plan shall be reported to the Ministry/Regional Office along with the Six Monthly Compliance Report.

(v) Self environmental audit shall be conducted annually. Every three years third party environmental audit shall be carried out.

(i) Statutory Obligations

(i) The environmental clearance shall be subject to orders of Hon'ble Supreme Court of India, Hon'ble High Court, NGT and any other Court of Law from time to time, and as applicable to the project.

(ii) This environmental clearance shall be subject to obtaining wildlife clearance, if applicable, from the Standing Committee of National Board for Wildlife.

(iii) The project proponent shall obtain Consent to Establish/Operate under the Air Act, 1981 and the Water Act, 1974 from the concerned State Pollution Control Board.

(iv) The project proponent shall obtain the necessary permission from the Central Ground Water Authority (CGWA).

(j) Monitoring of project

(i) Adequate ambient air quality monitoring stations shall be established in the core zone as well as in the buffer zone for monitoring of pollutants, namely PM_{10}, $PM_{2.5}$, SO_2 and NO_x. Location of the stations shall be decided based on the meteorological data, topographical features and environmentally and ecologically sensitive targets in consultation with the State Pollution Control Board. Online ambient air quality monitoring stations may also be installed in addition to the regular monitoring stations as per the requirement and/or in consultation with the SPCB. Monitoring of heavy metals such as Hg, As, Ni, Cd, Cr, etc to be carried out at least once in six months.

(ii) The Ambient Air Quality monitoring in the core zone shall be carried out to ensure the Coal Industry Standards notified vide GSR 742 (E) dated 25.9.2000 and as amended from time to time by the Central Pollution Control Board. Data on ambient air quality and heavy metals such as Hg, As, Ni, Cd, Cr and other monitoring data shall be regularly reported to the Ministry/Regional Office and to the CPCB/SPCB.

(iii) The effluent discharge (mine waste water, workshop effluent) shall be monitored in terms of the parameters notified under the Coal Industry Standards vide GSR 742 (E) dated 25.9.2000 and as amended from time to time by the Central Pollution Control Board.

(iv) The monitoring data shall be uploaded on the company's website and displayed at the project site at a suitable location. The circular No. J-20012/1/2006-IA.11 (M) dated 27.05.2009 issued by Ministry of Environment, Forest and Climate Change shall also be referred in this regard for its compliance.

(v) Regular monitoring of ground water level and quality shall be carried out in and around the mine lease area by establishing a network of existing wells and constructing new piezometers during the mining operations. The monitoring of ground water levels shall be carried out four times a year i.e. pre-monsoon, monsoon, post-monsoon and winter. The ground water quality shall be monitored once a year, and the data thus collected shall be sent regularly to Ministry of Environment, Forest and Climate Change/Regional Office.

(vi) Monitoring of water quality upstream and downstream of water bodies shall be carried out once in six months and record of monitoring data shall be maintained and submitted to the Ministry of Environment, Forest and Climate Change/Regional Office.

(vii) The project proponent shall submit six monthly reports on the status of the implementation of the stipulated environmental conditions to the Ministry of Environment, Forest and Climate Change/Regional Office. For half yearly monitoring reports, the data should be monitored for the period of April to September and October to March of the financial years.

(viii) The Regional Office of this Ministry shall monitor compliance of the stipulated conditions. The project authorities should extend full cooperation to the officer (s) of the Regional Office by furnishing the requisite data / information/monitoring reports.

(k) Miscellaneous

(i) Efforts should be made to reduce energy consumption by conservation, efficiency improvements and use of renewable energy.

(ii) The project authorities shall inform to the Regional Office regarding commencement of mining operations.

(iii) A copy of the environmental clearance shall be marked to concerned Panchayat. A copy of the same shall also be sent to the concerned State Pollution Control Board, Regional Office, District Industry Sector and Collector's Office/Tehsildar Office for information in public domain within 30 days.

(iv) The EC shall be uploaded on the company's website. The compliance status of the stipulated EC conditions shall also be uploaded by the project authorities on their website and updated at least once every six months so as to bring the same in public domain.

(v) The project authorities shall advertise at least in two local newspapers widely circulated, one of which shall be in the vernacular language of the locality concerned, within 7 days of the issue of the clearance letter informing that the project has been accorded environmental clearance and a copy of the clearance letter is available with the State Pollution Control Board and also at web site of the Ministry of Environment, Forest and Climate Change at www.environmentclearance.nic.in and a copy of the same shall be forwarded to the Regional Office.

(vi) The environmental statement for each financial year ending 31 March in Form-V is mandated to be submitted by the project proponent for the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently, shall also be uploaded on the Company's website along with the status of compliance of EC conditions and shall be sent to the respective Regional Offices of the MoEF&CC by e-mail. Concerns raised during public hearing

(vii) The above conditions will be enforced inter-alia, under the provisions of the Water (Prevention & Control of Pollution) Act, 1974, the Air (Prevention & Control of Pollution) Act, 1981, the Environment (Protection) Act, 1986 and the Public Liability Insurance Act, 1991 along with their amendments and Rules and any other orders passed by the Hon'ble Supreme Court of India/High Courts and any other Court of Law relating to the subject matter.

5. The proponent shall abide by all the commitments and recommendations made in the EIA/EMP report and also that during presentation to the EAC. All the commitments made on the issues raised during public hearing shall also be implemented in letter and spirit.

6. The proponent shall obtain all necessary clearances/approvals that may be required before the start of the project. The Ministry or any other competent authority may stipulate any further condition for environmental protection. The Ministry or any other competent authority may stipulate any further condition for environmental protection.

