Final Assessment Report

Environmental Carrying Capacity study for expansion of 2 X 600 MW Udupi Power Plant

Prepared by

Environmental Management and Policy Research Institute

Department of Forest, Ecology and Environment

Government of Karnataka

December 2021

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Submitted to

**Department of Forest, Ecology and Environment
Government of Karnataka**

Prepared by

Environmental Management & Policy Research Institute

Department of Forest, Ecology and Environment, Government of Karnataka
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December 2021

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Short forms	Abbreviations
APL	Adani Power Limited
BCM	Billion Cubic Meter
BOD	Biochemical Oxygen Demand
CGWB	Central Groundwater Board
CPCB	Central Pollution Control Board
DO	Dissolved Oxygen
E	Endangered
EC	Electrical Conductivity
EC	Environmental Clearance
EIA	Environmental Impact Assessment
EMPRI	Environmental Management and Policy Research Institute
EPA	Environment (Protection) Act
GIS	Geographic Information System
GLC	Ground Level Concentration
HAM	Hydro-geochemical Assessment Model
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature and Natural Resources
KSPCB	Karnataka State Pollution Control Board
KSRSAC	Karnataka State Remote Sensing Application Centre
LC	Least Concern
LISS	Linear Image Self Scanning Sensor
LPD	Litres Per Day
LULC	Land Use, Land Cover
MBGL	Meter Below Ground Level
ML	Migratory Local
MLD	Migratory-Long-Distance
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoU	Memorandum of Understanding
MW	Mega Watt
NAAQS	National Ambient Air Quality Standards
NGT	National Green Tribunal
NT	Near Threatened
PAN	Panchromatic
PM	Particulate Matter
PSSM	Pressure-support force-state index framework
PGCIL	Power Grid Corporation of India Limited
R&R	Rehabilitated & Resettlement
RF	Reserve Forest
SCH	Schedule

SH	State Highway
SPM	Suspended Particulate Matter
SWED	Salt Water Exclusion Dam
TCLP	Toxicity Characteristic Leaching Procedure
TPP	Thermal Power Plant
ULB	Urban Local Body
UCC	Urban land Carrying Capacity
UPCL	Udupi Power Corporation LTD.
Vu	Vulnerable
WLPA	Wildlife Protection Act

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ACKNOWLEDGEMENT

EXECUTIVE SUMMARY

The present study on **"Environmental Carrying Capacity study for expansion of 2X600 MW Udupi Power Plant"** was entrusted to the Environmental Management and Policy Research Institute (EMPRI) by the Department of Forest, Ecology and Environment, Government of Karnataka, vide their order no. FEE 08 EAA 2019 dated 12/05/2020 in compliance of the directions of honorable National Green Tribunal dated 14 March 2019 and 14 October 2019 in O.A. No. 578/2018 in Janajagrithi Samithi versus Union of India & Others clubbed with other O.As.

Accordingly, EMPRI undertook the study with the following specific objectives.

1. To collect the existing baseline data of environmental parameters and to assess the current environmental status considering the industrial and other land use activities.

2. To identify the critical ecosystems and biodiversity hotspots in the region.

3. To assess the carrying capacity of the project area for future industrial growth and development.

At the concept level, in the present context, environmental carrying capacity is assessed to understand the quantum of industrial and other developmental activities an area can sustain without harming the natural, built, and social environment in the landscape. The present study follows this conceptual approach, and adopts the methodological approaches prescribed by the Central Pollution Control Board (CPCB).

To meet the study objectives, EMPRI sourced external expertise and collaborated with environmental experts and testing labs for air pollution dispersion modelling using the latest Software version AERMOD and other aspects. Socio-economic impact of the operations of Udupi Power Corporation limited (UPCL) plant was assessed conducting a questionnaire survey in 36 villages located around the plant. Monitoring of the ambient air, sampling and analysis of groundwater, soil, surface water, flora, fauna, and emissions from the source (Stack Monitoring) has been carried out using standard sampling techniques and instruments. The details the methodological steps followed are mentioned in the report.

Accordingly, a summary of assessment results from testing, monitoring, and survey are presented hereunder.

Air: The major air pollutants studied are $PM_{2.5}$, PM_{10}, SO_2 and NO_2 at eight locations in and around the UPCL plant. The National Ambient Air Quality Monitoring (NAAQM) standards for these pollutants are presented in section 6.12 in the report. The Ambient Air Quality (AAQ) values of $PM_{2.5}$ and PM_{10} are ranging from 16.4 µg/m^3 (R & R Colony, Adamar Village) to 26.6µg/m^3 (Mudarangadi Village) and 45.5 µg/m^3 (R & R Colony, Adamar Village) to 58.8 µg/m^3 (Top of the Fire Station - UPCL) respectively. AAQ values of SO_2 and NO_2 are ranging from 6.7 µg/m^3 (Mudarangadi Village) to 13.2 µg/m^3 (Top of the Fire Station - UPCL) and 9.5 µg/m^3 (R & R Colony, Adamar Village) to 155 µg/m^3 (Top of the Fire Station - UPCL)

respectively. These results are within the National Ambient Air quality standards. for the monitored period**.**

However, as per the source emission dispersion modeling (Boiler – 1 & Boiler – 2 of UPCL) the maximum Ground Level Concentration at 0.8 km is observed more than National Ambient Air Quality Standards (NAAQS) and the impact is high due to both, SO_2 and NO_2. The concentration of SO_2 and NO_2 obtained from the dispersion model are 359 µg/m^3 and 149.9 µg/m^3 respectively, which exceed the National Ambient Air Quality standards (80 µg/m3 for SO_2 as well as NO_2). Stack monitoring results shows that the mass emission load of SO_2 and NO_2 emissions are 70.18 tons/day and 27.60 tons/day respectively (boiler 1 & 2), which are very high. Further, the AAQM stations established by the UPCL are observed to be defective during the study. Further details about these results are presented in chapter 6 (sections 6.12 to 6.15).

Water: The total availability of water (surface and ground water) and the water demand in the Udupi district for various purposes is evaluated. For this purpose, information on demand and availability is sourced from the report on Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), Udupi District Irrigation Plan. According to the above report, the total water available in the district was 16.7 BCM (Billion Cubic Meter) in 2016. The demand in the year 2016 was 0.32 BCM. The projected demand for 2020 was 0.74 BCM. The water resource carrying capacity for the Udupi district is 52 for 2016 and 22 for projected water demand for 2020. Since the water resource carrying capacity is greater than 3, it is considered safe for the time being. However, the groundwater samples had excessive metals such as the Aluminum (Al) in Pump House Groundwater location, and Lead (Pb) levels exceeded in the ash pond of UPCL. Iron (Fe), Sulphates and Ammonical Nitrogen (NH3) exceed the standard limits in the surface water samples in Ullooru village.

Soil: Heavy metals such as Fe and Mn were found to be in higher range followed by Zn, Cr and Cu in soil sample collected from the vicinity of the UPCL plant. In the soil samples, Fe, Mn, Zn, Cu, Ni, Cr, As, Mo, Pb etc. were present in various ranges and not conducive to be called as contaminant-free soil. This status needs to be carefully considered for any expansion or permission for new industries. Details are given in sections 6.10 and 6.13.

Coal ash: UPCL doesn't have a proper fly ash management system. The study team found that the dyke ponds are not maintained and the depth of dyke ponds are low and there is no overflow water collection facility. There is a possibility of overflow of water from dyke pond into the nearby villages and agricultural farms. The present ash generation per day is about 673 Tons per year. Study team found no evidence for productive reuse of fly ash by the UPCL. With further addition of thermal units, the ash generation would be almost double.

Environmental norms: During the study, it was noticed that UPCL has not followed environmental norms at several points including CRZ Rules and Stack Emissions Rules for SO_2. TCLP (Toxicity Characteristic Leaching Procedure) samples of coal from coal yard, bottom ash, pond ash and fly ash were analyzed. Analyzed heavy metal parameters were within the limits of TCLP standards, except Arsenic (As) in pond ash and fly ash. This indicates the

requirement of appropriate handling practices and material balance. There is a likelihood of soil and groundwater contamination in the vicinity.

Discharge pipeline: A serious lapse is observed during the study in not replacing the broken outfall pipeline, which has resulted in the release of the effluent near the shore itself instead of 670 mts. into the sea, and, it was not buried to a safe depth. Local fishermen also complained about its interference in the fishing operations in the intertidal and sub-tidal areas.

Biodiversity: The study area falls under the coastal region and a large chunk under Costal Regulation Zone (CRZ), Western Ghats and wetland regions, which support unique taxa. Flora and fauna including aves, reptiles, amphibians, butterflies, odonates and marine fauna were also documented in the study area. Western Ghats with its rich biodiversity is indicative of the caution to be exercised in the region with reference to ecological sensitivity. Currently, Western Ghats is one of the eight hotspots of biological diversity in the world. With regard to floristic biodiversity, a total of 474 floristic individuals were identified, out of which 40 species of angiosperms have been documented belonging to 36 genera and 32 families along with two species of Pteridophytes. Out of 42 species recorded, 13 species were endemic. Among these, six species are endemic to the Western Ghats, five species to peninsular India and two species to India. *Syzygium caryophyllatum* and *Wendlandia notoniana* are threatened species (Endangered category) as per the International Union for Conservation of Nature and Natural Resources (IUCN). With regard to faunal diversity, 21 species of mammals, 27 species of reptiles, 18 species of amphibians, 181 species of birds, 112 species of butterflies, and 27 species of Mollusks were recorded indicating the rich biodiversity of study region. In the present study, only documentation of the floral and faunal diversity has been undertaken. The impact on the ecology of the area, biodiversity of both land and aquatic life (both freshwater and marine) requires detailed investigative studies and is thereby one of the limitations of the current study. EMPRI team and even fishermen community have observed the dead cuttlefish bones (internal part of cuttlefish, *Sepiella inermis*), Dolphins (Calves) and turtles on the seashore. It needs to be investigated for understanding the impact of UPCL operations on the lives of these threatened animals.

Local people perception: Survey of 387 families across 36 villages within a radius of 10 Kms from the UPCL was carried out with the help of subject experts using a structured questionnaire in local Kannada language. Questionnaire mainly focused on collecting the opinion about people's livelihood and environmental conditions. Several villagers in the core and buffer zone (identified for the purpose of the study) of the UPCL have expressed their concern on the air, water and soil pollution by UPCL operations. They also opined that their health has been adversely affected and most of them expressed their opinion against UPCL or any other major industry in the region. The villagers perceived and were concerned about their health, reduction in the agricultural, horticultural, fishing and dairy farming activities, which have reduced drastically after the setting up of the thermal power plant due to coal dust and fly ash. Details are given in section 6.21.

Rehabilitated and Resettled people (R&R): R&R complained that the National Rehabilitation and Resettlement policy 2007 has not been followed by UPCL. Many alleged

that they were forcibly evicted and not yet got the jobs as promised by the company. R & R People are very agitated as their grievances have not been addressed. They alleged that their basic needs have not been addressed and their living conditions/ lifestyle has deteriorated after the commissioning of this Thermal Power Plant.

Man-animal conflict: The animals which stray into the human habitation driven back to the wild. Compensation for crop damage, cattle kills and human injury by wild animals is provided by the government to the affected people. This information shows that the study area is highly sensitive from the point of the ecological balance of the region and any additional disturbance would further escalate the man-animal conflict and this is one of the reasons for exercising caution with reference to the expansion of the existing facility at UPCL. Details are given in section 6.23.

In conclusion: Several aspects pertaining to the carrying capacity of 10 km radial area around the proposed thermal power plant expansion site have been studied. The capacity to withstand the present as well as the future pollution levels, loss of natural resources, and agriculture from the expansion of the existing or establishment of new industry would require serious mitigation of adverse impacts. Expansion of the capacity of the power plant is likely to have adverse implications from air pollution including dust, marine ecology, and groundwater and soil contamination from heavy metals. Inadequate/non-functional environmental management practices/facilities followed/established by UPCL need corrective actions before expansion plan is considered. It is felt that additional studies, for example on the effect of coal dust on agricultural crops; dust fall and its impacts; implications of the violation of CRZ notification rules for marine biodiversity; and, impacts of air pollution and water contamination on the health of villagers; would be useful for better socio-ecological and economic outcomes.

Chapter-1

INTRODUCTION

All living creatures depend on the natural environment for their sustenance. Human beings with superior intellect have modified the natural environment based on their need and greed. The enormous increase in the human population has put more pressure on the natural resources. Due to the rapid industrial and economic development, the natural resources including the environment are under severe stress, such as excessive resource consumption, environmental degradation, pollution. These issues have become rampant and increasingly critical across the globe. (Liu et al 2013 & Jameson, S.C. and Ammar, M.S.A. 2007).

Human activities may not be unsustainable in themselves but the thin line that separates them from being beneficial to mankind and becoming harmful is the basis for the environmental recognition addressing the concept of carrying capacity. If the activities are carried out beyond carrying capacity, the activities may prove disastrous and hence the assessment of carrying capacity becomes more important.

The **Carrying Capacity** of an environment is the maximum population size of a biological species that can be sustained by that specific environment, given the food, habitat, water, land, air and other resources available.

In order to know whether the study area has the capacity to withstand the present pollution load as well as the future pollution load after expansion of the thermal power plant, assessing the environmental carrying capacity for the region was necessary.

At the concept level, the carrying capacity is assessed to know the number of red category industries an area can sustain without harming the environment and the same is followed in this study to assess the carrying capacity of the area in relation to the expansion of UPCL.

The study area is erstwhile Udupi Taluk (presently Kapu Taluk) where M/s. Udupi Power Corporation Limited (UPCL) is located includes the assessment of the impact of industrial development in the erstwhile Udupi Taluk and to come out with the calculation of Environmental Carrying capacity of erstwhile Udupi Taluk (Kapu, portion of Karkala and Mangalore Taluks).

The Government of Karnataka has entrusted the EMPRI to study the "Environmental Carrying Capacity of Udupi Taluk in relation to the expansion of existing 2X600 MW Udupi Power Plant" and to assess the carrying capacity with respect to the environmental indicators. EMPRI has followed the standard procedures as framed by Central Pollution Control Board, New Delhi.

1.1 About UPCL

(Source: Udupi Power Corporation Limited)

- M/s Udupi Power Corporation Limited (UPCL) is operating the Coal based thermal power plant (1200 MW, 2 x600MW - Phase-1) at village Yelluru and Santhru in a notified industrial area and seawater pipeline landfall point at Yermal Tenka, Taluk Udupi (Now Kaup), Udupi District, Karnataka.

- Situated in the western coastal region of India, the plant is situated in the village of Yelluru, Kaup taluk, (erstwhile Udupi Taluk). The Udupi Power Corporation is located in the Udupi District (erstwhile Dakshina Kannada District) of Karnataka, comprising villages of Yelluru, Tenka, Santhoor and Bada and is about 35 km north of Mangalore City in Karnataka State, India. It is flanked by Konkan Railway on the west, local roads to Mudarangadi village on the east and north and Padubidri - Karkala state highway on the south.

- **Fuel:**
  Coal feed rate with full load (per hour & per day) Station operated at maximum daily PLF of 88.82%, for which Coal Feed Rate/Day was: 9778 Tones Station Coal Feed Rate/Hour at Full Station Load - 449-456 TPH (Unit-wise coal feed date: 225-228 TPH/Unit), The requirement of coal quantity for these units is met through imported coal. The annual coal requirement is 6.20 MTPA at Plant Load Factor (PLF) 85%. UPCL has tied up with coal mine companies in Australia and Indonesia and also procures through International Competitive Bidding (ICB) and spot purchases. Furnace oil is procured from the Indian Oil Companies depot in the region.

- **Plant details:**
  No. of Hours plant operated in 2020-21.
    i. Unit#1 Operating Hours- 2480 Hrs. (103.3 Days)
    ii. Unit#2 Operating Hours- 3151 Hrs. (131.3 Days)
    iii. Station Operating Hours- 5631 Hrs. (234.6 Days)

  Each steam turbine is of 3000 rpm, tandem compound, single re-heat, condensing type machine with extractions for regenerative feed water heating. The turbine is designed for mainstream pressure of 170 kg/cm2 (a) and inlet temperature of 537°C.

- **Power generation:**
  Power evacuation for the existing Phase-I (2x600 MW) unit is done through 400 kV outdoor switchyard to Hassan Substation of Power Grid Corporation of India Limited (PGCIL) through the double circuit and also through 400/220 kV interconnecting transformer to 220 kV switchyard to feed Kemmar substation. Each unit of 600 MW capacities has one sub critical coal fired steam generator connected to a reheat type condensing steam turbine and generator with sea water cooled condenser and all other

required auxiliaries. The Udupi Power Project supplies 90% of the power it generates to the State of Karnataka and 10% to the State of Punjab. The plant load factor of the unit has been continuously declining since 2017-18 to date. It was 31.10% of its installed capacity during 2019-20 and has further declined to 21% by the end of 2020.

- **Water:**
  Seawater is used to meet the condenser cooling and other water requirements. A re-circulating type of circulating water (CW) system with natural draft cooling towers is installed. Desalination of seawater is carried out to meet the freshwater requirement for the plant, and the cooling water is discharged back to the sea.