7. Any appeal against this environmental clearance shall lie with the National Green Tribunal, if preferred, within a period of 30 days as prescribed under Section 16 of the National Green Tribunal Act, 2010.

8 The coal company/project proponent shall be liable to pay the compensation against the illegal mining, if any, and as raised by the respective State Governments at any point of time, in terms of the orders dated 2nd August, 2017 of Hon'ble Supreme Court in WP (Civil) No.114/2014 in the matter of 'Common Cause Vs Union of India & othrs'.

9. The project proponent, without prejudice to this environmental clearance, shall be bound to comply with any other interpretation of the orders of Hon'ble Supreme Court also, in due course of time.

10. This EC supersedes the earlier EC granted vide letter No.J-11015/391/2012-IA.II(M) dated 21st May, 2014 with a capacity 18.75 MTPA.

28/2/2018

(S. K. Srivastava)
Scientist E

Copy to:

1. The Secretary, Ministry of Coal, Shastri Bhawan, New Delhi
2. The APPCF, Regional office (EZ), Ministry of Environment Forests and Climate Change, A-31, Chandrashekarpur, Bhubaneswar - 751023
3. The Secretary, Department of Environment & Forest, Government of Odisha, Secretariat, Bhubaneswar
4. The Member Secretary, Central Ground Water Authority, Ministry of Water Resources, Curzon Road Barracks, A-2, W-3 Kasturba Gandhi Marg, New Delhi
5. The Member Secretary, CPCB, CBD-cum-Office Complex, East Arjun Nagar, Delhi -110032
6. The Member Secretary, Odisha State Pollution Control Board, Neelakanth Nagar, Unit-VIII, Bhubaneswar
7. The District Collector, Jharsuguda, Government of Odisha
8. Monitoring File 9. Guard File 10. Record File 11. Notice Board

28/2/2018

(S. K. Srivastava)
Scientist E

PLATES

M/s Mahanadi Coalfields Limited

Job Title: EIA-EMP of Lakhanpur OCP Expn. Phase II (21.0 Mty)				Job No. 706137	
Subject: Location Map Showing Orissa Coalfields	Activity	Name	Desig.	Signature	Date
	Processed	N. K. Singh	Asst.Mgr. (Env)		
	Processed	B. G. Ray	Asst.Mgr. (Geo)		
	Checked	T. K. Das	HOD (Geomatics)		
	Approved	S. K. Srivastava	R.D. (RI-VII)		
CMPDI ISO 9001:2000 Company	Scale 0 3.0 6.0 9.0 12.0 18.0 24.0 Km			Sheet 1 of 1	
	Drg.No. R 7 G M T x x x x x x			REV.No. 0	