- **Ash Management: (**Bottom Ash to Fly Ash ratio in 2020-21 is 11 : 89)
  Bottom ash is collected in silos in moist form and fly ash is collected in dry form in storage silos. The generated fly ash is utilised by cement manufacturers as per their agreement. Unutilised ash is disposed of at identified ash disposal areas.

- **Expansion of The Power Plant**: Expansion of The Power Plant involves the construction of new seawater intake and outfall pipelines. Thermal power generation is achieved by coal as principal fuel using supercritical boilers. This involves dredging in the sub-tidal and inter-tidal zones. The plant will adopt a closed seawater system for condenser cooling and coal as the fuel for steam generation. Approximately 213.6 MCM (87.6 for existing 2x600 MW TPP and 126 for proposed 2x800 MW TPP) of seawater per year is required for the plant for condenser cooling system and desalination, out of which ~175 MCM (20,000 M3/hr from existing 2x600 MW TPP and from proposed 2x800 MW TPP) of seawater per year will be discharged back into the sea. Cooling Tower Blowdown and balance, treated effluent will be disposed through the marine disposal facility. The cooling system by design criteria specified will limit the rise in temperature of the released water to 5^0 C. The seawater intake point and its disposal after use, as well as construction and operational activities may likely to affect the marine life and the ecosystem as such depletion. (CSIR-National Institute of Oceanography, India, 2016). Hence EIA study is important as per the proponent.

1.2 Background of the study

As per the directions of the Hon'ble National Green Tribunal, Principal Bench, New Delhi, in Janajagrithi Samithi versus Union of India & others, dated 14/03/2019 and 14/10/2019 in the Original Application (O.A) Nos.578/2018, 579/2018, 580/2018, and appeal No. 176/2018 in relation to the expansion of Udupi Power Plant. The Department of Forest, Ecology and Environment, Government of Karnataka vide order no. FEE08 EAA 2019, dated 12/05/2020, has entrusted Environmental Management and Policy Research Institute (EMPRI) to study the Environmental Carrying Capacity of the project area in relation to the expansion plans of Udupi Power Corporation Limited in the Udupi Taluk.

The Hon'ble National Green Tribunal, in its order dated 14/03/2019 para 124 mentioned that "Before embarking upon it, we deem it appropriate to direct the Ministry of Environment, Forest and Climate Change (MoEF&CC) to ensure that the project proponent carries out an additional EIA study, in terms of additional ToR prepared pursuant to our findings at paras 124 and 125 supra, followed by strict observance of procedure under Stage-III of EIA Notification, 2006 before being finally placed for appraisal by the EAC for consideration for the grant of Environmental Clearance Paras 124 and 125 referred to above are reproduced below for convenience:

As per Para 124, the question that then requires determination is, should the EC be quashed and set aside? After careful consideration, we find that further studies are unavoidable in order to ensure that the EIA is complete. We, therefore, direct as follows:

    (i)   ***Baseline data of the area in relation to the existing project of 2x600 MW shall be scrupulously collected;***

    (ii)   ***In addition to the above, the State of Karnataka shall get a carrying capacity study of the area carried out.***

    (iii)   ***The baseline data and the carrying capacity study shall be considered as components for studying the impact in relation to the proposed expansion;***

    (iv)   ***Fresh public hearing shall be conducted strictly in accordance with the procedure laid down in Appendix IV of EIA Notification, 2006 ensuring wide participation of the people affected by the project."***

The above direction with reference to the baseline and the carrying capacity forms the basis for assigning this study to EMPRI by the Government of Karnataka.

Based on the orders of the Hon'ble National Green Tribunal, dated 14th March 2019 and 14th October 2019 in relation to the expansion of existing 2x600 MW Udupi Power Plant, the Govt. of Karnataka has entrusted the task of studying the Environmental Carrying Capacity of Udupi Taluk to Environmental Management and Policy Research Institute vide its letter no. FEE 08 EAA 2019 dated 12.05.2020.

1.3 Brief description of the Udupi District

Physical features

The study area is located between the foothills of the Western Ghats in the East and the Arabian Sea in the West, Udupi is one of the three coastal districts in the State, which lies between 13^0 34' North latitude and 74^0 75' East longitudes covering a geographical area of 3582 sq. km. This constitutes about 1.86 percent of the total geographical area of the state.

Udupi district lies in the coastal region and is situated at the foot of the Western Ghats running along the West Coast of Karnataka. Udupi is located at the southwest corner of the Karnataka State. It has the greatest extent of 98 km. from north to south and 66 km. from east to west covering a total geographical area of 3,582 sq. km. The most conspicuous areas of the very high and very low areas of the district are located at 100 and 500 metres of contour lines above the mean sea level respectively.

Udupi District is one of the thirty districts in Karnataka State. It came into existence as a separate district (District Code 569) on August, 24th 1997. The district comprises administrative subdivisions Brahmavara, Byndoor, Hebri, Kapu, Kundapura, Karkala, Udupi Taluks. Administratively, the district has 233 villages 3653 sub-villages, 158 Grama Panchayat (GPs), one city municipal Council (Udupi City), three Town Municipal councils (Kundapura, Kapu and Karkala) and one Town Panchayat (Brahmavara).

The district comprises three distinct physiographic regions: coastal belt, Midland plain terrain and malnad. The midland part between the Western Ghats and the coast which constitutes more than 50% of geographical area, is upland plain terrain intercepted with forested low hilly topography with valleys. Udupi district has varied climatic zones. As the Western Ghats are located on the eastern part of the district, the rivers and streams of this district necessarily flow from east to west.

The Different land use types reflect different ecological sensitivity. Based on the landscape ecology, human activities tend to make the outline of a landscape patch. Due to industrial development and other developmental activities, the region is experiencing unprecedented changes in land use and land cover. Geographically, the district contains rock formations belonging to the earliest period of the earth's history, namely the Archean epoch; except on the coastal strip. The coastal region contains recent and sub-recent deposits and the lateritic formations.

The population is one of the strongest tools for assessing the environmental carrying capacity. As per the 2011 census, the total population of Udupi district is 11.77 lakh, of which 5.62 lakh were males and 6.15 lakh, females. The population of the Udupi district has increased by 65118 persons during the decade 2001-11. Most of people are dependent on agriculture. Agriculture and allied activities are the backbones of the district's rural economy and in the coastal area fishing is the main occupation. There are no major irrigation projects in the district. Apart from agriculture and fishing, the people are very much interested in animal

husbandry. The Livestock rearing plays an important role in the rural economy in the district. It supplements family income from agriculture and also provides employment. Udupi district has rich resources for fisheries development. Its coastal line is about 100 Km. Fishing is a major economic activity in the district. Udupi is known for marine fishing and its exports. (District at A Glance: Udupi District- Statistical Report - FY2018-19).

The district is endowed with rich natural resources and this is a pointer to show that, if these resources are not handled properly it would be disastrous for the ecology of the region in the name of development and industrial development etc. Only by adhering to strict environmental regulations, it can be managed sustainably. The detailed information including maps and tables on these aspects are attached in **Annexure-3 (EMPRI's Interim Report).**

The standard steps followed in this study to assess the carrying capacity is as per CPCB's guidelines "Methodology for assessment of environmental carrying capacity", are as follows

Step 1: Goal and Scope

Step 2: Field Inspection, Information review

Step 3: Inventory

Step 4: Environmental indicators

Step 5: Carrying capacity

Step 6: Comparison of environmental Indicators

Step 7: Interpretation

During this study, all these steps have been followed in the assessment of carrying capacity against each of the environmental indicators.

Chapter-2

GOAL AND SCOPE

2.1 Goal

The study aims to conduct an assessment of the Environmental Carrying Capacity as a function of environmental inputs, natural resources, infrastructure, urban services, public perception, industrial setting, and societal support.

2.2 Scope

The following is the scope of conducting the carrying capacity of the study area for the expansion of UPCL power plant by addition of 2 x 800 capacity.

The **Study area** comprises of an area of a 10 kms radius around the UPCL Plant.

- Compilation of all the available secondary data pertaining to the environmental parameters and the operations of the existing UPCL

- Collection of primary data pertaining to air quality, water quality, soil quality, critical ecosystems, biodiversity within the study area.

- Undertaking a socio-economic survey in the study area.

- Undertaking environmental monitoring and carry out a source emission dispersion modeling.

2.3 Objectives

The present study has the following objectives

1. To collect the existing baseline data of environmental parameters and to assess the current environmental status considering the industrial and other land use activities.

2. To identify the critical ecosystems and biodiversity hotspots in the region.

3. To assess the carrying capacity of the project area for future industrial growth and development.

The macro-level assessment of major resources and waste flows within the system boundary. The region will be assessed for direct resource use such as Air, water, land and biodiversity, and waste flow such as effluent, stacks emission and particulate matters. The environmental indicators are identified based on the specific resource and waste flows are listed as Air emissions.

2.4 Carrying Capacity

Carrying capacity is a concept that limits the potential ability of natural resources and species to withstand human intervention. It may be described as a test of the ability of land, water and air to keep itself usable and toxicity free despite pollution and effluent discharges and harmful deposits over it.

Carrying capacity also refers to the number of individuals who can be supported in a given area within the limits of natural resources, and without degrading the social, cultural and economic environment for the present and future generations. The carrying capacity for any given area is not fixed. However, it can be extended to a certain level by sustainable technologies. A degraded environment shrinks the carrying capacity resulting from the environment with no ability to support even the number of people who could formerly have lived in the area on a sustainable basis.

The carrying capacity of an environment is the maximum population size of a biological species that can be sustained in that specific environment, given the food, habitat, water, and other resources available for living. Therefore, the environment carrying capacity has become a great concern of research interest. Environmental carrying capacity includes multiple factors such as atmospheric environment, land environment, social economy and dilution-related self-purification capacity of water environment, and reflects the threshold of supporting capacity in a region with specific natural resources and ecological environment. The studies indicated that environmental degradation, resource exploitation and utilization have caused serious adverse effects on the ecological environment, and resource and environment carrying capacity has been substantially reduced.

The concept of carrying capacity is rooted in demography, biology, and applied ecology (Clarke 2002). In ecology, carrying capacity is defined as "the maximum population of a species that a habitat can support without permanently impairing the habitat's productivity" (Rees 1997). Carrying capacity is an indicator of regional sustainability, and achieving regional sustainability is important because social institutions and ecological functions are closely linked at this scale (Graymore 2009). The concept of a sustainable carrying capacity is defined by a regional ecosystem's characteristics based on two premises. First, it must be possible to sustain the regional ecosystem's normal operations. Therefore, researchers must calculate the quantity of resources and environmental capacity required to sustain these functions. Second, it is necessary to evaluate the regional population and intensity of activities that the natural resources can support after considering the needs of the ecosystem. The theory of environmental carrying capacity has been widely applied in environment planning and management. The carrying capacity depends strongly on environmental resources. However, there have also emerged some theoretical studies of carrying capacity based on regional different resources because this capacity is most often included within the larger theory of sustainable development. For example, Falkenmark and Lundqvist (1998) used estimates of the maximum global use of water resources to study how carrying capacity is determined by regional water resources (Falkenmark, Lundqvist .1998). Another example is a study of the Florida Keys Basin's carrying capacity in the United States (NRC 2002), in which researchers modeled carrying capacity under different land-use scenarios.

2.5 Assessment

Carrying Capacity is a function of the following:

1. Environmental impacts and natural resources

2. Infrastructure and Urban services

3. Public Perception

4. Institution Setting

5. Society Supporting Capacity

Assessment of Environmental Carrying Capacity is always useful and crucial. It provides the basis for formulating sustainable development policies. It helps the policymakers to understand the ground reality of the environment for a specific region and cause.

Chapter-3

FIELD INSPECTION, INFORMATION REVIEW AND LITERATURE SURVEY

The field inspection is for collecting of both secondary and primary data with reference to air, water, soil, land, noise, coastal waters, biodiversity, people's perception survey and operations under UPCL.

The assessment of carrying capacity in this report is based on the "Methodology for environment carrying capacity drafted by Central Pollution Control Board (CPCB) 2019, which gives step by step procedures to assess the carrying capacity. Here proper formulae are given to evaluate each environmental parameter like urban land, water resource carrying capacity, atmospheric assimilation capacity, solid waste and sewage management. The main formula is also given to assessing the environment carrying capacity.

Secondary data collection: the secondary data sources in this study are literature, data from Udupi Power Corporation Limited (UPCL), National Highway Authority of India (NHAI), College of Fisheries (CoF), Environment Impact Assessment Report (EIA-2016) and Environment Compliance (EC) report, Pradhan Matri Krishi Sinchayee Yojana (PMKSY) 2016, Karnataka State Remote Sensing Applications Centre (KSRSAC) and Karnataka Forest Department (KFD).

3.1 Review of literature

There have been several studies carried out on carrying capacity. The sector-specific assessment of carrying capacity has been done by several researchers. The salient findings of some of the research works are discussed below:

Graymore et al., (2009) in their study - "*Sustaining Human Carrying Capacity: A tool for regional sustainability assessment*" have evaluated the effectiveness of current sustainability assessment methods at the regional scale. The prevailing methods were developed for the global, national and state scales were not entirely effective in assessing sustainability at the spatial scale. A new method for assessing sustainability was developed and tested, which it believes is applicable at the regional scale. The framework, Sustaining Human Carrying Capacity (SHCC), evaluates the sustainability of regional human activities by considering the pressures these activities have on regional ecosystems.

The study by **Rees et al., (1997)** describes the role of cities in the expanding human ecological niche and its implications for sustainable urban development. This study used a new technique, ecological footprint analysis, to convert the material and energy flows required to sustain the human population and industrial metabolism of ''the city'' into a land/ecosystem area equivalent.

Kumar et al., (2013) in their study of "Environment Impact Assessment of Thermal Power Plant for Sustainable Development" had given details of serious impacts on land, soil, air and various social impacts by the thermal power plant which are also said to emit a large amount of mercury and generate a large quantity of fly ash which destroys the surrounding environment. These plants also consume a large amount of water. Due to these problems, they require a proper Environmental impact assessment before commencement of the project which is not done judiciously in our country. The study also discusses various mitigation measures for the control of pollution caused by thermal power plants along with some new technologies.

District Irrigation plan-PMKSY (2016). The Irrigation Plan and water Scenario of Udupi District are portrayed in PMKSY (Pradhan Mantri Krishi Sinchayee Yojana report. The data of total water availability, water usage, water recycling and total demand were collected and assessed for carrying capacity study.

Mareddy (2017) in his study of "Impacts on air environment" presents impact prediction is a mandatory procedure to be followed initially. In evaluating the environmentally potential adverse impacts for any proposed industrial project, plan, and legislative action. The impact prediction is always carried out under the worst possible conditions to mitigate or to eliminate environmental hazards. These predictions thus calculated are superimposed over the baseline data to calculate the net impact on the environment after a project comes into production. The study concluded that the possibility of an increase in the background concentration of even a minor constituent of the atmosphere may lead to significant changes in the atmospheric properties.

S.K. Goyal et al., (2007). In their study discussed the assimilation potential (assimilative capacity) of the atmosphere which can be represented in two ways: one as the ventilation coefficient and the other as the dispersion potential of emission loads discharged into the region. In this study, the atmospheric assimilation potential of a typical urban area in Kochi city has been determined with respect to sulphur dioxide (SO_2). The ventilation coefficient is directly proportional to the assimilation potential of the atmosphere and has been computed using meteorological parameters in all four seasons (winter, summer, monsoon and post-monsoon) of the years 1998–1999 represented by January, April, July and October respectively. Among all the seasons, monsoon and post-monsoon have the poorest assimilative capacity throughout the day. The model predictions indicate that monsoon is the most critical season having maximum pollution, followed by summer and post-monsoon. The lowest pollution was observed in winter. The assimilative capacity in terms of the ventilation coefficient is very poor indicating high pollution potential in all the seasons.

The following Environmental Impact Assessment reports and other reports for the study area have been considered for the baseline data and other relevant information.

i. Udupi Power Corporation Limited "Supplementary EIA Report for Augmentation of Unit Capacity from 2*507.5 MW to 2*600 MW" February 2009

ii. Environmental Impact Assessment Study for Expansion of 2x600 MW TPP of Udupi Power Corporation Ltd. to 2800 MW by Addition of 2x800 MW Units at Yelluru, Dist. Udupi, Karnataka. Draft Report year 2017.

iii. Report submitted by the Expert Committee "M/s. Udupi Power Corporation LTD.", Karnataka to The HON'BLE NATIONAL GREEN TRIBUNAL, Principal Bench, New Delhi, as per the Orders dated 01.06.2020

iv. Environment Impact Assessment of "Proposed Nandikoor Industrial Area at Nandikoor Village, Udupi Taluk, Udupi District, Karnataka by M/s ABC Techno Labs India Pvt Ltd on behalf of the Karnataka Industrial Areas Development Board (KIADB) in December 2015.

3.2. Methodology followed for the collection of primary data as follows

- **Field Visits**

The Field visits were made from September 2020 to August 2021, totalling to a number of 234 visits to the study site covering 10 kilometre radius, 36 villages, 3 taluks, two districts, major ecosystems and biodiversity hotspots in the study area. During these visits, the People's Perspective Survey, documentation of flora, fauna and interacting with villagers were carried out. Several visits were also repeated, to pay more attention to the documentation of flora and fauna in the reserve forest and other parts of the study area covering nearby mangrove ecosystems, estuaries, freshwater ecosystems, different lakes and forest patches. At the same time, several visits were also made to UPCL Power Plant for continuous interaction and data collection.

- **Meeting the Udupi Power Corporation Ltd officials and collection of Data**

During the study period, the team visited the Unit and discussed with UPCL officials on the various Environmental Protection measures in the UPCL. They accommodated the team to various locations of the plant. The first visit was made during September 2020, subsequently during December 2020 followed by February 2021 with UPCL and KSPCB Officials. The last visit was on April 2021.

- **Interviewing of the local people in the 36 villages to know their perception of the projects and to record the socio-economic wellbeing.**

A structured questionnaire in the Kannada language was used to collect the information. A random sample of 36 villages within a radius of 10Kms was first selected. In the second stage, a random sample of 387 families was selected from the 36 villages for determining the sample size for the study. The small sample techniques as suggested by Robert V. Krejcie and Daryle W Morgan was adopted. The data collected in the prescribed questionnaire were further processed and tabulated using appropriate statistical software.

- **Collection and analysis of the Surface & Groundwater samples**

Water samples both Surface and Groundwater samples were collected at different locations. Samples were collected at surface, mid-depth and bottom. Van Dorn water sampler was used for collection. Samples for Dissolved Oxygen was collected in DO bottles (300 ml capacity) soon after the sampler was retrieved. One end of the nozzle tube was inserted into the sample bottle bottom and filled till 300 ml and the water was allowed to overflow from the bottle to ensure that no bubble is trapped or carried out in the bottle. To the brim-full DO bottles 2 ml of Winkler A (manganese sulphate) and 2 ml of Winkler B (alkali azide KI) were added. The stopper was then inserted and the bottle is shaken vigorously for about 1 minute to bring each molecule of dissolved oxygen in contact with manganese (II) hydroxide. After the fixation of oxygen, the precipitate was allowed to settle. The DO bottles were kept in dark and transported to the laboratory for analysis.

The water samples analysis for salinity, total suspended solids, turbidity, nutrients and trace metals were collected from the sampling locations using clean polyethylene bottles and were transported to the laboratory in a portable icebox.

Standard methods of analysis that were followed for all the parameters are mentioned in the results section.

- **Collection and analysis of the Sea Water samples as on 04-04-2021**

The seawater samples from point A and point B were collected, these two points are marked; A as seawater intake point, B as the effluent discharged point from the UPCL and C as the seashore. The distance from C to A is 1430 meters; from C to B is 670 meters is depicted in Figure No: 3.1.

Figure 3.1: Marine water Sampling by EMPRI study team

- **Collection and analysis of the Seawater samples as on 29-12-2020**

The study team along with the team of College of Fisheries, Mangaluru collected seawater and sea soil samples from the sea points at A and B, Arabian sea where College of Fisheries Mangalore collects seawater and sea soil samples to conduct coastal water quality monitoring analysis for UPCL seawater intake and effluent discharge point of Padubidri, Udupi district.

Hence, the collected seawater and sea soil is not from the discharge point D (670 meters from Tenka Yermal seashore), the study team has not found much variations in the analysis of the samples. (Figure No: 3.2) From the above, it is clear that the concerned organisation (College of Fisheries) have not collected the seawater samples in the particular discharge points and the samples were collected when there was no discharge of effluents from UPCL. Hence the long term monitoring of analysing of seawater samples is strictly recommended when there is a discharge of effluent from UPCL.

Map showing the distance between the GPS points of the samples collected from Arabian sea off Thenka.

1:45,000

Distance Between the Points			
Sl.no	From	To	Distance in KMS
1	A	B	2.6090
2	B	C	3.4570
3	A	C	5.0140
4	C	D	0.6700

Legend

GPS_Points

Distance

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 3.2: Marine water Sampling Locations by CoF study team

Chapter- 4

INVENTORY

The major data within the study area and outside the study area (in the district) region-wise and activities are provided as follows.

- Population
- Air emission
- Water resources
- Water consumption
- Land resources
- Land-use and Land-cover (LULC)
- Soil
- Critical Ecosystem & Biodiversity Hot spots in the region
- Traffic volume survey
- Industries

4.1 Population

According to the 2011 census, the absolute population of the Udupi district was 11.77 lakh, of which 5.62 lakh were males and 6.15 lakh, females. The number of inhabitants in the Udupi area has expanded by 65118 people during the decade 2001-11 and as far as rated it has enrolled a decadal development of 5.8 percent. The decadal development pace of population of the area has recorded declining pattern from 1981-1991 onwards; it declined from 9.4 percent to 7.1 percent during 1991 - 2001 and to 5.8 percent during 2001-11. The decadal development of the population is below the state normal of 15.7 percent.

4.2 Air emissions

Samplers have been located to meet the goals of the specific monitoring requirement. For this study, sampling was carried out to determine the compliance with the National Ambient Air Quality Standards (NAAQS) and samplers were located as described in CPCB guidelines.

Stack Emission Monitoring: The assessment is exercised as per the technical and quality aspects to meet the requirements of the standard test method.

4.3 Water resources

The water resource accessible in the study area is figured in three sections viz., Groundwater, Surface water and other water resources. All water accessible in the study area is the amount of accessible groundwater, Surface water and other accessible water resources assuming if any.

4.4 Water consumption

Udupi district has climatically four seasons: rainy season from June to September, following the withdrawal of monsoon, two months of warm and damp weather during October to November, winter season between December and February and hot and sultry summer season from March to May. The district is blessed with heavy rainfall from June to September from South-West Monsoon. Normal annual rainfall is about 4182 mm which is the highest in the state. With the heavy rainfall, the district has many rivers and tributaries. The district has river basins of Shambhavi (Mulki), Swarna, Yennehole, Madisala, Sita, Haladi, Chakravani, Souparnika (Kollur), Gangolli and Sankadagudi hole sub-basins. These rivers mainly flow from the Western Ghats and are perennial during normal rainfall years. Their tributaries and smaller streams, however, become dry during summer. The prevailing high gradient in the hilly terrain and heavy rainfall brings a great volume of water in these rivers during the monsoon. These rivers join the Arabian Sea and are prone to tidal effects to considerable lengths in the inland area.

The groundwater level fluctuates from season to season due to the seasonal variations of rainfall. The water levels are deepest before the commencement of the southwest monsoon in May and shallowest in August/November. Water levels rise after rains indicating the building up of groundwater storage in the groundwater reservoir, which gets depleted by evaporation and exploitation during the non-monsoon period. In general Udupi district shows water level fluctuation between 2 and 4m (rise in water level). Fluctuation of more than 4 m occurs in the eastern and southern parts of the district.

4.5 Land resources

The land resources of the district, including both non-developable and developable areas, have been evaluated using GIS software. Floor area requirement per head: Based on examination of the financial status of the current population and thinking about the future conceivable lattice of various classes, a normal intelligent region necessity is to be determined. Here the Floor region necessity per head is determined by taking the normal of the population developed for two unique years.

4.5.1 Land Use Land Cover changes

Land Use/Land Cover information is mainly used for planning and utilization of natural resources. Land Use Mapping has become one of the important applications of remote sensing. Remote Sensing and Geographical Information Systems (GIS) are two powerful means for monitoring the rapidly changing land use and land cover. In the present study, it is proposed to understand the spatial distribution of land use/land cover for a given area using geospatial techniques.

The study aims to analyse the Land Use/Land Cover changes for the years 2002 and 2019. It is essential to understand the magnitude and direction of these changes both spatially and temporally to know about the changes in the regional environment.

Different land-use types reflect different ecological sensitivity. Based on the landscape ecology, human activities tend to make the outline of a landscape patch. Thermal power plants and their surroundings are experiencing unprecedented changes in land use and land cover owing to the concentrated developmental activities in the region. The study on the rate of urbanization growth process along with LULC changes gives an idea in advance about the infrastructure planning and resource management in the study area.

4.5.2 Study Area

The study area extends from longitudes 74°48'0"E - 74°58'30"E and latitude 13°4'30"N - 13°15'0"N in Yelluru in the coastal district of Udupi, Karnataka. The study area is defined by taking a 10 km radius from Udupi Power Corporation limited of Yelluru village which has Western Ghats in the east and Arabian Sea in the West. 10 km radius is the norm for carrying out Environmental Impact Assessment studies. Figure 4.1 and 4.2 shows the study area map and core & buffer zones respectively. The study area covers 36 villages as listed in the Table 4.1.
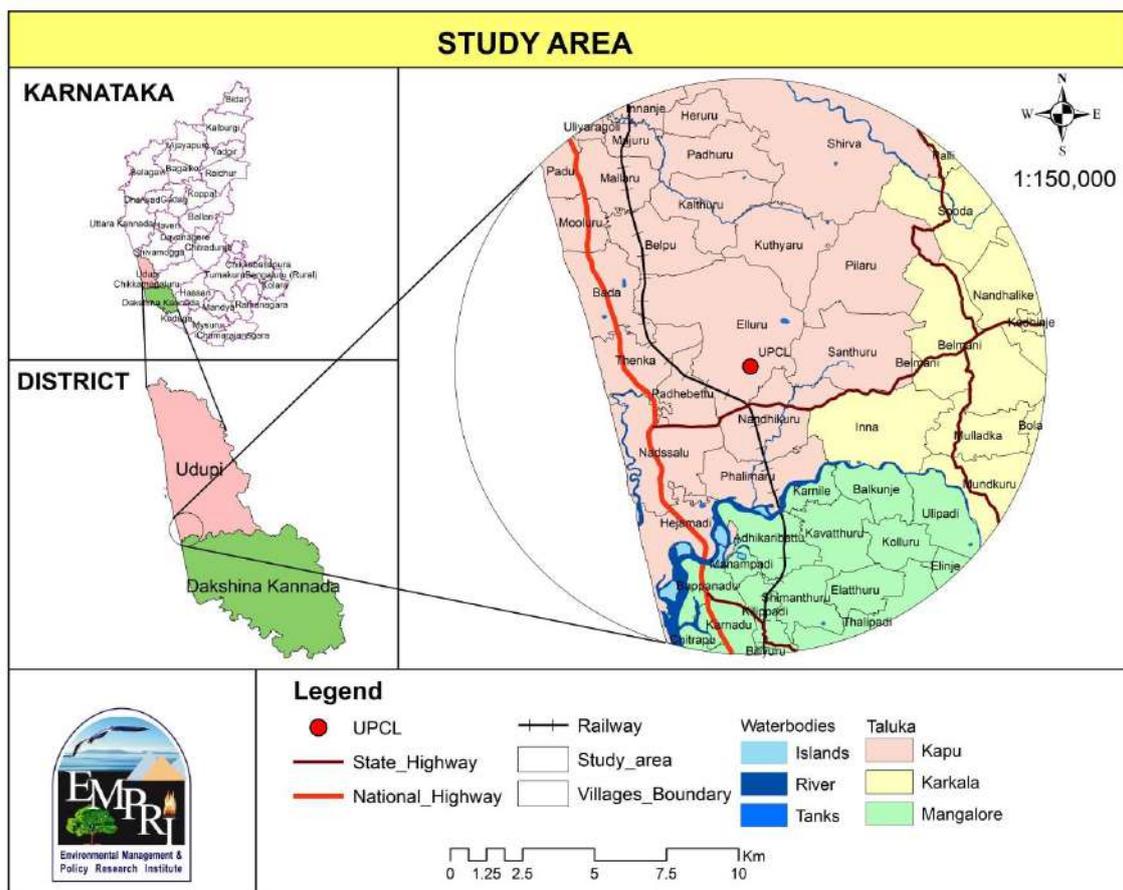
Figure 4.1: Study Area Map showing 10.0 km radius of Buffer area.
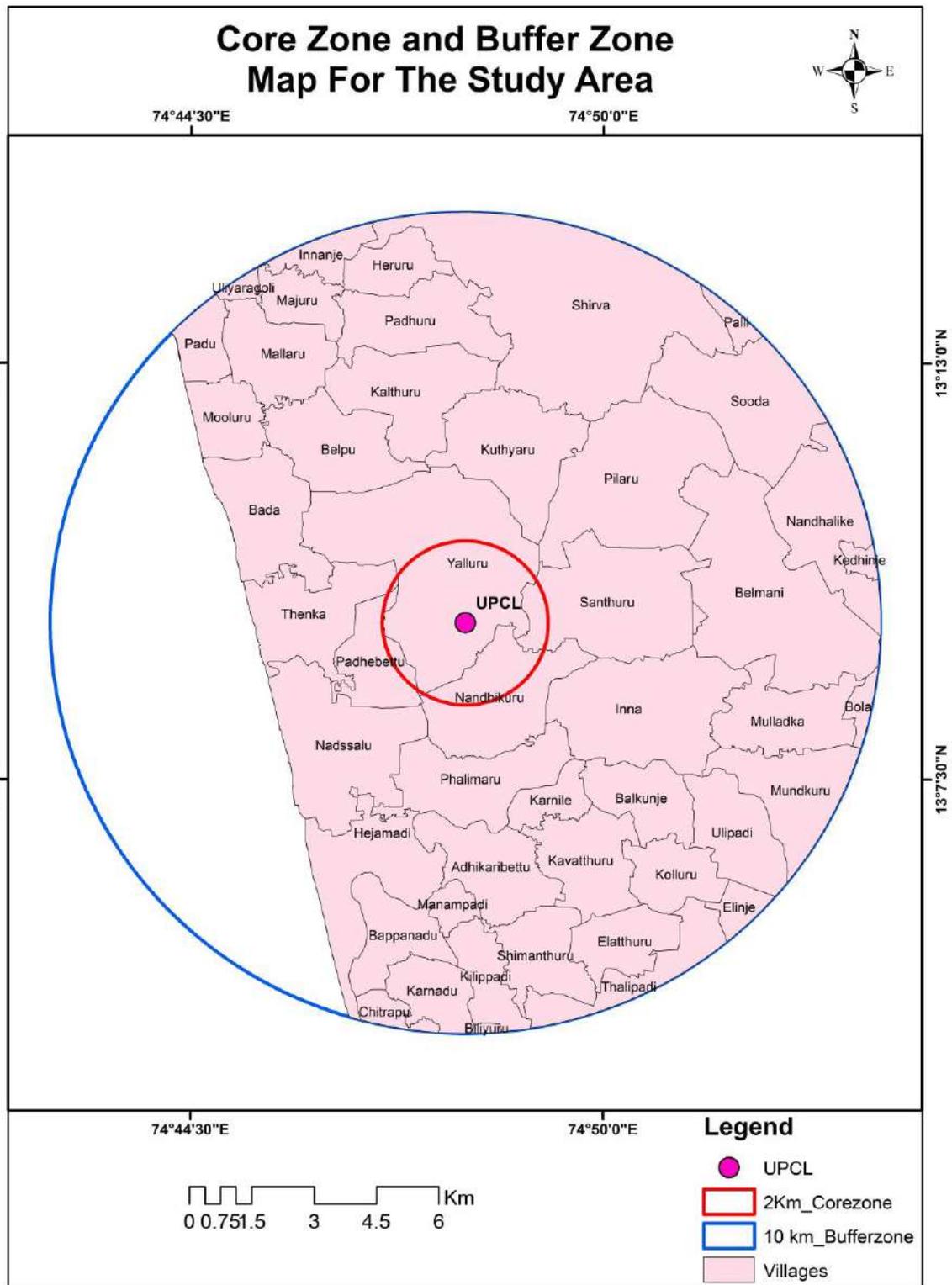
Figure 4.2: Map with 2 km radius as Core Zone and 10 km radius as Buffer Zone.