PLATE NO. IA

SUNDARGARH

JHARSUGUDA

NH 200

HIRAKUD DAM

IB-VALLEY COALFIELD

SAMBALPUR

NH 6

DEOGARH

NH 200

KENDUJHARGARH

Brahmani

RENGALI DAM

NH 6

BARGARH

N

NH 23

BLOCK IDENTIFIED FOR COAL BED METHANE

BLOCK IDENTIFIED FOR COAL BED METHANE

NH 42

TALCHER COALFIELD

ANGUL

BAUDA

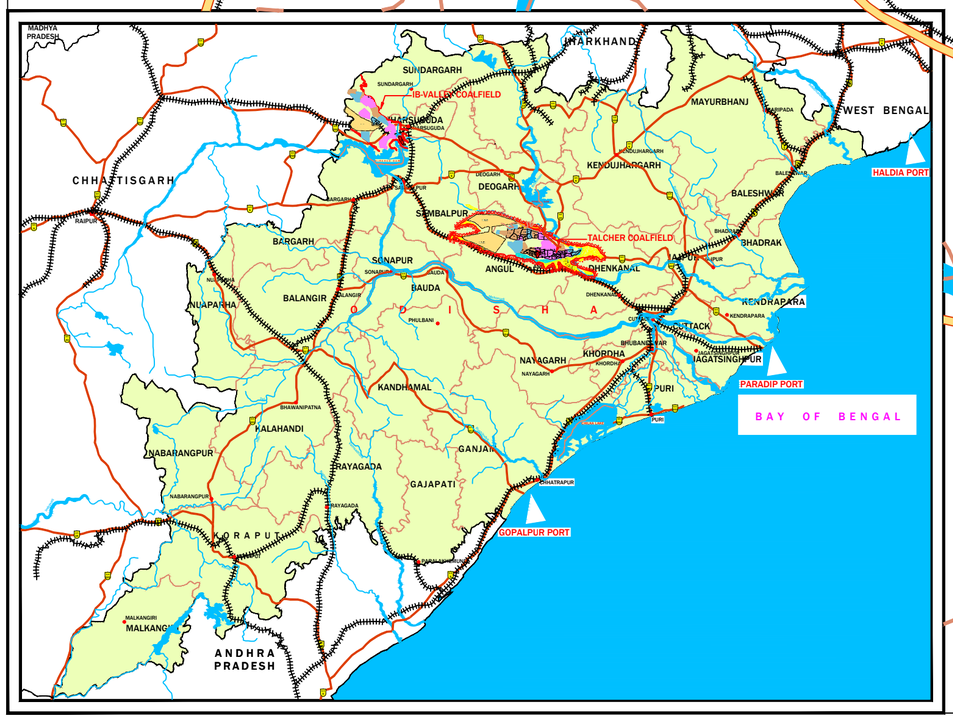
ANGUL

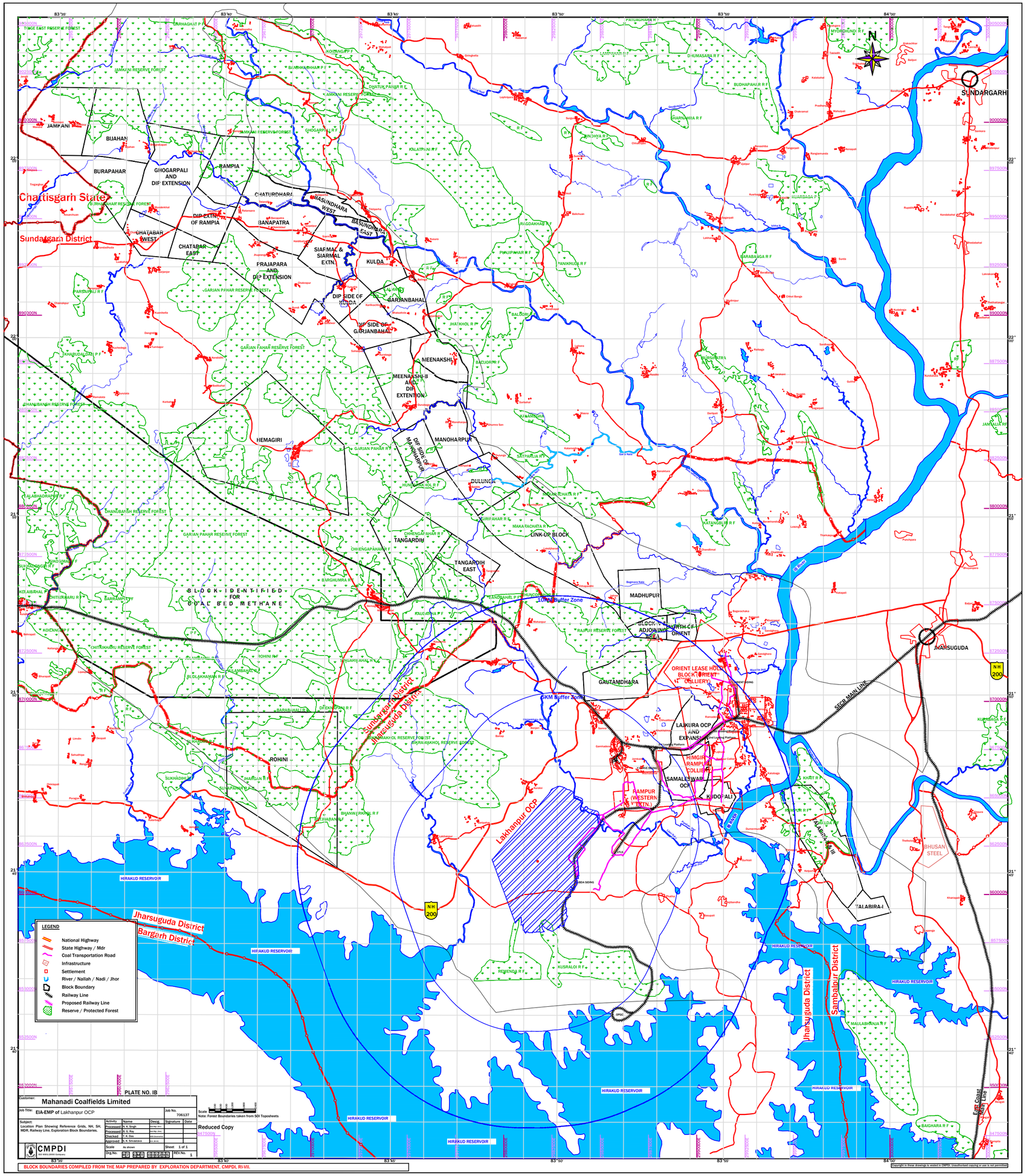
DHENKANAL

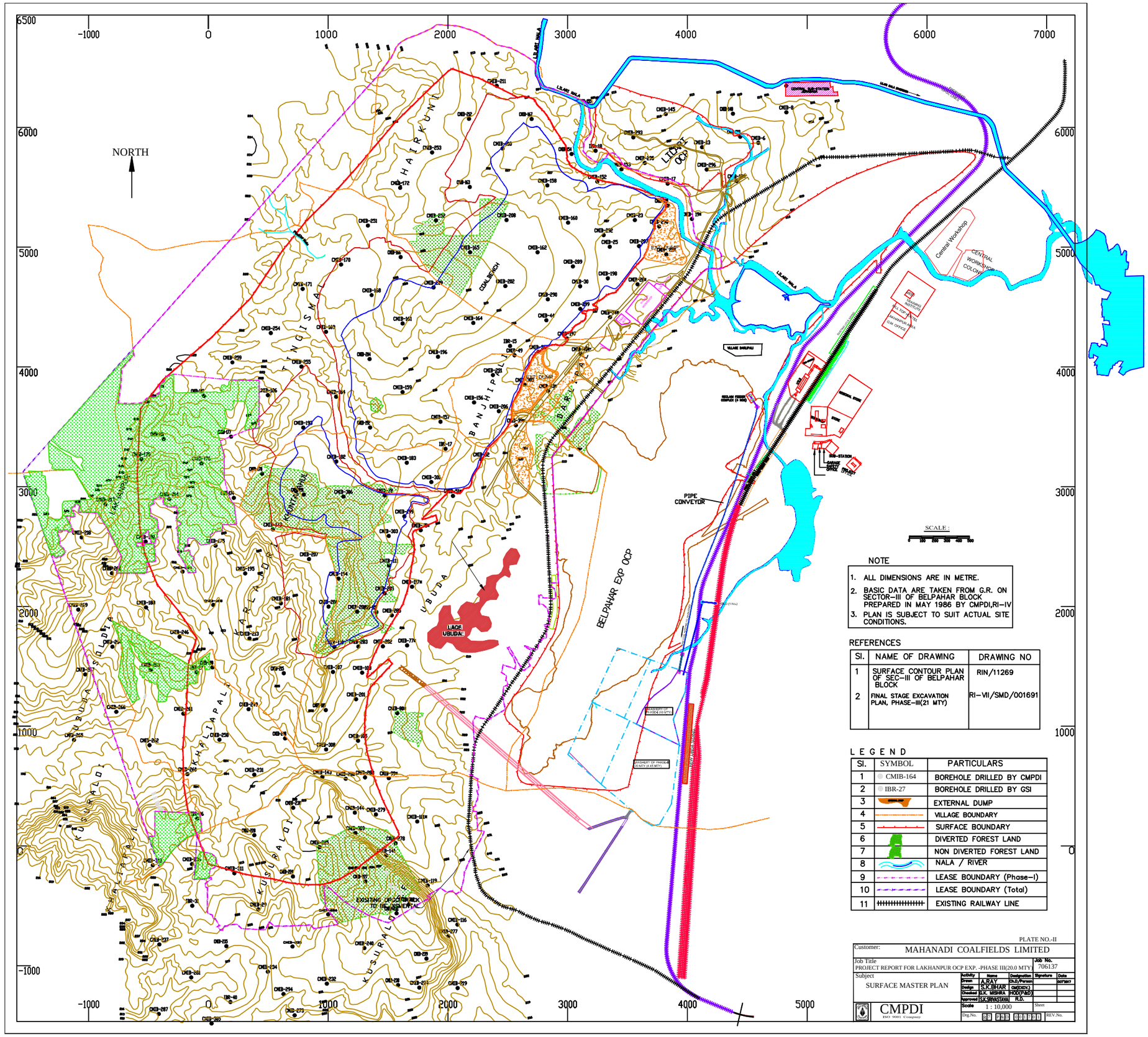
NH 224

Mahanadi

O D I S H A




BLOCK IDENTIFIED FOR COAL BED METHANE
JAMPANI
BIJAHAN
BURAPAHAR
GHOGARPALI AND DIP EXTENSION
RAMPIA
CHATURDHARA
BASUNDHARA WEST
BASUNDHARA EAST
DIP EXTN. OF RAMPIA
BANSPAPRA
CHATABAR WEST
CHATABAR EAST
FRAJAPARA AND DIP EXTENSION
SIARMAL & SIARMAL EXTN
KULDA
DIP SIDE OF KULDA
GARJANBAHAL
DIP SIDE OF GARJANBAHAL
MEENAKSHI
MEENAKSHI-B AND DIP EXTENTION
HEMAGIRI
MANOHARPUR
DIP SIDE OF MANOHARPUR
DULUNGA
TANGARDIH
TANGARDIH EAST
LINK-UP BLOCK
MADHUPUR
BLOCK ADJOINING NORTH OF ORIENT AREA
GAUTAMDHARA
ROHINI
LAIKURA OCP AND EXPANSION
HIMGIR RAMPUR COLLIERY
SAMALESWARI OCP
KUDOPALI
RAMPUR (WESTERN PATH)
Lakhanpur OCP
ORIENT LEASE HOLD BLOCK (ORIENT COLLIERY)
JHARSUGUDA
SUNDARGARH
BHUSAN STEEL
TALABIRA-I
BAGHARA R F
Chattisgarh State
Sundargarh District
Jharsuguda District
Bargerh District
Sambalpur District
10KM Buffer Zone
6KM Buffer Zone
HIRAKUD RESERVOIR
SECR MAIN LINE
EAST COAST RAILWAY
NH 200
LEGEND
National Highway
State Highway / Mdr
Coal Transportation Road
Infrastructure
Settlement
River / Nallah / Nadi / Jhor
Block Boundary
Railway Line
Proposed Railway Line
Reserve / Protected Forest
PLATE NO. IB
Customer: Mahanadi Coalfields Limited
Job Title: EIA-EMP of Lakhanpur OCP
Job No. 706137
Subject: Location Plan Showing Reference Grids, NH, SH, MDR, Railway Line, Exploration Block Boundaries.
Activity | Name | Desig. | Signature | Date
Processed | N. K. Singh | Sr.Mgr. Geol.
Processed | S. S. Roy | Sr.Mgr. Geol.
Checked | T. K. Das | GM (Geology)
Approved | R. K. Srivastava | Dir. (Tech.)
CMPDI ISO 9001:2015 Company
Scale As shown
Sheet 1 of 1
Drg.No.
REV No. 1
Scale 0 2 4 6 8 10 12 14 16 Kms
Note: Forest Boundaries taken from SOI Toposheets
Reduced Copy
BLOCK BOUNDARIES COMPILED FROM THE MAP PREPARED BY EXPLORATION DEPARTMENT, CMPDI, RI-VII.
Copyright in these drawings is vested in CMPDI. Unauthorised copying or use is not permitted.