Sl. No	Village Name	Sl. No	Village Name	Sl. No	Village Name
1	Adhikaribettu	13	Yalatthuru	25	Padhebettu
2	Balkunje	14	Bada	26	Padhuru
3	Bappanadu	15	Belapu	27	Phalimaru
4	Mulladka	16	Hejamadi	28	Pilaru
5	Belman	17	Heruru	29	Santhoor
6	Karnire	18	Kalthuru	30	Shirva
7	Kavatthuru	19	Kuthyaru	31	Tenka
8	Kilippadi	20	Majuru	32	Yelluru
9	Kolluru	21	Mallaru	33	Inna
10	Manampadi	22	Mooluru	34	Mundkuru
11	Shimanthuru	23	Nadssalu	35	Nandhalike
12	Ulipadi	24	Nandikoor	36	Sooda
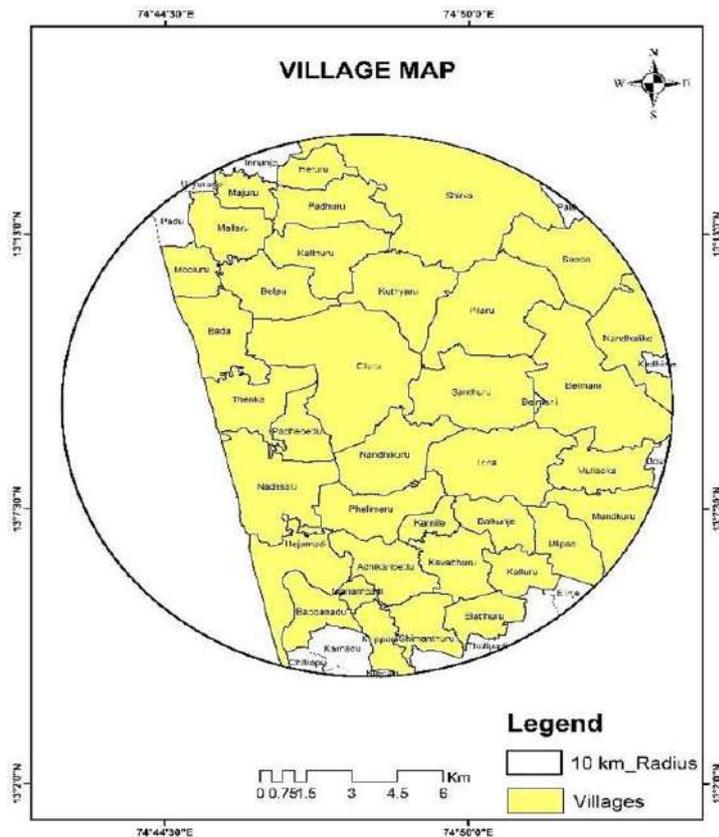
Figure 4.3: List of Villages in the Study Area

4.5.3 Datasets

Land Use / Land Cover (LULC) change detection studies are basically carried out by applying various remote sensing techniques using different spatio-temporal image data. To execute the tasks of image classification and processing there are various Digital Interpretation (DIP) Techniques. In the current study Visual Interpretation technique was practiced to obtain the LULC patterns of the study area. In addition to the basic satellite imagery, other reference base data is necessary to achieve the objectives of image interpretation. This chapter provides the insight into the various data products used in this project.

4.5.4 Data Products

For a comprehensive study of Landuse-Landcover change detection studies the following data products were used,

1. Toposheets
2. Satellite imageries
3. Collateral – non spatial information
4. Google earth reference
5. GPS based data from Ground truth verification

4.5.5 Toposheets

The Survey of India Toposheets have been taken as base maps for referring details of settlements, available administrative boundaries, reservoir FRL limits, etc. There are 2 toposheets of 1:50,000 scale for the study area (Figure. 4.4). The toposheets also aid in geo-referencing the satellite imagery, identification of existing features such as forests, scrub regions, sheet rocky areas and so on. The lists of toposheets used in this study are tabulated in the Table 4.2.

Table 4.2: Details of Path & Row of Satellite Imagery considered for the Study Area

Sl.No.	Survey of India Toposheet Number
1.	48K12
2.	48P16
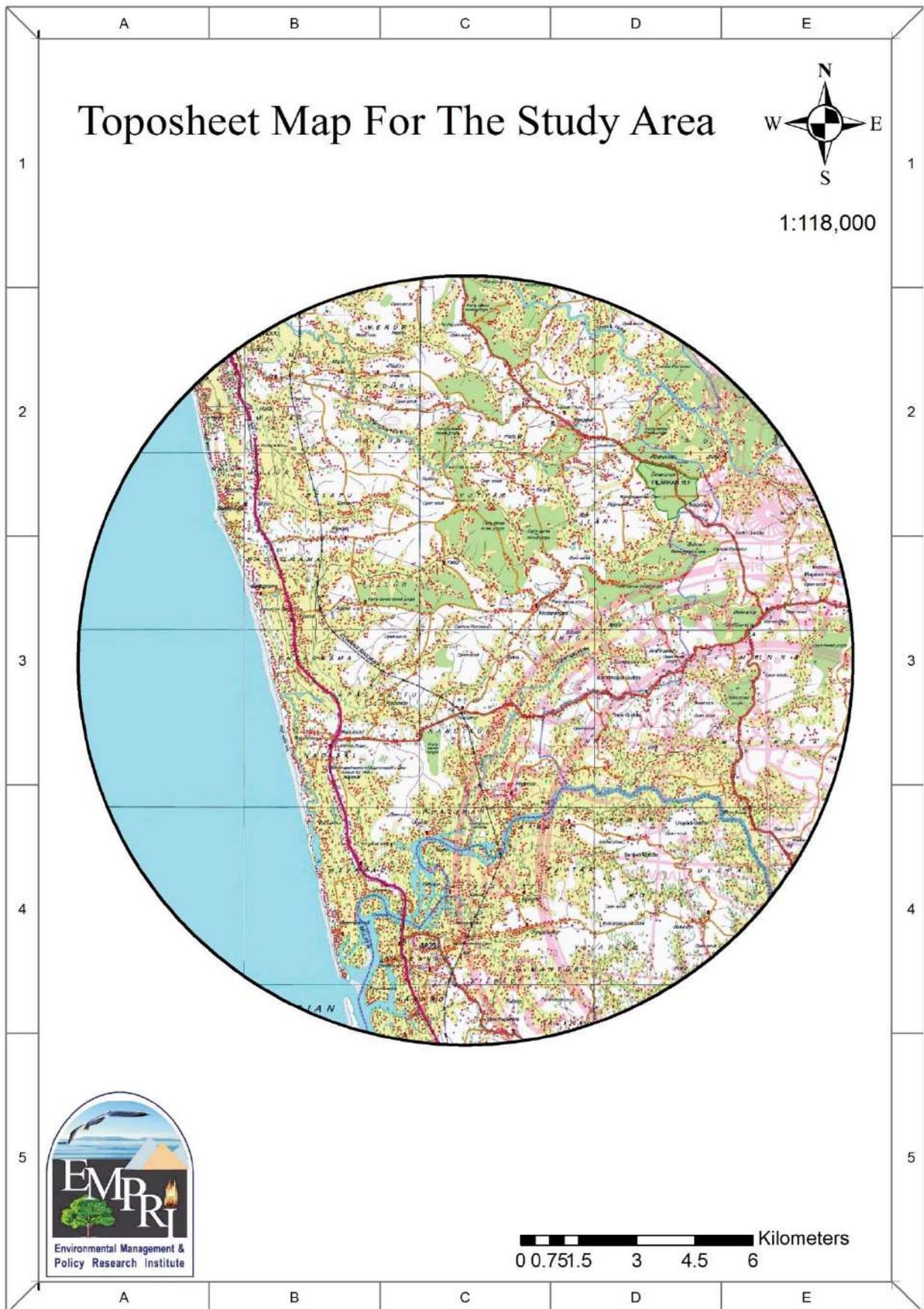
Figure 4.4: Toposheet map for the study area

4.5.6 Satellite imagery

The Satellite imagery is the chief data product which helps to delineate the LULC classification for the desired scale depending upon the resolution of the imagery. For the current study satellite imagery of the year 2002 (Figure.4.5) 2019 (Figure 4.6) has been used to detect the decadal changes in LULC features in the study area. For the image classification it is desired to have cloud free imageries for clear visual interpretations. The cloud free satellite imagery of the year is usually available during winter season (December-March). The satellite imageries during winter season of year 2002 and 2019 are being procured from National Remote Sensing Center (NRSC) data center for this study. There are totally 2 scenes of imagery for this study as shown in the Figure 4.5 and 4.6

LISS III imagery of Resourcesat-1 satellite with PAN imageries of IRS 1D satellite for the study area of winter 2002 is used. LISS IV imagery from Resource sat – 2 satellite of winter 2019 is used. Image pre-processing operations such as Layer stacking, geo- referencing, ortho-rectification, resolution merge has been done on the imageries to achieve high resolution accuracy of 5.0m.

Spatial resolution: Spatial resolution describes the ability of a sensor to identify the smallest size detail of a pattern on an image. Details of spatial resolution of Satellite imagery considered for the study area is given in the Table 4.3.

Table 4.3: Details of Spatial Resolution of Satellite Imagery for the Study Area

Sensor	Spatial Resolution
LISS III	23.4m
PAN	5.8m
LISS IV	5.8m

Swath: A swath is the area of ground the satellite sees with each orbit, the wider the swath the greater the ground coverage. The swath of the LISS III imagery is 127 – 141 Km and PAN imagery is 63 - 70Km and LISS IV imagery is 23 – 70 Km.

Considering the merged data of LISS III + PAN and LISS IV imagery there are totally 2 scenes of imagery used in this project.

Path – Row: The path and row of each scene for the imagery used in this project is as given in Table 4.4.

Resampling: The level of detail (of features/phenomena) represented by a satellite image is often dependent on the cell (pixel) size, or spatial resolution, of the raster. The high resolution PAN (Panchromatic) imageries obtained from NRSC has a formal pixel resolution of 5.8m which when processed by resampling techniques a spatial resolution ranging from 5.0m - 5.8m can be achieved (source). The imagery products of PAN and LISS IV obtained from NRSC for the current project has a pixel resolution of 5.0m.

Table 4.4: Details of Path & Row of Satellite Imagery Considered for the Study Area

Sl.No.	LISS III	PAN	LISS IV
1.	97-64	97_64_B	97_64_B
2.		97_64_D	97_64_D

Scale of LULC dataset: The scale of the data prepared is given by the formula

$$0.25 \ mm \ \times scale \ = resolution \ of \ imagery$$

$$\therefore Scale \ = \ \frac{resolution \ of \ imagery}{0.25 \ mm}$$

$$Scale \ = \ \frac{5.0 \ m}{0.25 \ mm} = 20,000$$

Thus, the scale of the LULC classes obtained would be on a scale of 1:20,000.

Map Showing (Liss III+PAN) Satellite Imagery for the Study Area-2002

1:118,000
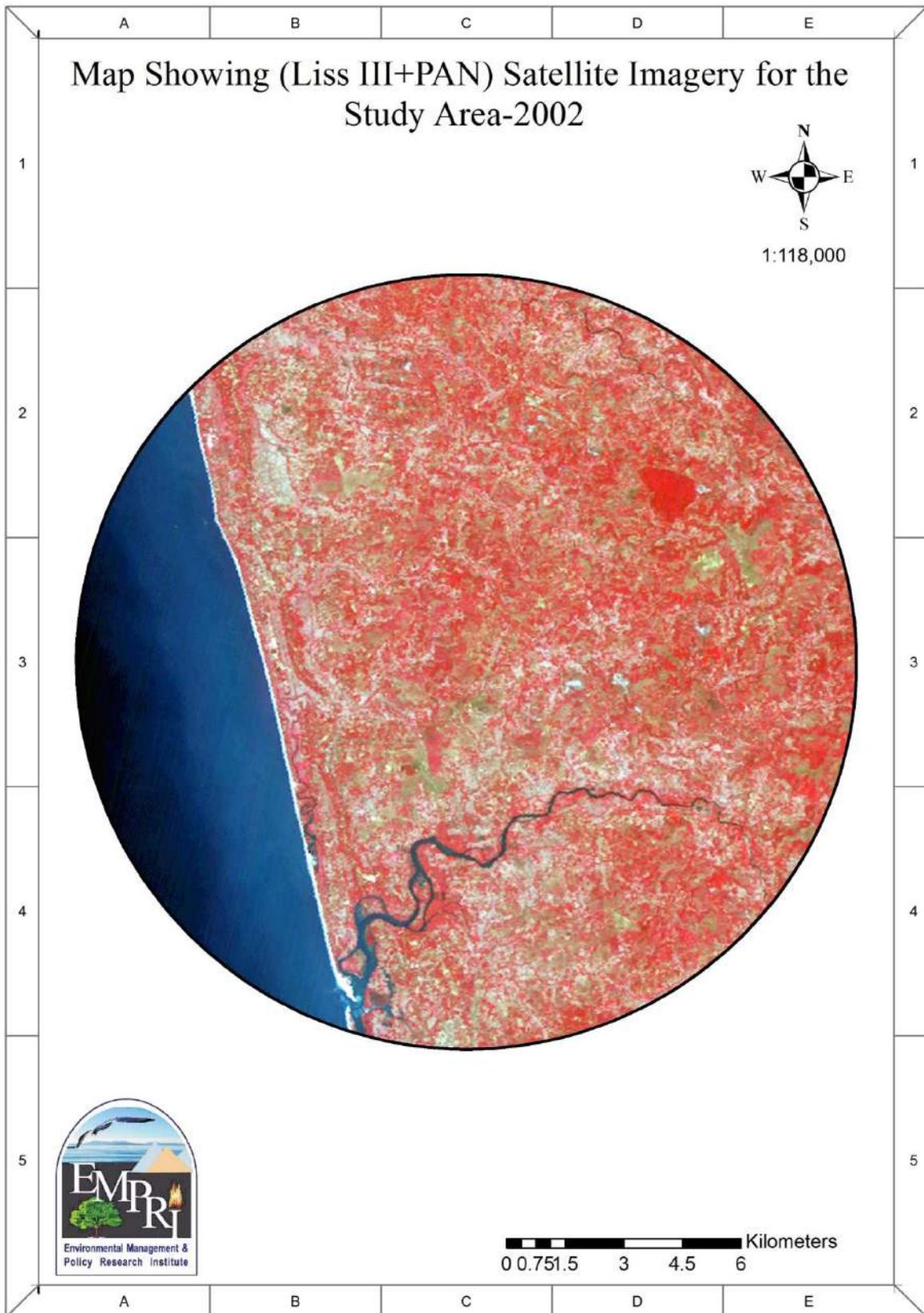
Figure 4.5: Satellite Imagery Map-2002
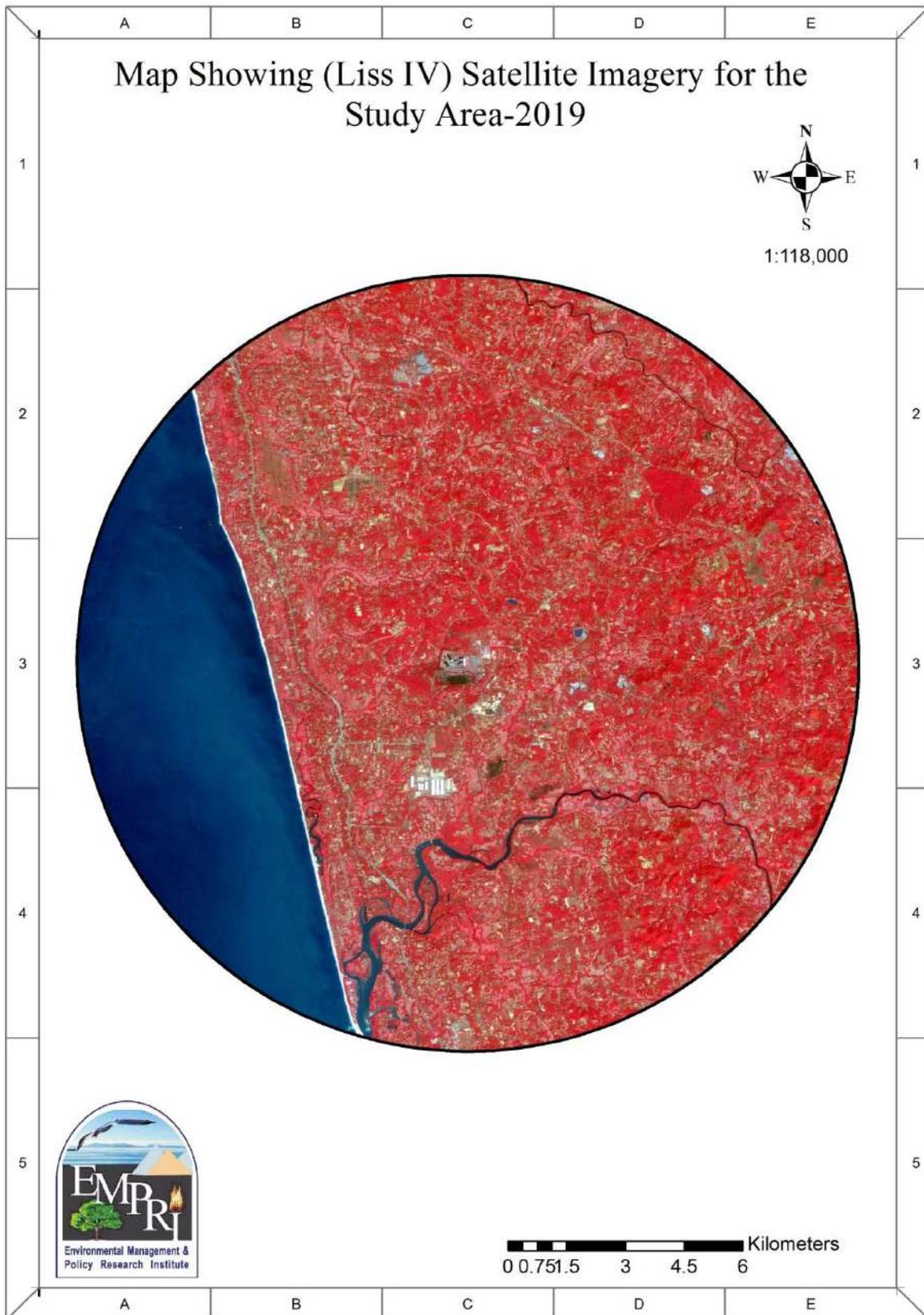
Figure 4.6: Satellite Imagery Map-2019

4.5.7 Google Earth Imagery

Google Earth is Geographical information program which contain virtual globe as well as maps of entire globe. The maps are resultant of superimposition of satellite imagery, aerial photography and Geographical information system on to a 3D platform. The satellite images displayed here are of different resolution and can be zoomed to finer level. The resolution varies from place to place with resolution ranging from 60 cm, 2.5, 15m and so on based on the satellite sensor.