NOTE

1. ALL DIMENSIONS ARE IN METRE.
2. BASIC DATA ARE TAKEN FROM G.R. ON SECTOR–III OF BELPAHAR BLOCK PREPARED IN MAY 1986 BY CMPDI,RI–IV
3. PLAN IS SUBJECT TO SUIT ACTUAL SITE CONDITIONS.

REFERENCES

Sl.	NAME OF DRAWING	DRAWING NO
1	SURFACE CONTOUR PLAN OF SEC–III OF BELPAHAR BLOCK	RIN/11269
2	FINAL STAGE EXCAVATION PLAN, PHASE–II(21 MTY)	RI–VII/SMD/001691

L E G E N D

Sl.	SYMBOL	PARTICULARS
1	CMIB-164	BOREHOLE DRILLED BY CMPDI
2	IBR-27	BOREHOLE DRILLED BY GSI
3		EXTERNAL DUMP
4		VILLAGE BOUNDARY
5		SURFACE BOUNDARY
6		DIVERTED FOREST LAND
7		NON DIVERTED FOREST LAND
8		NALA / RIVER
9		LEASE BOUNDARY (Phase–I)
10		LEASE BOUNDARY (Total)
11		EXISTING RAILWAY LINE

PLATE NO.–II

Customer: MAHANADI COALFIELDS LIMITED

Job Title: PROJECT REPORT FOR LAKHANPUR OCP EXP. -PHASE III(20.0 MTY)

Job No. 706137

Subject: SURFACE MASTER PLAN

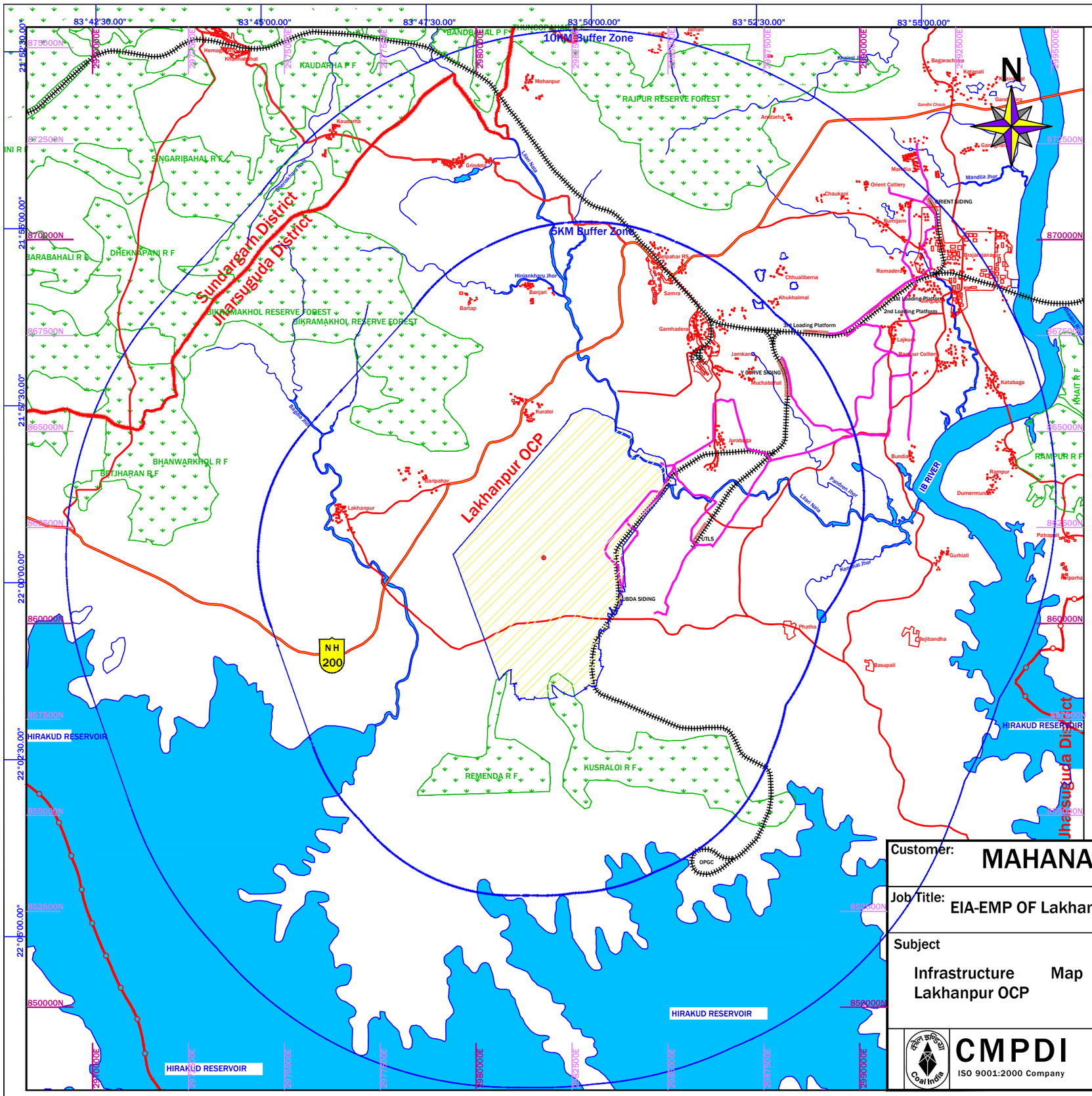
Activity	Name	Designation	Signature	Date
Drawn	A.RAY	Ch.D/Person		06/13/17
Design	S.K. BHAR	GM(SDEV.)		
Checked	D.K. MISHRA	HOD(P&D)		
Approved	S.K.SRIVASTAVA	R.D.		

Scale: 1 : 10,000

Sheet

CMPDI ISO 9001 Company

Drg.No. SP PSD 001701 REV.No.



LEGEND

- NATIONAL HIGHWAY
- STATE HIGHWAY / MDR
- COAL TRANSPORTATION ROAD
- OTHER ROAD
- INFRASTRUCTURE (CHP)
- SETTLEMENT
- RIVER / NALLAH / NADI / JHOR
- 500kV DC POWERLINE
- EXISITING RAILWAY LINE
- FOREST
- VILLAGE

Note: Forest Boundaries taken from SOI Toposheets

Customer: **MAHANADI COALFIELDS LIMITED** — **Plate No. VI**

Job Title: EIA-EMP OF Lakhanpur OCP — Job No. 706137

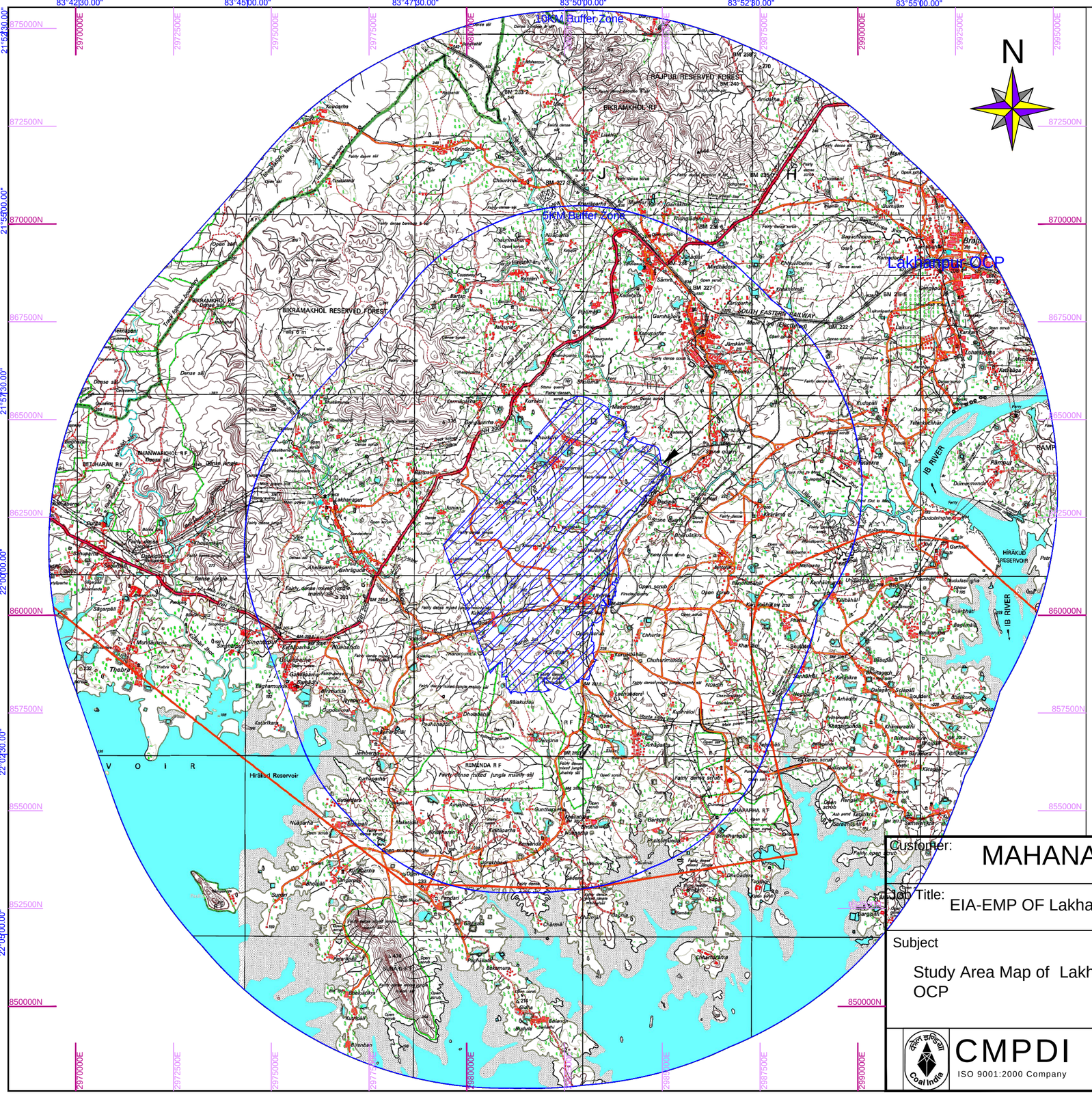
Subject: Infrastructure Map of Lakhanpur OCP

Activity	Name	Desig.	Signature	Date
Processed	N. K. Singh	Asst.Mgr. (Env)		
Processed	B. G. Ray	Asst.Mgr. (Geo)		
Checked	T. K. Das	HOD (Geomatics)		
Approved	S. K. Srivastava	R.D. (RI-VII)		