4.5.8 GPS based data from Ground Truth Verification

Ground truth / field verification is an important component in mapping and its validation exercise. Utmost care and planning is taken while collecting ground data and its verification. To facilitate a good ground truthing the following steps were followed;

1. Identification and listing of all the doubtful areas for ground verification and all such areas with respect to toposheet were referred to know their geographical location and accessibility on the ground.

2. Field traverse plan was prepared to cover maximum doubtful areas in the field. It is also ensured that each traverse covers as many Land Use / Land Cover classes as possible, apart from the doubtful areas.

3. The number of points to be covered for each category is pre-determined before field visits. These observations are required both for quality checking as well as accuracy estimation, in addition to use in interpretation.

The field verification for the doubtful areas was carried out using GPS instrument and the observations were reported and incorporated while preparing the LULC classification.

4.5.9 Methodology

LULC is one of the essential data needed for evaluating the situation with any region. This is the primary step for identifying, planning and management of the areas to be protected as eco-sensitive zones, and in this study we have used it to evaluate the available land for any developmental activities.

In order to create LULC layer in GIS compatible manner and to provide an organized structure for future spatial analysis LULC layer data model was prepared. While creating the LULC database from Visual Interpretation Techniques, this data model was followed. Further, Overlay analysis was carried

out which helped in visualizing in-depth decadal changes occurred in Land-Use patterns. The process flow helped for the LULC change detection was plotted in the following flow chart.

Flowchart for outline process steps followed in LULC Change Detection
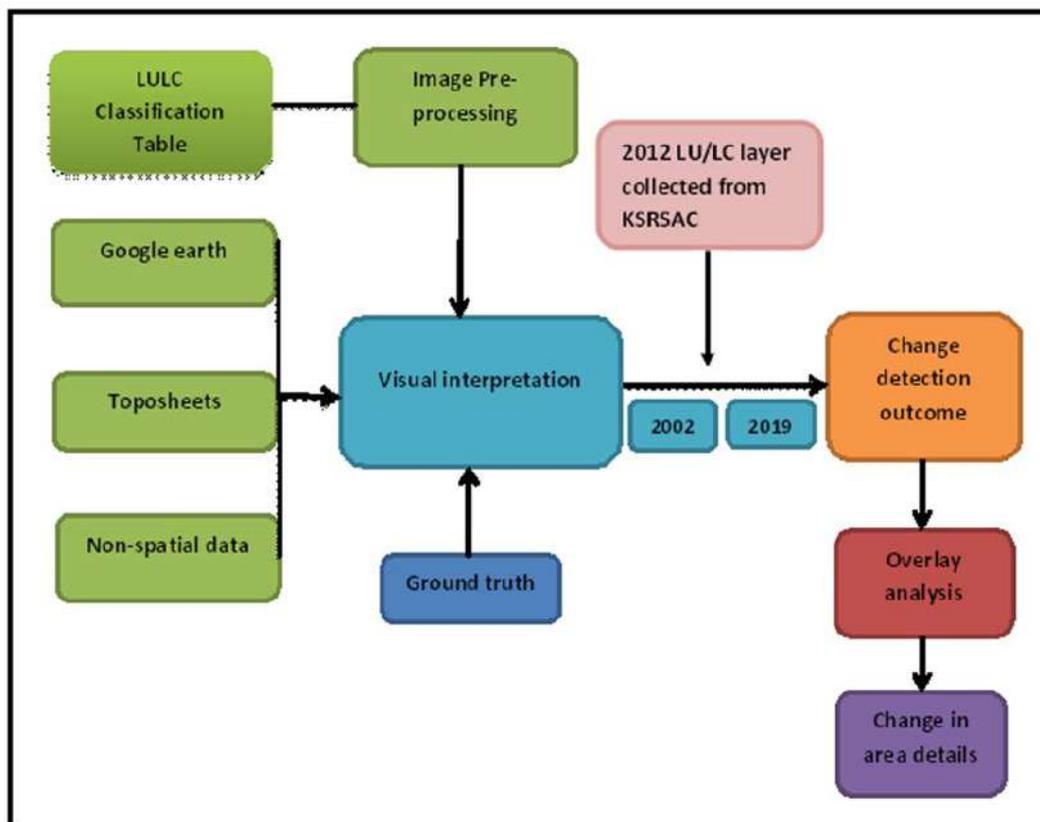
The geometrically corrected Resourcesat-2 LISS IV & IRS P6 LISS III + PAN merged satellite data, within the desired framework is the primary input for LULC classification and mapping. Survey of India topographic map layer on 1:50K scale was used as base layer. A good amount of collateral data on themes like wasteland, forest, vegetation etc. was used as an important source of reference for LULC classification (Table - 4.5). These legacy layers were re-projected as per the current mapping specifications before using them. The projection system followed in this study was Projected Coordinate system: WGS 1984_UTM 43N.

To match the LULC classification and mapping on best possible scale using the LISS IV & LISS III+PAN merged imagery, the following LULC layer data model Table was derived from SIS- DP manual (NRSC, 2009) published by NRSC (ISRO). These LULC classes were followed in preparing the LULC dataset for the present project.

Based on the above described inputs and the reference data visual interpretation was carried out on 2002, and 2019 imageries and 2012 LU/LC layer was collected from Karnataka State Remote Sensing Application Centre (KSRSAC) from 2002 and 2019.

Table 4.5: Land use – Land Cover Classification for the Project Study Area

Sl.No.	Level – I	Level - II	Level - III
1	Built Up	Built Up (Urban)	Built Up (Urban)
		Built Up (Rural)	Built Up (Rural)
		Industrial/Mining	Industrial/Mining
		Transportation	Transportation
2	Agricultural Land	Crop land	Crop land
		Agriculture plantation	Agriculture plantation
3	Forest	Forest	Dense
			Open
4	Grassland & Grazing Land	Grassland & Grazing land	Grassland & Grazing land
5	Wastelands	Scrub land	Scrub land Dense
			Scrub land Open
		Sandy areas	Sandy areas
		Barren rocky	Barren rocky
		Waterlogged	Waterlogged
6	Water bodies	River / Stream / Drain	River / Stream / Drain
		Canal	Canal
		Lakes / Ponds	Lakes / Ponds
		Reservoir / Tanks	Reservoir / Tanks

LULC classification change detection analysis was carried out for quantifying the difference that has occurred over the period of 17 years. Apart from change detection analysis overlay analysis is carried out, which was performed using the tools to overlay multiple feature classes to combine, erase, modify or update spatial feature, resulting in new feature class. Finally the changes were tabulated and maps were generated.

Source: Contemplated Table for (IRS 1D –PAN + LISS-III /LISS IV Mx) from SIS-DP manual, Preparation of Geo Spatial Layers using High Resolution (Cartosat – 1 Pan + LISS- IV Mx) Ortho-rectified Satellite Imagery, NRSC (ISRO), DoS, GoI. Dec 2009.

4.6 Critical Ecosystems and Biodiversity Hotspots in the region

Standard methods were followed in identifying the Critical Ecosystem & Biodiversity Hot Spots. The available Flora & Fauna have been identified and listed as a part of the mandated Objectives the critical ecosystems and the biodiversity hotspots in the region were studied and reported in the following paragraphs.

4.6.1 Description of the study site

Vegetation

The characteristic features of secondary evergreen or semi-evergreen forests are the preservation of a dense cover and structure, which are very similar to the initial climax forest but lacking the characteristic species of the initial climax forest (Pascal 1988). These forests, found in regions where anthropogenic pressure was initially very high, were protected after they were designated as reserve forests. In India, one such secondary forest is the Pilarkan Reserve Forest (74° 51' E and 13°12' N), covering an area of 124.32 hectares situated 3 km south-east of Shirva in Udupi District of Karnataka. Bhat (1993) reported 160 species of angiosperms belonging to 135 genera in 75 families as well as the soil and climatic characteristics of this reserve forest. The soil is lateritic with an underlying rock of peninsular gneiss. The climate is of wet monsoon type with an annual rainfall of about 3500mm. This reserve forest is partly natural and partly the result of massive planting of *H. parviflora* and other species after the First World War (Bhat 1993) (Figure 4.7).
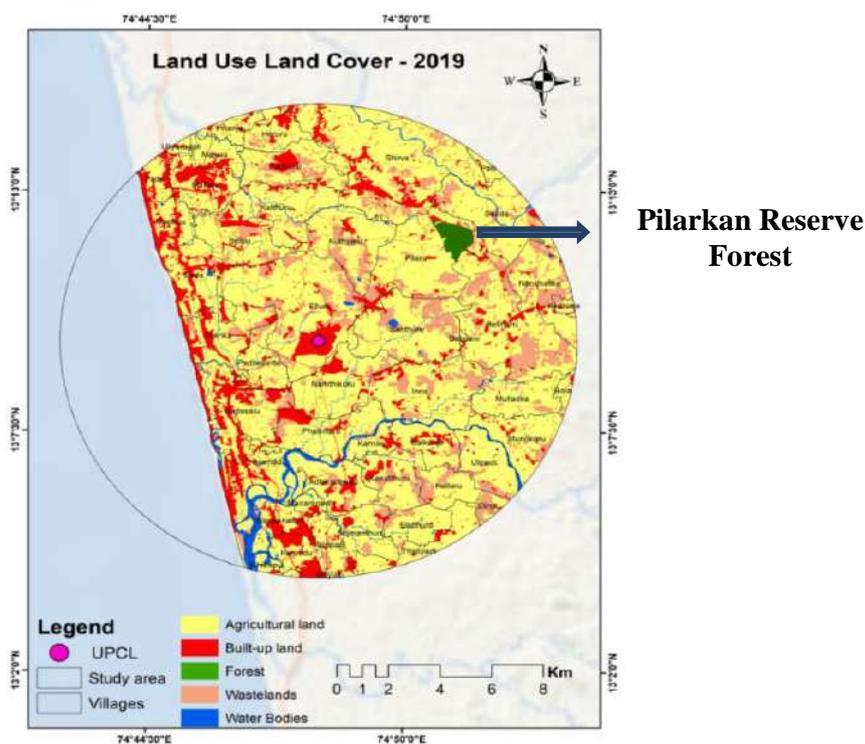
Figure 4.7: Location Map of Pilarkan Reserve Forest at the Study Area

Sampling area

The entire reserve forest comes under a *kan* or *Devara kadu* (sacred grove) containing a small temple in the middle. The people around this forest consider this forest a sacred place and they are against any felling of trees. They strongly believe that any felling inside the forest will result in unforecastable happenings.

There is a small stream in the middle of the forest which dries up during the summer. There is less number of trees towards the exterior, which may be due to the collection of dry leaves and branches, which is permitted to the locals. The area has an average altitude of 28 meters above sea level, average annual rainfall of about 4285 mm and the temperature ranges from 22 0C in winter to 37 0C in summer. The area is mainly covered by an irregular topography with depressions, numerous chain mountains, flat lands, gorges scattered trees and dense shrubs of patch natural vegetation.

Sampling design

The study was conducted in Pilarkan Reserve Forest (74° 51' E and 13°12' N), covering an area of 124.32 hectares located in 3 km south-east of Shirva in Udupi District of Karnataka. The data was collected by laying a square sample plot of 0.145 ha.

Floristic data collection/ Methodology

A field visit was carried out in the month of October 2020 to understand and assess the status of flora and fauna and natural habitats. Reconnaissance survey was made across the natural forest in order to obtain vegetation patterns and determine representative sampling site. The vegetation data were collected using a systematic sampling method. One quadrate was laid on 0.01sampling percentage such a way so as to include the areas with variation in the density. The woody species specimens were collected by laying quadrates of 38.1 × 38.1 m (1451.61m^2) and within the plot laid 5 x 5m for shrubs and 1 x 1m for regeneration study. The coordinates of the quadrate, all corners and centre of the plot were recorded using a GPS and the coordinates are $13^0$1150'1" 74^o5109'09", $13^0$1149'03", $74^0$5108'51", $13^0$1149'24", $74^0$5107'10", $13^0$1150'15" $74^0$5107'60" and E mid-point $13^0$1149'55" $74^0$5108'16" (Figure 4.8).
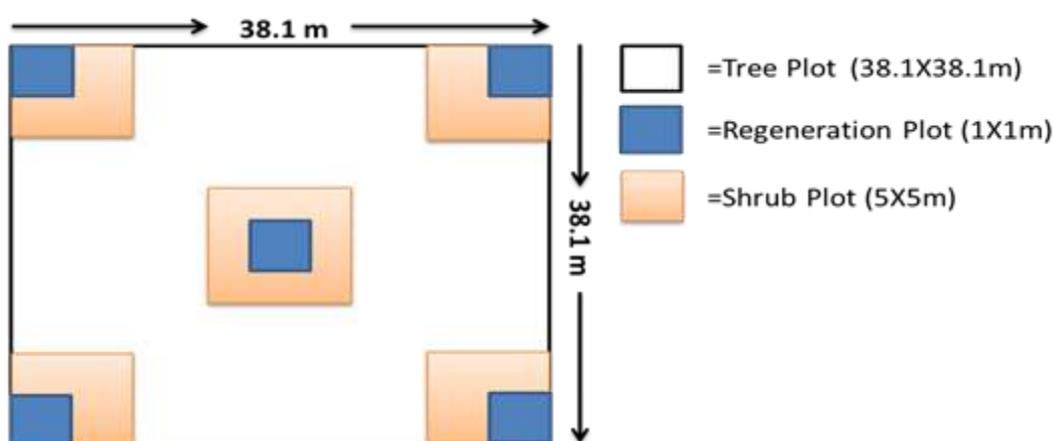
Figure 4.8: Layout the Quadrants for Floristic Assessment

All the trees >10 cm at 1.37-meter height (gbh) within the transect were botanically identified to the species level by using field guides (Pascal and Ramesh, 1987) and local

floras (Saldanha, 1996; Keshavmurthy and Yoganarasimhan, 1990; Bhat, 2003). The regeneration and shrub growth of tree species was enumerated using measuring tape.

Data Analysis

Vegetational analysis was conducted using descriptive statistics to determine the relative dominance, relative frequency, relative density and the importance value of each species in the study site. Trees with the highest importance values were those that present in the greatest number or one with the greatest size. Once importance value was determined, a specific community was described in terms of its most important species. Thus, communities were often described by the species or genera that were determined to be the most dominant in the community (Smith and Smith, 2002).

Various estimates of diversity were calculated using PAST (Hammer et al 2001). A simple estimate of diversity is species richness (number of species). Basal area was estimated as an area of a circle (πr^2); the sum of the individual basal area was represented as a basal area of the plot and expressed as square meters. Biomass of each individual tree was estimated all metrically using equation developed for calculation of biomass for CTFS forest dynamics plots by J. Chave based on Chave et al 2014. This equation estimates biomass based on the diameter of an individual tree. Half of biomass is considered as carbon content based on IPCC definition. Table 4.9 shows the calculation of biomass estimation.

Observations of Floristic Analysis:

Tree, shrubs and herbs population were enumerated by direct counting method. Different species were identified by referring the key provided and measuring the height, girth of each species. Using some basic formulas, the biomass and carbon of tree species of the forest was estimated. Total 474 individual tree were identified, out of which 40 species of Angiosperms have been documented belonging to 36 genera and 32 families. Two species of Pteridophytes were also seen. Later the individuals were categorised as Herb, Shrub, Trees, and Climbers etc. The complete list of floral diversity is as follows (Table 4.6) (Table 4.7) and (Table 4.8).

Out of total 42 species recorded, 13 species were endemic. Among those, 6 species were endemic to Western Ghats, 5 species to Peninsular India and 2 species were endemic to India. '*Syzygium caryophyllatum* and *Wendlandia notoniana*' were threatened species (Endangered category) as per International Union for Conservation of Nature and Natural Resources (IUCN). Among the recorded plant species, tree habit is the most dominant habit type (n = 18) and followed by shrubs (n=12). The least recorded habit type were Ferns, Orchids and Herbs (Figure no. 4.10). In both the level of genera and species, Rubiaceae was the dominant family recorded in the study area, which was followed by the families Dipterocarpaceae, Melastomataceae, Myristicaceae and Orchidaceae contributing two species each (Figure no. 4.9).
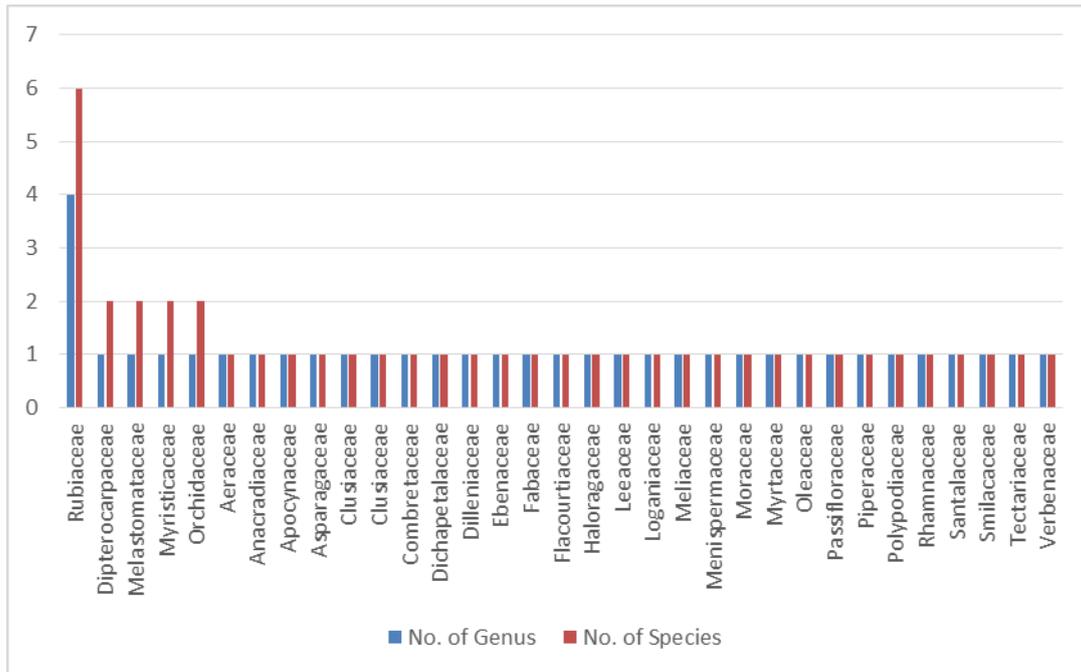
Figure 4.9: Family-wise representation of Plants
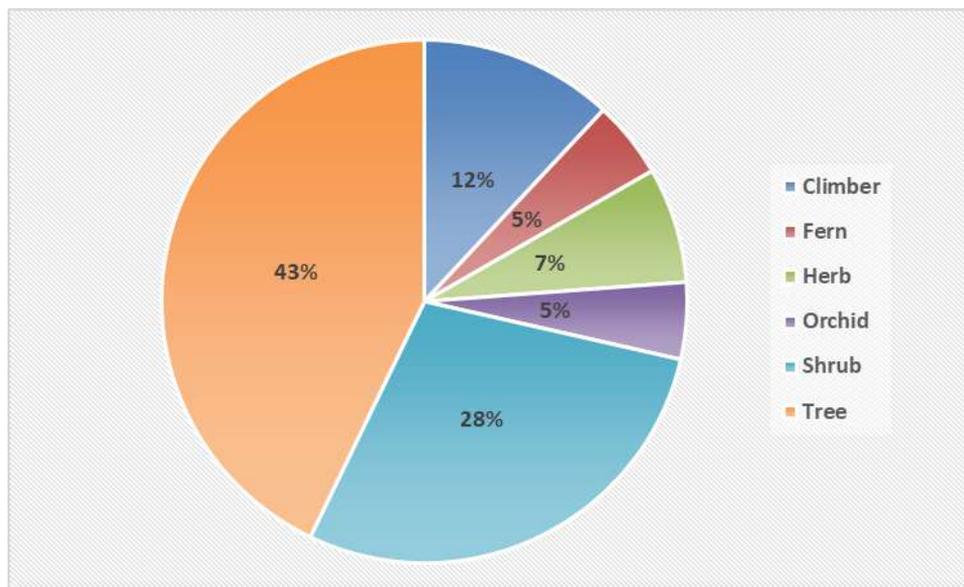
Figure 4.10: Classification of Plants by Habit type

Table 4.6: List of Species in Pilarkan Reserve Forest and IUCN Classification

Sl. No	Species	Family	Category	Threat Status
1	*Adenia hondala* (Gaertn.)W.J. de Wilde	Passifloraceae	Climber	-
2	*Anamirta cocculus* (L.) Wight. & Arn.	Menispermaceae	Climber	-
3	*Artocarpus hirsutus* Lam.	Moraceae	Tree	Endemic & Threatened
4	*Bulbophyllum sterile* (Lam.) Suresh	Orchidaceae	Orchid	-
5	*Canthium coromandellicum* (Burm.f.) Alston	Rubiaceae	Herb	-
6	*Carissa spinarum* L.	Apocynaceae	Shrub	-
7	*Cissus javana* DC.	Haloragaceae	Climber	-
8	*Clerodendrum infortunatum* L.	Verbenaceae	Shrub	-
9	*Combretum latifolium* Blume	Combretaceae	Climber	-
10	*Dichapetalum gelonioides* (Roxb.) Engl.	Dichapetalaceae	Shrub	-
11	*Dillenia pentagyna* Roxb.	Dilleniaceae	Tree	-
12	*Diospyros buxifolia* (Blume.) Hiern.	Ebenaceae	Tree	-
13	*Dracaena terniflora* Roxb.	Asparagaceae	Herb	-
14	*Drynaria quercifolia* (L.) J. Sm.	Polypodiaceae	Fern	-
15	*Flacoutia montana* J. Graham	Flacourtiaceae	Tree	-
16	*Garcinia Morella* (Gaertn.) Desr.	Clusiaceae	Tree	-
17	*Holigarna ferruginea* Marchand	Anacradiaceae	Tree	Endemic
18	*Hopea parviflora* Bedd.	Dipterocarpaceae	Tree	Endemic
19	*Hopea ponga* (Dennst.) Mabb.	Dipterocarpaceae	Tree	Endemic
20	*Ixora brachiata* Roxb.	Rubiaceae	Tree	Endemic
21	*Ixora coccinea* L.	Rubiaceae	Shrub	
22	*Knema attenuata* (Hook.f. & Thoms) Warb.	Myristicaceae	Tree	Endemic & Least Concern
23	*Leea indica* (Burm.f.) Merr.	Leeaceae	Shrub	-
24	*Mammea suriga* (Buch. -Ham.ex Roxb.) Koesterm.	Clusiaceae	Tree	-
25	*Memecylon edule* Roxb.	Melastomataceae	Tree	-
26	*Memecylon randerianum* S.M.Almedia & M.R.Almeida	Melastomataceae	Shrub	-
27	*Myristica malabarica* Lam	Myristicaceae	Tree	Endemic
28	*Naregamia alata* Wight. & Arn.	Meliaceae	Herb	-
29	*Olea dioica* Roxb.	Oleaceae	Tree	-
30	*Piper nigrum* L.	Piperaceae	Climber	-
31	*Pothos scandens* L.	Aeraceae	Shrub	
32	*Psychotria dalzellii* Hook.f	Rubiaceae	Shrub	Endemic
33	*Psychotria flavida* Talbot.	Rubiaceae	Shrub	Endemic
34	*Rhynchostylsis retusa* (L.) Blume	Orchidaceae	Orchid	-
35	*Scleropyrum pentandrum* (Dennst.) Mabb.	Santalaceae	Tree	-
36	*Smilax zeylanica* L.	Smilacaceae	Shrub	-
37	*Strychnos minor* Dennst.	Loganiaceae	Shrub	-
38	*Syzygium caryophyllatum* (L.) Alston.	Myrtaceae	Tree	-
39	*Tectaria polymorpha* (Wall. ex Hook.) Copel.	Tectariaceae	Fern	-
40	*Ventilago maderaspatana* Gaertn.	Rhamnaceae	Shrub	-
41	*Wendlandia notoniana* Wall. ex Wight & Arn	Rubiaceae	Tree	-
42	*Xylia xylocarpa* (Roxb.) Taub.	Fabaceae	Tree	-

<h3 style="text-align: center; color: #1F5C99;">Table 4.7: Regeneration Plot (1 x 1 M)</h3>

Sl.No.	Species Name	No. of Individuals	Family	Status
1	*Psychotria thwaitesii*	7	Rubiaceae	
2	*Piper nigrum*	6	Piperaceae	
3	*Grass spp.*	56	Poaceae	
4	*Epiphyte spp.*	1	Orchidaceae	
5	*Hopea parviflora*	1	Dipterocarpaceae	Endemic
6	*Wild Climber*	3	-	

<h3 style="text-align: center; color: #1F5C99;">Table 4.8: Shrub Plot (5 x 5 M)</h3>

Sl.No.	Scientific name	No. of Individuals	Family	Status
1	*Artocarpus hirsutus*	2	Moraceae	Endemic & Threatened
2	*Diospyros buxifolia*	3	Ebenaceae	
3	*Hopea parviflora*	9	Dipterocarpaceae	Endemic
4	*Myristica malabarica*	4	Myristicaceae	Endemic
5	*Wendlandia notoniana*	8	Rubiaceae	
6	*Psychotria thwaitesii*	145	Rubiaceae	
7	*Leea indica*	27	Leeaceae	
8	*Ixora brachiata*	1	Rubiaceae	Endemic

<h3 style="text-align: center; color: #1F5C99;">Table 4.9: Biomass and Carbon Estimation at Pilarkan Reserve Forest</h3>

Girth Class	Species Name	No. of Individuals	Basal Area Cm2	Biomass (Kg)	Carbon (Kg)
1 to 10	*Holigarna arnottiana*	3	89.5358	2.72	1.36
	Flacourtia montana	1	71.69	1.67	0.83
	Artocarpus hirsutus	1	15.61	0.65	0.32
	Wendlandia notoniana	8	245.18	7.45	3.72
	Hopea ponga	1	76.55	1.75	0.87
	Hopea parviflora	3	112.55	3.2	1.6
	Mundelu	1	71.69	1.67	0.83
	Mundi	1	13.46	0.6	0.3
	Vitex altissima	3	54.88	2.07	1.04
	Diospyros buxifolia	62	2274.56	64.5	32.25
	Memecylon edule	7	219.62	6.53	3.26
	Myristica malabarica	27	851.86	25.54	12.77
	Mimusops elengi	11	250.206	8.59	4.29
10.1 to 20	*Holigarna arnottiana*	1	127.45	2.62	1.31
	Ficus drupacea	1	109.05	2.31	1.15
	Alstonia scholaris	1	249.808	4.76	2.38
	Artocarpus hirsutus	1	161.307	3.2	1.6
	Dillenia pentagyna	1	97.58	2.11	1.05
	Hopea parviflora	11	1674.256	33.57	16.78
	Diospyros buxifolia	8	978.601	20.28	10.14
	Myristica malabarica	2	201.77	4.33	2.17
	Mimusops elengi	1	92.08	2.02	1.01
20.1 to 40	*Holigarna arnottiana*	1	718.915	14.06	7.03
	Artocarpus hirsutus	2	1453.76	28.63	14.32
	Hopea parviflora	19	13925.05	277.15	138.57
	Mangifera indica	1	630.97	12.18	6.09
	Myristica malabarica	1	718.91	14.06	7.03
40.1 to 60	*Artocarpus hirsutus*	1	1913.78	44.79	22.39
	Hopea parviflora	17	29515.6	680	340
> 60	*Hopea parviflora*	3	9264.25	250.55	125.27

I. Avi-fauna

The sampling was carried out during the winter months starting from first week of September 2020 to late April 2021 covering eight months of survey. The extensive survey was carried out in 36 different villages in the South Canara region, covering three major Taluks i.e. present Kapu and Karkala Taluks of Udupi District and Mangalore Taluks of Dakshina Kannada District. Birds were sampled using whole area search with opportunistic observation as well as through point sample observations. Identification of birds was done using standard field guides (Grimmett et al. 2016; Ali 2002). More time was spent where human habitations, agricultural fields and lakes were present. The surrounding agriculture fields were mostly with paddy as a major crop provided extra foraging space and food for certain wetland birds, insectivore birds and other grain eating bird species. Birds are studied as bio-indicators of an ecosystem across the globe due to their varied size and adaptations of which, some are specific to their food or the habitat they live in. Following Table 4.10 gives the list of avifauna documented from the study area.

Table 4.10: The list of Avi-fauna

Sl No	Family	Common Name	Scientific Name	IUCN Status	WLPA Schedule	Migratory Status
1	Anatidae	Lesser Whistling Duck	*Dendrocygna javanica*	LC	Sch-IV	R
2		Comb Duck	*Sarkidiornis melanotos*	LC	Sch-IV	R
3		Cotton Teal	*Nettapus coromandelianus*	LC	Sch-IV	R
4		Indian Spot-billed Duck	*Anas poecilorhyncha*	LC	Sch-IV	R
5	Phasianidae	Indian Peafowl	*Pavo cristatus*	LC	Sch-I	R
6		Grey Francolin	*Francolinus pondicerianus*	LC	Sch-IV	R
7		Red Spurfowl	*Galloperdix spadicea*	LC	Sch-IV	R
8		Grey Junglefowl	*Gallus sonneratii*	LC	Sch-IV	R
9	Podicipedidae	Little Grebe	*Tachybaptus ruficollis*	LC	Sch-IV	R
10	Columbidae	Rock Pigeon	*Columba livia*	LC	Sch-IV	R
11		Spotted Dove	*Streptopelia chinensis*	LC	Sch-IV	R
12		Laughing Dove	*Streptopelia senegalensis*	LC	Sch-IV	R
13		Asian Emerald Dove	*Chalcophaps indica*	LC	Sch-IV	R
14		Yellow-legged Green Pigeon	*Treron phoenicopterus*	LC	Sch-IV	R
15		Green Imperial-Pigeon	*Ducula aenea*	LC	Sch-IV	R
16	Cuculidae	Greater Coucal	*Centropus sinensis*	LC	Sch-IV	R
17		Blue-faced Malkoha	*Phaenicophaeus viridirostris*	LC	Sch-IV	R
18		Asian Koel	*Eudynamys scolopaceus*	LC	Sch-IV	R
19		Common Hawk Cuckoo	*Hierococcyx varius*	LC	Sch-IV	R
20	Apodidae	Indian House Swift	*Apus affinis*	LC	Sch-IV	R
21		Asian Palm Swift	*Cypsiurus balasiensis*	LC	Sch-IV	R
22	Rallidae	Common Moorhen	*Gallinula chloropus*	LC	Sch-IV	R

Sl No	Family	Common Name	Scientific Name	IUCN Status	WLPA Schedule	Migratory Status
23		Common Coot	*Fulica atra*	LC	Sch-IV	R
24		Purple Swamphen	*Porphyrio porphyrio*	LC	Sch-IV	R
25		White-breasted Waterhen	*Amaurornis phoenicurus*	LC	Sch-IV	R
26	Burhinidae	Great Thick-knee	*Esacus recurvirostris*	N T	Sch-IV	R
27	Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*	LC	Sch-IV	R
28	Charadriidae	Yellow-wattled Lapwing	*Vanellus malabaricus*	LC	Sch-IV	R
29		Red-wattled Lapwing	*Vanellus indicus*	LC	Sch-IV	R
30		Little Ringed Plover	*Charadrius dubius*	LC	Sch-IV	R
31	Jacanidae	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	LC	Sch-IV	R
32		Bronze-winged Jacana	*Metopidius indicus*	LC	Sch-IV	R
33	Scolopacidae	Common Sandpiper	*Actitis hypoleucos*	LC	Sch-IV	MLD
34		Green Sandpiper	*Tringa ochropus*	LC	Sch-IV	MLD
35		Marsh Sandpiper	*Tringa stagnatilis*	LC	Sch-IV	MLD
36		Wood Sandpiper	*Tringa glareola*	LC	Sch-IV	MLD
37		Common Redshank	*Tringa totanus*	LC	Sch-IV	MLD
38	Laridae	Brown-headed Gull	*Chroicocephalus brunnicephalus*	LC	Sch-IV	ML
39		River Tern	*Sterna aurantia*	VU	Sch-IV	R
40	Ciconiidae	Asian Openbill	*Anastomus oscitans*	LC	Sch-IV	R
41		Woolly-necked Stork	*Ciconia episcopus*	N T	Sch-IV	R
42		Lesser Adjutant	*Leptoptilos javanicus*	VU	Sch-IV	R
43		Painted Stork	*Mycteria leucocephala*	N T	Sch-IV	R
44	Anhingidae	Oriental Darter	*Anhinga melanogaster*	N T	Sch-IV	R
45	Phalacrocoracidae	Little Cormorant	*Microcarbo niger*	LC	Sch-IV	R
46		Great Cormorant	*Phalacrocorax carbo*	LC	Sch-IV	R
47		Indian Cormorant	*Phalacrocorax fuscicollis*	LC	Sch-IV	R
48	Pelecanidae	Spot-billed Pelican	*Pelecanus philippensis*	N T	Sch-IV	R
49	Ardeidae	Grey Heron	*Ardea cinerea*	LC	Sch-IV	R
50		Purple Heron	*Ardea purpurea*	LC	Sch-IV	R
51		Great Egret	*Ardea alba*	LC	Sch-IV	R
52		Intermediate Egret	*Ardea intermedia*	LC	Sch-IV	R
53		Little Egret	*Egretta garzetta*	LC	Sch-IV	R
54		Western Reef Egret	*Egretta gularis*	LC	Sch-IV	R
55		Cattle Egret	*Bubulcus ibis*	LC	Sch-IV	R
56		Indian Pond Heron	*Ardeola grayii*	LC	Sch-IV	R
57		Black-crowned Night Heron	*Nycticorax nycticorax*	LC	Sch-IV	R
58	Threskiornithidae	Black-headed Ibis	*Threskiornis melanocephalus*	N T	Sch-IV	R
59		Indian Black Ibis	*Pseudibis papillosa*	LC	Sch-IV	R
60	Accipitridae	Black-winged Kite	*Elanus caeruleus*	LC	Sch-I	R
61		Oriental Honey Buzzard	*Pernis ptilorhynchus*	LC	Sch-I	R
62		Crested Serpent Eagle	*Spilornis cheela*	LC	Sch-I	R