CMPDI — ISO 9001:2000 Company

Scale 0 0.5 1.0 1.5 2.0 3.0 4.0 Km — Sheet 1 of 1

Drg.No. R 7 GMT x x x x x x — REV.No. 0



CONVENTIONAL SYMBOLS

- Express highway: with toll; with bridge; with distance stone
- Roads metalled: according to importance
- Roads double carriageway: according to importance
- Unmetalled road. Cart-track. Pack-track and pass. Foot-path
- Streams: with track in bed; undefined. Canal
- Dams: masonry or rock-filled; earthwork. Weir
- River: dry with water channel; with island & rocks. Tidal river
- Submerged rocks. Shoal. Swamp. Reeds
- Wells: lined; unlined. Tube-well. Spring. Tanks: perennial; dry
- Embankments: road or rail; tank. Broken ground
- Railways, broad gauge: double; single with station; under constrn
- Railways, other gauges: double; single with distance stone; do
- Mineral line or tramway. Kiln. Cutting with tunnel
- Contours with sub-features. Rocky slopes. Cliffs
- Sand features: (1)flat.(2)sand-hills (permanent). (3)dunes(shifting).
- Towns or Villages: inhabited; deserted. Fort
- Huts: permanent; temporary. Tower. Antiquities
- Temple. Chhetri. Church. Mosque. Idgāh. Tomb. Graves
- Lighthouse. Lightship. Buoys: lighted; unlighted. Anchorage
- Mine. Vine on trellis. Grass. Scrub
- Palms: palmyra; other. Plantain. Conifer. Bamboo. Other trees
- Areas: cultivated; wooded. Surveyed tree
- Boundary, international
- „ state: demarcated; undemarcated
- „ district; subdivision, tahsil or tāluk; forest
- Boundary pillars: surveyed; unlocated.
- Heights, triangulated: station; point; approximate. Δ 200 .200 .200
- Bench-mark: geodetic; tertiary; canal .BM 63·3 .BM 63·3 .63
- Post office. Telegraph office. Overhead tank.
- Rest house or Inspection bungalow. Circuit house. Police station
- Camping ground. Forest: reserved; protected CG RF PF
- Spaced names: administrative; locality or tribal KIKRI NĀGA
- Hospital. Dispensary. Veterinary: Hospital / Dispensary
- Aerodrome. Helipad. Tourist site
- Power line: with pylons surveyed; with poles unsurveyed

Customer: MAHANADI COALFIELDS LIMITED

Plate No. V

Job Title: EIA-EMP OF Lakhanpur OCP

Job No. 706137

Subject: Study Area Map of Lakhanpur OCP

Activity	Name	Desig.	Signature	Date
Processed	N. K. Singh	Asst.Mgr. (Env)		
Processed	B. G. Ray	Asst.Mgr. (Geo)		
Checked	T. K. Das	HOD (Geomatics)		
Approved	S. K. Srivastava	R.D. (RI-VII)		

CMPDI
ISO 9001:2000 Company

Scale 0 0.5 1.0 1.5 2.0 3.0 4.0 Km

Sheet 1 of 1

Drg.No. R 7 G M T x x x x x x

REV.No. 0

REGISTERED OFFICE
Gondwana Place, Kanke Road
Ranchi -834 031
(Jharkhand)

REGIONAL INSTITUTES

क्षेत्रीय संस्थान-I
वेस्ट एंड, जी.टी.रोड
आसनसोल-713 301
(पश्चिम बंगाल)

क्षेत्रीय संस्थान-II
कोयला भवन, कोयला नगर
धनबाद- 826 005
(झारखंड)

क्षेत्रीय संस्थान-III
गोंदवाना प्लेस,कांके रोड
राँची- 834 031
(झारखंड)

क्षेत्रीय संस्थान-IV
जरीपटका, कस्तूरबा नगर
नागपुर-440 014
(महाराष्ट्र)

क्षेत्रीय संस्थान-V
सीपत रोड
बिलासपुर-495 001
(छत्तीसगढ़)

क्षेत्रीय संस्थान-VI
पोस्ट :जयंत कॉलरी,
जिला : सिंगरौली
पिन नं0- 486 890
(मध्य प्रदेश)

क्षेत्रीय संस्थान-VII
गृह निर्माण भवन
सचिवालय मार्ग
भुवनेश्वर-751001
(उड़ीसा)

Regional Institute - I
West End, G.T Road
Asansol - 713 301
(West Bengal)

Regional Institute - II
Koyla Bhawan, Koyla Nagar
Dhanbad - 826 005
(Jharkhand)

Regional Institute - III
Gondwana Place, Kanke Road
Ranchi- 834 031
(Jharkhand)

Regional Institute - IV
Jaripathka, Kasturba Nagar
Nagpur - 440 014
(Maharashtra)

Regional Institute - V
Seepat Road
Bilaspur - 495 001
(Chattisgarh)

Regional Institute - VI
P.O Jayant Colliery
Dist. - Singrauli
PIN - 486 890
Madhya Pradesh

Regional Institute - VII
Grih Nirman Bhawan
Sachivalaya Marg
Bhubneswar - 751 001
(Orissa)

सेन्ट्रल माईन प्लानिंग एंड डिजाइन इन्स्टीच्यूट लिमिटेड

(कोल इंडिया की अनुषंगी कम्पनी)
एक मिनी रत्न कम्पनी

Central Mine Planning & Design Institute Limited

(A Subsidiary of Coal India Limited)
A Mini Ratna Company

गोंदवाना प्लेस, काँके रोड, राँची - 834 031, भारत
दूरभाष : (91-0651) 2230002, 2230483
फैक्स : (91-0651) 2231447

Gondwana Place, Kanke Road, Ranchi - 834 031, INDIA
Phone : (91 - 0651) 2230002, 2230483
Fax : (91 - 0651) 2231447

ମହାନଦୀ କୋଲଫିଲ୍ଡସ ଲିମିଟେଡ
महानदी कोलफील्ड्स लिमिटेड
Mahanadi Coalfields Limited
(A Subsidiary of Coal India Limited)

OFFICE OF THE PROJECT OFFICER
LAKHANPUR OPENCAST PROJECT
LAKHANPUR AREA
PO- UBUDA, VIA- BELPAHAR (768 217)
DIST-JHARSUGUDA, (ODISHA)
PH-06645-605900, 06645-605914
Fax- 06645-233353
Email Address- polkpocp_mcl@rediffmail.com

Ref.No. MCL/LA/PO/LKPOCP/Envt.19-20/35 Date: -24-08-2019

To,

The Additional Principal Chief Conservator of Forests (C),
Ministry of Environment, Forest and Climate Change
Regional Office (EZ), A/3, Chandersekharpur,
Bhubaneswar – 751023.