Sl No	Family	Common Name	Scientific Name	IUCN Status	WLPA Schedule	Migratory Status
63		Short-toed Snake Eagle	*Circaetus gallicus*	LC	Sch-I	R
64		Booted Eagle	*Hieraaetus pennatus*	LC	Sch-I	MLD
65		White-eyed Buzzard	*Butastur teesa*	LC	Sch-I	R
66		Western Marsh Harrier	*Circus aeruginosus*	LC	Sch-I	MLD
67		Pallid Harrier	*Circus macrourus*	N T	Sch-I	MLD
68		Crested Goshawk	*Accipiter trivirgatus*	LC	Sch-I	R
69		Shikra	*Accipiter badius*	LC	Sch-I	R
70		Black Kite	*Milvus migrans*	LC	Sch-I	R
71		Brahminy Kite	*Haliastur indus*	LC	Sch-I	R
72		White-bellied Sea Eagle	*Haliaeetus leucogaster*	LC	Sch-I	R
73	Strigidae	Brown Fish Owl	*Ketupa zeylonensis*	LC	Sch-IV	R
74		Spotted Owlet	*Athene brama*	LC	Sch-IV	R
75	Tytonidae	Common Barn Owl	*Tyto alba*	LC	Sch-IV	R
76	Trogonidae	Malabar Trogon	*Harpactes fasciatus*	LC	Sch-IV	R
77	Upupidae	Common Hoopoe	*Upupa epops*	LC	Sch-IV	R
78	Bucerotidae	Great Hornbill	*Buceros bicornis*	VU	Sch-I	R
79		Malabar Grey Hornbill	*Ocyceros griseus*	VU	Sch-IV	R
80		Malabar Pied Hornbill	*Anthracoceros coronatus*	N T	Sch-I	R
81	Alcedinidae	Common Kingfisher	*Alcedo atthis*	LC	Sch-IV	R
82		Oriental Dwarf Kingfisher	*Ceyx erithaca*	LC	Sch-IV	R
83		Stork-billed Kingfisher	*Pelargopsis capensis*	LC	Sch-IV	R
84		White-throated Kingfisher	*Halcyon smyrnensis*	LC	Sch-IV	R
85		Pied Kingfisher	*Ceryle rudis*	LC	Sch-IV	R
86	Meropidae	Blue-bearded Bee-eater	*Nyctyornis athertoni*	LC	Sch-IV	R
87		Green Bee-eater	*Merops orientalis*	LC	Sch-IV	R
88		Blue-tailed Bee-eater	*Merops philippinus*	LC	Sch-IV	R
89		Chestnut-headed Bee-eater	*Merops leschenaulti*	LC	Sch-IV	R
90	Coraciidae	Indian Roller	*Coracias benghalensis*	LC	Sch-IV	R
91	Megalaimidae	Malabar Barbet	*Psilopogon malabaricus*	LC	Sch-IV	R
92		Coppersmith Barbet	*Psilopogon haemacephalus*	LC	Sch-IV	R
93		White-cheeked Barbet	*Psilopogon viridis*	LC	Sch-IV	R
94	Falconidae	Common Kestrel	*Falco tinnunculus*	LC	Sch-IV	R
95	Psittaculidae	Rose-ringed Parakeet	*Psittacula krameri*	LC	Sch-IV	R
96		Plum-headed Parakeet	*Psittacula cyanocephala*	LC	Sch-IV	R
97		Malabar Parakeet	*Psittacula columboides*	LC	Sch-IV	R
98		Vernal Hanging Parrot	*Loriculus vernalis*	LC	Sch-IV	R
99	Pittidae	Indian Pitta	*Pitta brachyura*	LC	Sch-IV	ML
100	Artamidae	Ashy Woodswallow	*Artamus fuscus*	LC	Sch-IV	R
101	Aegithinidae	Common Iora	*Aegithina tiphia*	LC	Sch-IV	R
102	Campephagidae	Small Minivet	*Pericrocotus cinnamomeus*	LC	Sch-IV	R

Sl No	Family	Common Name	Scientific Name	IUCN Status	WLPA Schedule	Migratory Status
103		Orange Minivet	*Pericrocotus flammeus*	LC	Sch-IV	R
104		Large Cuckooshrike	*Coracina javensis*	LC	Sch-IV	R
105	Laniidae	Bay-backed Shrike	*Lanius vittatus*	LC	Sch-IV	R
106		Long-tailed Shrike	*Lanius schach*	LC	Sch-IV	R
107		Indian Golden Oriole	*Oriolus kundoo*	LC	Sch-IV	ML
108	Oriolidae	Black-naped Oriole	*Oriolus chinensis*	LC	Sch-IV	MLD
109		Black-hooded Oriole	*Oriolus xanthornus*	LC	Sch-IV	R
110		Black Drongo	*Dicrurus macrocercus*	LC	Sch-IV	R
111		Ashy Drongo	*Dicrurus leucophaeus*	LC	Sch-IV	ML
112	Dicruridae	White-bellied Drongo	*Dicrurus caerulescens*	LC	Sch-IV	R
113		Bronzed Drongo	*Dicrurus aeneus*	LC	Sch-IV	R
114		Greater Racket-tailed Drongo	*Dicrurus paradiseus*	LC	Sch-IV	R
115	Rhipiduridae	White-spotted Fantail	*Rhipidura albogularis*	LC	Sch-IV	R
116		Black-naped Monarch	*Hypothymis azurea*	LC	Sch-IV	R
117	Monarchidae	Indian Paradise-flycatcher	*Terpsiphone paradisi*	LC	Sch-IV	ML
118		Rufous Treepie	*Dendrocitta vagabunda*	LC	Sch-IV	R
119		White-bellied Treepie	*Dendrocitta leucogastra*	LC	Sch-IV	R
120	Corvidae	House Crow	*Corvus splendens*	LC	Sch-V	R
121		Large-billed Crow	*Corvus macrorhynchos*	LC	Sch-IV	R
122		Rufous-tailed Lark	*Ammomanes phoenicura*	LC	Sch-IV	R
123	Alaudidae	Ashy-crowned Sparrow Lark	*Eremopterix griseus*	LC	Sch-IV	R
124		Malabar Lark	*Galerida malabarica*	LC	Sch-IV	R
125		Barn Swallow	*Hirundo rustica*	LC	Sch-IV	ML
126	Hirundinidae	Wire-tailed Swallow	*Hirundo smithii*	LC	Sch-IV	R
127		Red-rumped Swallow	*Cecropis daurica*	LC	Sch-IV	R
128	Stenostiridae	Grey-headed Canary-flycatcher	*Culicicapa ceylonensis*	LC	Sch-IV	ML
129	Paridae	Cinereous Tit	*Parus cinereus*	LC	Sch-IV	R
130	Sittidae	Velvet-fronted Nuthatch	*Sitta frontali*	LC	Sch-IV	R
131		Flame-throated Bulbul	*Pycnonotus gularis*	LC	Sch-IV	R
132		Red-vented Bulbul	*Pycnonotus cafer*	LC	Sch-IV	R
133	Pycnonotidae	Red-whiskered Bulbul	*Pycnonotus jocosus*	LC	Sch-IV	R
134		White-browed Bulbul	*Pycnonotus luteolus*	LC	Sch-IV	R
135		Yellow-browed Bulbul	*Acritillas indica*	LC	Sch-IV	R
136		Green Leaf Warbler	*Phylloscopus nitidus*	LC	Sch-IV	MLD
137		Greenish Leaf Warbler	*Phylloscopus trochiloides*	LC	Sch-IV	ML
138	Acrocephalidae	Blyth's Reed Warbler	*Acrocephalus dumetorum*	LC	Sch-IV	MLD
139		Clamorous Reed Warbler	*Acrocephalus stentoreus*	LC	Sch-IV	R
140		Common Tailorbird	*Orthotomus sutorius*	LC	Sch-IV	R
141	Cisticolidae	Ashy Prinia	*Prinia socialis*	LC	Sch-IV	R
142		Plain Prinia	*Prinia inornata*	LC	Sch-IV	R

Sl No	Family	Common Name	Scientific Name	IUCN Status	WLPA Schedule	Migratory Status
143	Zosteropidae	Oriental White-eye	*Zosterops palpebrosus*	LC	Sch-IV	R
144	Leiothrichidae	Jungle Babbler	*Turdoides striata*	LC	Sch-IV	R
145		Indian Scimitar Babbler	*Pomatorhinus horsfieldii*	LC	Sch-IV	R
146		Puff-throated Babbler	*Pellorneum ruficeps*	LC	Sch-IV	R
147		Yellow-billed Babbler	*Turdoides affinis*	LC	Sch-IV	R
148	Irenidae	Asian Fairy-bluebird	*Irena puella*	LC	Sch-IV	R
149	Muscicapidae	Indian Robin	*Saxicoloides fulicatus*	LC	Sch-IV	R
150		Oriental Magpie Robin	*Copsychus saularis*	LC	Sch-IV	R
151		Tickell's Blue Flycatcher	*Cyornis tickelliae*	LC	Sch-IV	R
152		Verditer Flycatcher	*Eumyias thalassinus*	LC	Sch-IV	ML
153		Indian Blue Robin	*Larvivora brunnea*	LC	Sch-IV	ML
154		Malabar Whistling Thrush	*Myophonus horsfieldii*	LC	Sch-IV	R
155		Pied Bushchat	*Saxicola caprata*	LC	Sch-IV	R
156	Turdidae	Orange-headed Thrush	*Geokichla citrina*	LC	Sch-IV	R
157	Sturnidae	Southern Hill Myna	*Gracula indica*	LC	Sch-I	R
158		Rosy Starling	*Pastor roseus*	LC	Sch-IV	MLD
159		Brahminy Starling	*Sturnia pagodarum*	LC	Sch-IV	R
160		Common Myna	*Acridotheres tristis*	LC	Sch-IV	R
161		Jungle Myna	*Acridotheres fuscus*	LC	Sch-IV	R
162	Chloropseidae	Jerdon's Leafbird	*Chloropsis jerdoni*	LC	Sch-IV	R
163		Golden-fronted Leafbird	*Chloropsis aurifrons*	LC	Sch-IV	R
164	Dicaeidae	Pale-billed Flowerpecker	*Dicaeum erythrorhynchos*	LC	Sch-IV	R
165		Nilgiri Flowerpecker	*Dicaeum concolor*	LC	Sch-IV	R
166	Nectariniidae	Purple-rumped Sunbird	*Leptocoma zeylonica*	LC	Sch-IV	R
167		Purple Sunbird	*Cinnyris asiaticus*	LC	Sch-IV	R
168		Loten's Sunbird	*Cinnyris lotenius*	LC	Sch-IV	R
169		Little Spiderhunter	*Arachnothera longirostra*	LC	Sch-IV	R
170	Motacillidae	White-browed Wagtail	*Motacilla maderaspatensis*	LC	Sch-IV	R
171		Western Yellow Wagtail	*Motacilla flava*	LC	Sch-IV	MLD
172		Paddyfield Pipit	*Anthus rufulus*	LC	Sch-IV	R
173	Passeridae	House Sparrow	*Passer domesticus*	LC	Sch-IV	R
174	Ploceidae	Baya Weaver	*Ploceus philippinus*	LC	Sch-IV	R
175	Estrildidae	Red Munia	*Amandava amandava*	LC	Sch-IV	R
176		Indian Silverbill	*Euodice malabarica*	LC	Sch-IV	R
177		White-rumped Munia	*Lonchura striata*	LC	Sch-IV	R
178		Scaly-breasted Munia	*Lonchura punctulata*	LC	Sch-IV	R
179		Tricoloured Munia	*Lonchura malacca*	LC	Sch-IV	R
180	Picidae	Lesser Golden-backed Woodpecker	*Dinopium benghalense*	LC	Sch-IV	R
181		Greater Golden-backed Woodpecker	*Chrysocolaptes guttacristatus*	LC	Sch-IV	R

II.   **IUCN Status of Birds:** Birds are often considered to be outstanding indicators of the health of the overall environment. Population of Birds is threatened due to various reasons. One of the main reasons being loss of habitat, deforestation, the draining of wetlands, planting of non-native trees. The loss of areas due to urban developments and intensive agriculture are major threats to birds. **International Union for Conservation of Nature and Natural Resources** (IUCN) has given the following categories for species which are globally threatened. Out of 181 species from the study area, four species are '**Vulnerable**' they are (Great Hornbill, Malabar Grey Hornbill, Lesser Adjutant and River Tern). Eight are **'Near Threatened'** (Pallid Harrier, Malabar Pied Hornbill, Great Thick-knee, Painted Stork, Oriental Darter, Spot-billed Pelican, Woolly-necked Stork and Black-headed Ibis). In Figure No: 4.11 the percent of globally threatened species of birds from the study area are represented.

Image showing IUCN Category of threatened species.
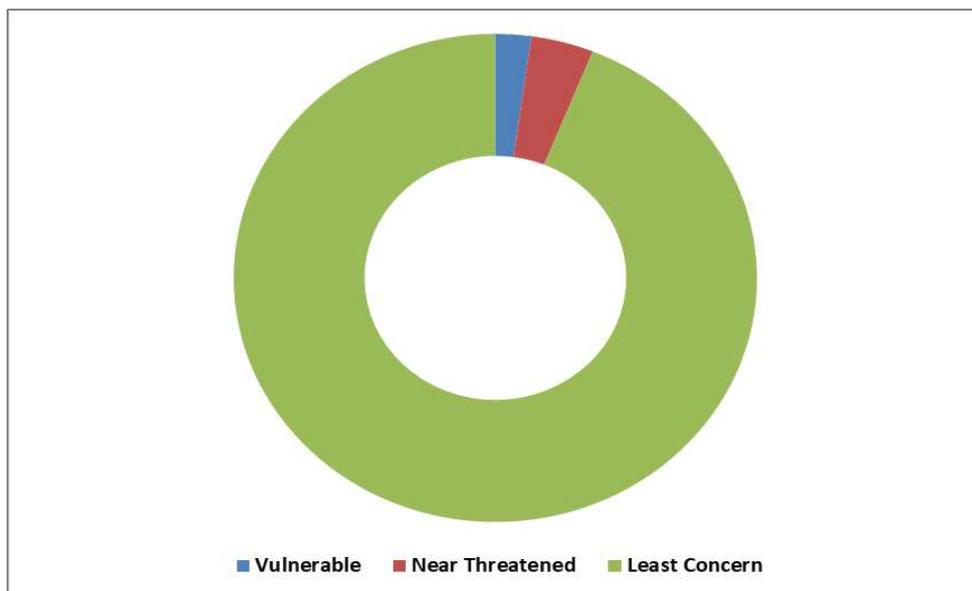
Figure 4.11: IUCN Status of Birds from the study area

III. **Migratory and Resident Status of Birds:** Birds which do not migrate are known as resident birds. These residents' birds make few habitats as their permanent home for feeding and breeding. One of the most fascinating reasons for the flight of birds is their migration, and these birds are known as migratory birds. There are many ways of migration, few major ways are: Nocturnal Migration, Long-distance migration, Diurnal migration, Short-distance migration and Altitudinal migrations. Out of 181 species of birds documented from the study area, 23 species found to be migratory in which 10 species are local migrants and 13 being Long Distance Migrants. (Figure No. 4.12) Major bird migration in India is seen during the winter because most of the migrants are from Siberia, Russia, and Europe continents. Study on the avian fauna has to be done across the different seasons to get a better picture on migration status of birds of Udupi.
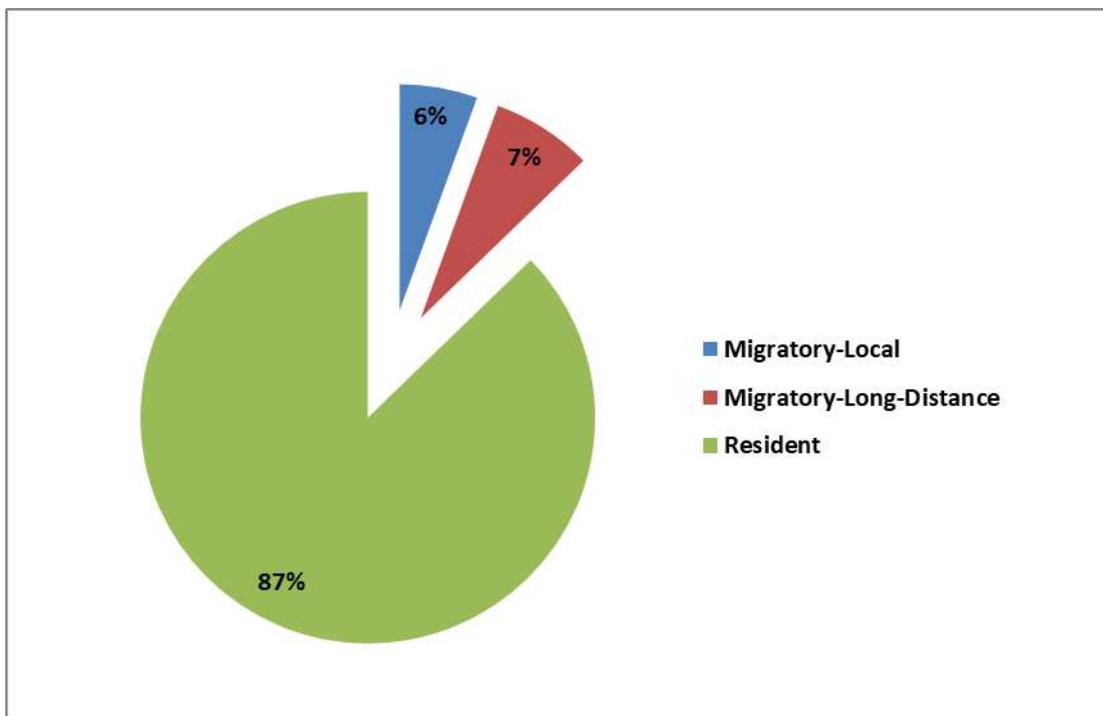
Figure 4.12: Migratory & Resident Status of Birds from the Study Area