Kind Attention:

Director(S)
MoEF&CC, Eastern Zone
Chandrashekharpur,
Bhubaneshwar-751023

Sub: Mitigation plan for Study on Carrying capacity of Riverine Ecosystem of Lakhanpur Opencast Project, Mahanadi Coalfields Limited

Dear Sir,

Lakhanpur Opencast Project was granted Environment Clearance vide No: Dated: 28.02.2018. The Environment Clearance condition (xi) and (xii) states that,

Quote

(xi) In view of the mining potential of the area and the prevailing environmental concerns, carrying capacity of the riverine eco-system shall be studied through some expert agencies to assess impact on the environmental components.

(xii) A mitigation plan based on the study to be submitted to the MoEF&CC Regional Office/SPCB and displayed on company's website.

Unquote

In view of the above the mentioned conditions a study was conducted by Central Mine Planning and Design Institute Limited (CMPDIL), Ranchi and the mitigation plan based on the studyis mentioned below

Recommendation	Mitigation plan
To strengthen the catch drains and garland drains; this will help to prevent the run-off of suspended solids getting carried over into the surrounding water regime	There are two nallahs in and around the mining activity of Lakhanpur OCP, a seasonal Pulijhore nallah between Quarry 4 and Quarry 5 and Lilari nallah flowing near the boundary of the mine. Catch

	drains have been constructed around the OB dumps and internal transportation road, the surface run off collected are diverted to mine sumps and used for industrial activities. Garland drains have been made around the periphery of the mine working boundary to prevent inrush of storm water. Thus suspended solids are prevented getting carried over into nearby water regime
Undertake proper management and reclamation of the mined out areas through plantation; this will help to arrest the erosion due to the mining activity. Plantation activities would also be carried out in additional areas in a phase wise manner, once the mining is completed in the respective stretches.	Progressive biological reclamation of the area is being carried out. An area of 164.62 Ha have been reclaimed which comprises of 17.5 Ha of External OB dump, 34.985 Ha of Block plantation, 6.93Rkm of avenue plantation and 105.2 Ha of internal backfilled area. The areas near the nallah i.e. External OB dump and parts of internally backfilled are densely planted and drains have been constructed to arrest the erosion. For the year 2019-20, 22.5 Ha (9000 Plants) of bamboo plantation is being carried out in the mine.
As stipulated in the Forest Clearance granted for the project, additional studies pertaining to erosion and its impacts on land and soil will also be conducted and suitable mitigation plan will be implemented.	Plantation activities and gully plugging are being carried out in backfilled area to arrest soil erosion. However, study will be conducted pertaining to erosion and its impacts on land and soil and the mitigation plan of the same will be implemented.
Siltation wetland should be constructed at sewage entering sites at every village located on the river bank.	Sewage generated in the Integrated colony of the mines is treated in a Sewage Treatment Plant. The villages along the bank of Lilari nallah within the leasehold area of the mine have been rehabilitated and resettled.
Desilting and cleaning work should be conducted at the shallow sites of the Nallah	Desilting, deepening and cleaning work including removal of vegetation and other wastes of the Lilari and Pulijhore nallah are being carried before the onset of the monsoon.

Public awareness program can be organized to create awareness for cleaning, conservation and management of riverine ecosystem	Programs like Celebration of World Environment day and Swachhta Pakhwada are being conducted, general public and stakeholders of the organization are being encouraged to participate in the events for awareness regarding cleaning and conservation of the environment.
Plantation can be done at riparian zone of the river to reduce the soil erosion of the river bank, which may enhance the natural habitat of local faunal species.	Plantation has been done on the banks of the Lilari and Pulijhore nallah flowing within the mine lease area.
Scientific monitoring survey should be conducted to determine the pollution levels at the source itself so that the exact effect of pollutants from catchment area can be identified beforehand for planning of additional pollution control measures, as required	The storm water and strata water are collected and stored in mine sumps; the effluent from vehicle washing is treated in ETP with zero discharge circuit and the qualities at these points are being monitored quarterly. Surface water quality (23 Parameters) of upstream and downstream of Pulijhore and Lilari nallah and also at IB river is being monitored once in six months. Further continuous online water quality monitoring has been installed at IB river.

Thanking you

Yours Faithfully

24.08.19

Project Officer
Lakhanpur OCP

Copy to:

1. The Member Secretary, Odisha State Pollution Control Board, Paribesh Bhawan, A/118, Nilakantha nagar, Unit-VIII, Bhubaneswar, ODISHA
2. General Manager, Lakhanpur Area
3. General Manager (Envt. & Forest), MCL HQ
4. General Manager (Operations), Lakhanpur Area
5. Area Environment Officer, Lakhanpur Area
6. Nodal Officer (Environment), LKPOCP
7. Office copy