IV. **Protection of Birds under Wildlife Protection Act 1972:**

The Wildlife (Protection) Act, 1972 is an Act of the Parliament of India enacted for the protection of wild animals, birds and plants. It has six schedules which gives the varying degrees of protection. Schedule I and part II of Schedule II provide absolute protection - offences under these are prescribed the highest penalties. Species listed in Schedule III and Schedule IV is also protected, but the penalties are much lower. In India except few crows and pigeons, all the other species are protected either in schedule I or Schedule IV. Indian Peafowl, few Eagles and Kites are listed in Schedule-I. From the present study, out of 181 species, 17 species are protected under Schedule –I, 163 species are under Schedule-IV and only one species is in Schedule-V. The details of species schedule wise are shown in Table No 4.10 and Figure no. 4.13.
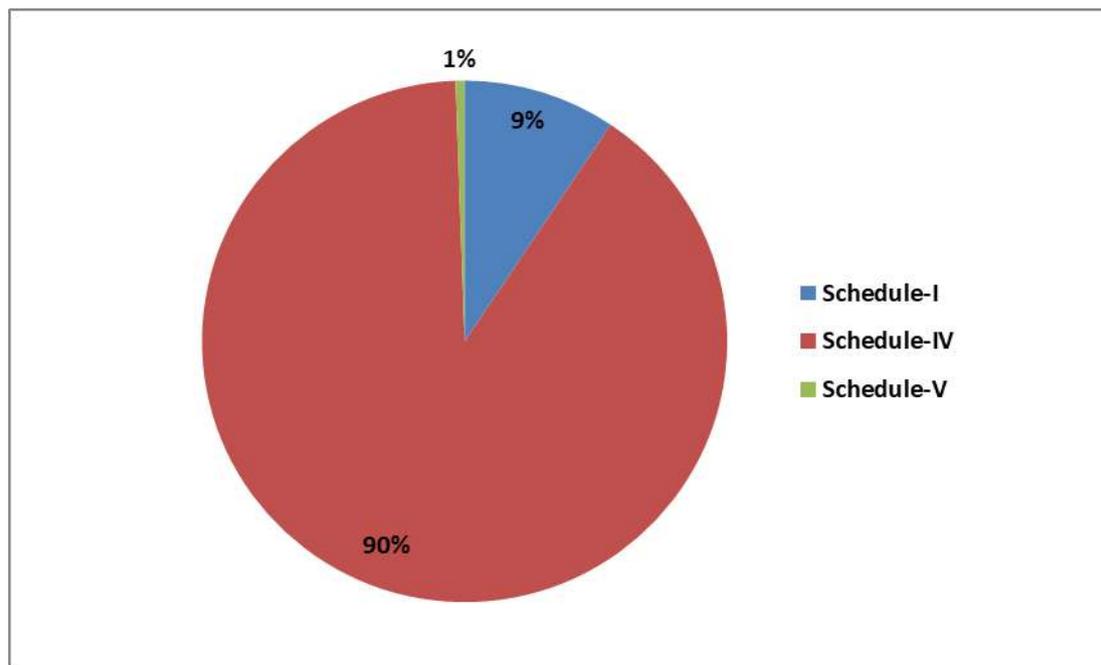
Figure 4.13: Protection of Birds under Wildlife Protection Act 1972:

V.   List of Butterflies:

Butterflies are the most beautiful and colorful creatures on the earth and are called as the flying jewels or winged jewels of nature. They act as biodiversity indicators as well as nature's gardeners. Amongst all the insect groups, they are the best and most taxonomically studied and well observed not only by the entomologists but also by laymen. More than 28000 species of butterfly are found all over the world. India being a vast country with wide contrasts in physical features, climate and vegetation, possesses one of the richest and most varied butterfly fauna in the world. India hosts about 1,504 species of butterflies of which peninsular India hosts 351 and the Western Ghats 334. Butterflies play a vital role in pollination of various flowering plants besides a key component of the food chain. Following Table 4.11 gives the list of butterflies documented from the study area.

Table 4.11: List of Butterflies

No	Family	Sl No	Common Name	Scientific Name
1	**Blues**	1	Angled Pierrot	*Caleta decidia*
		2	Apefly	*Spalgis epeus*
		3	Blue-bordered Plane	*Bindahara moorei*
		4	Common Cerulean	*Jamides celeno*
		5	Common Guava Blue	*Virachola Isocrates*
		6	Common Hedge Blue	*Acytolepis puspa*
		7	Common Imperial	*Cheritra freja*
		8	Common Lineblue	*Prosotas nora*
		9	Common Pierrot	*Castalius rosimon*
		10	Common Silverline	*Spindasis vulcanus*
		11	Dark Grass Blue	*Zizeeria karsandra*

No	Family	Sl No	Common Name	Scientific Name
		12	Gram Blue	*Euchrysops cnejus*
		13	Grass Jewel	*Freyeria trochylus*
		14	Grass Jewel	*Freyeria putli*
		15	Indian Sunbeam	*Curetis thetis*
		16	Lesser Grass Blue	*Zizina otis*
		17	Lime Blue	*Chilades lajus*
		18	Metallic Cerulean	*Jamides alecto*
		19	Monkey Puzzle	*Rathinda amor*
		20	Pale Grass Blue	*Pseudozizeeria maha*
		21	Pea Blue	*Lampides boeticus*
		22	Plains Cupid	*Chilades pandava*
		23	Red Pierrot	*Talicada nyseus*
		24	Tailless Lineblue	*Prosotas dubiosa*
		25	Tiny Grass Blue	*Zizula hylax*
		26	Zebra Blue	*Leptotes plinius*
2	**Brush footed**	27	Angled Castor	*Ariadne ariadne*
		28	Anomalous Nawab	*Charaxes agrarius*
		29	Baron	*Euthalia aconthea*
		30	Baronet	*Symphaedra nais*
		31	Black Rajah	*Charaxes solon*
		32	Blackvein Sergeant	*Athyma ranga*
		33	Blue Tiger	*Tirumala limniace*
		34	Chestnut-streaked Sailer	*Neptis jumbah*
		35	Chocolate Pansy	*Junonia iphita*
		36	Clipper	*Parthenos Sylvia*
		37	Commander	*Moduza procris*
		38	Common Bushbrown	*Mycalesis perseus*
		39	Common Castor	*Ariadne merione*
		40	Common Crow	*Euploea core*
		41	Common Evening Brown	*Melanitis leda*
		42	Common Five-ring	*Ypthima baldus*
		43	Common Four-ring	*Ypthima huebneri*
		44	Common Lascar	*Pantoporia hordonia*
		45	Common Leopard	*Phalanta phalantha*
		46	Common Sailer	*Neptis hylas*
		47	Common Treebrown	*Lethe rohria*
		48	Cruiser	*Vindula erota*
		49	Danaid Eggfly	*Hypolimnas misippus*
		50	Dark Blue Tiger	*Tirumala septentrionis*
		51	Double-branded Crow	*Euploea Sylvester*
		52	Gaudy Baron	*Euthalia lubentina*
		53	Glad-eye Bushbrown	*Mycalesis junonia*
		54	Glassy Tiger	*Parantica aglea*
		55	Great Eggfly	*Hypolimnas bolina*
		56	Grey Count	*Tanaecia lepidea*
		57	Grey Pansy	*Junonia atlites*
		58	Indian Nawab	*Charaxes bharata*
		59	Lemon Pansy	*Junonia lemonias*
		60	Malabar Tree-Nymph	*Idea malabarica*
		61	Map Butterfly	*Cyrestis thyodamas*
		62	Medus Brown (Nigger)	*Orsotriaena medus*
		63	Painted Lady	*Vanessa cardui*
		64	Peacock Pansy	*Junonia almanac*
		65	Plain Tiger	*Danaus chrysippus*
		66	Rustic	*Cupha erymanthis*
		67	Sahyadri (Tamil) Lacewing	*Cethosia mahratta*
		68	Small Leopard	*Phalanta alcippe*

No	Family	Sl No	Common Name	Scientific Name
		69	Striped Tiger	*Danaus genutia*
		70	Tamil Yeoman	*Cirrochroa thais*
		71	Tawny Coster	*Acraea terpsicore*
		72	Yellow Pansy	*Junonia hierta*
3	**Skipper**	73	African Marbled Skipper	*Gomalia elma*
		74	Brown Awl	*Badamia exclamationis*
		75	Bush Hopper	*Ampittia dioscorides*
		76	Chestnut Bob	*Iambrix salsala*
		77	Common Banded Awl	*Hasora chromus*
		78	Common Branded Redeye	*Matapa aria*
		79	Common Snow Flat	*Tagiades japetus*
		80	Dark Palm-Dart	*Telicota bambusae*
		81	Giant Redeye	*Gangara thyrsis*
		82	Grass Demon	*Udaspes folus*
		83	Grizzled Skipper	*Spialia galba*
		84	Karwar Swift	*Caltoris canaraica*
		85	Pygmy Scrub Hopper	*Aeromachus pygmaeus*
		86	Suffused Snow Flat	*Tagiades gana*
4	**Swallowtail**	87	Blue Mormon	*Papilio polymnestor*
		88	Common Banded Peacock	*Papilio crino*
		89	Common Jay	*Graphium doson*
		90	Common Mormon	*Papilio polytes*
		91	Common Rose	*Pachliopta aristolochiae*
		92	Crimson Rose	*Pachliopta hector*
		93	Five-bar Swordtail	*Graphium antiphates*
		94	Lime Butterfly	*Papilio demoleus*
		95	Malabar Banded Peacock	*Papilio buddha*
		96	Narrow-banded Bluebottle	*Graphium teredon*
		97	Paris Peacock	*Papilio paris*
		98	Red Helen	*Papilio helenus*
		99	Sahyadri Birdwing	*Troides minos*
		100	Tailed Jay	*Graphium agamemnon*
5	**Whites & Yellows**	101	Common Albatross	*Appias albina*
		102	Common Grass Yellow	*Eurema hecabe*
		103	Great Orange-tip	*Hebomoia glaucippe*
		104	Indian Jezebel	*Delias eucharis*
		105	Indian Wanderer	*Pareronia hippia*
		106	Lemon Emigrant	*Catopsilia pomona*
		107	Mottled Emigrant	*Catopsilia pyranthe*
		108	Painted Sawtooth	*Prioneris sita*
		109	Psyche	*Leptosia nina*
		110	Small Grass Yellow	*Eurema brigitta*
		111	Three-spot Grass Yellow	*Eurema blanda*
		112	Yellow Orange-tip	*Ixias pyrene*

VI. Marine Organisms

The marine molluscs are the best bio indicators of seawater. They are very sensitive to temperature, salinity and chemicals. During the visits, the Study team in one of the visits observed 81 cuttlebone (internal part of cuttlefish, *Sepiella inermis*) and in another visit also observed 62 cuttlebones near the UPCL discharge point Tenka Yermal seashore. The scientific literature also claims that cuttlefishes are very sensitive to temperature, salinity and chemicals. **The release of hot water discharged to the sea may be one of the reasons for cuttlefish's high rate of mortality**.

The Study team also observed deaths of two Dolphin young ones (calves) within the span of 3 days near the beaches of Padubidri (Figure no. 4.16), the young dolphins are also very sensitive to the temperature and chemicals. Apart from this, the Study team also found 3 dead turtles (Figure 4.14) and a turtle hatchling in the seashore of Kapu Taluk (Figure 4.15). All these sea creatures are endangered species. Hence the observations of the study team need to be given attention with further emphasis on these endangered animals as well as on critical ecosystems like oceans.

The following Table 4.12 gives the list of Marine Molluscs.

Table 4.12: List of Marine Molluscs

Family	Sl No.	Species
Muricidae	1	*Purpura bufo*
	2	*Indothias lacera*
Olividae	3	*Agaronia gibbosa*
Mytilidae	4	*Mytilopsis spp.*
Arcidae	5	*Anandara granosa*
	6	*Anandara pilula*
	7	*Anandara indica*
Donacidae	8	*Donax scrotum*
	9	*Donax incarnatus*
Tellinidae	10	*Tellina virgata*
Psammobiidae	11	*Hiatula diphos*
Veneridae	12	*Marcia opima*
	13	*Sunetta meroe*
	14	*Sunetta spp.*
	15	*Sunetta scripta*
	16	*Meretrix casta*
Mactridae	17	*Mactra chemntzi*
	18	*Mactrinula striatula*
Turitellidae	19	*Turitella spp.*
Rostellaridae	20	*Tibia spp.*
Naticidae	21	*Natica picta*
	22	*Natica vitellus*
Cypridae	23	*Cypraea spp.*
Ostridae	24	*Saccostrea cucullata*
	25	*Crassostrea spp.*
Dentaliidae	26	*Dentalium spp.*
Sepiidae	27	***Sepiella inermis* (Cuttle Fish)****

Figure 4.14: Dead Olive Ridley Sea Turtle on the coast off Kapu.

Figure 4.15: A hatchling of an Olive Ridley Sea Turtle going back to the sea off Kapu.

Figure 4.16: Dead Dolphin Calf on the sea coast off Padubidri, Kapu.

VII. Amphibians

Amphibians are unique amongst vertebrate animals as they lead a bimodal life. These are ectothermic in nature and have moist permeable skin that have made them highly sensitive to the changes in air, water and land. Hence, throughout the world Amphibians are considered as the best bio indicators amongst vertebrate animals. The local environmental changes on amphibians have to be studied in detail. The amphibians are active predators and constitute an important link in the food chain. They contribute incalculable services to agriculture. Hence, they are true friends of farmers. The Study team as well as the farmers observed a considerable amount of decline in the amphibian population at the time of field visits. The reasons for the loss of amphibian species and population may be due to the increase in the salinity and chemicals released into the environment by the coal based thermal power plant, UPCL. The scientific literature also

claims that Amphibians are very sensitive to salinity, chemicals and temperatures. The local climate change and loss of habitat may play an important role in the decline of amphibians as well as reptiles. The decline of amphibians and reptiles has a significant impact on other creatures including human beings. Following Table 4.13 gives the list of amphibians documented from the study area.

The study on herpetofauna would have been more appropriate if it is done across the seasons, as many species of amphibians and reptiles tend to shift with seasons as well as according to the changes in the surrounding temperature, relative humidity and other environmental conditions.

Table 4.13: List of Amphibians

Sl No	Family	Scientific Name	Common Name	IUCN Status
1	Bufonidae	*Duttaphrynus melanostictus*	Common Indian Toad	Least Concern
2	Dicroglossidae	*Euphlyctis cyanophlyctis*	Common Skittering Frog	Least Concern
3		*Euphlyctis hexadactylus*	Green Pond Frog	Least Concern
4		*Fejervarya caperata*	Wrinkled Fejervarya	Least Concern
5		*Fejervarya spp.*	Wrinkled Frog Variety	Least Concern
6		*Hoplobatrachus tigerinus*	Indian Bull Frog	Least Concern
7		*Minervarya rufescens*	Reddish Burrowing Frog	Least Concern
8		*Minervarya syhadrensis*	Sahyadri Cricket Frog	Least Concern
9		*Sphaerotheca dobsonii*	Dobson's Burrowing Frog	Least Concern
10	Ichthyophiidae	*Ichthyophis spp.*	Caecilian Variety	Least Concern
11	Microhylidae	*Microhyla ornate*	Ornate Narrow-mouthed Frog	Least Concern
12		*Uperodon taprobanicus*	Painted Baloon Frog	Least Concern
13	Ranidae	*Hydrophylax malabaricus*	Fungoid Frog	Least Concern
14		*Indosylvirana aurantiaca*	Golden Frog	Vulnerable
15	Rhacophoridae	*Polypedates maculatus*	Common Indian Tree Frog	Least Concern
16		*Polypedates spp.*	Tree Frog Variety	Least Concern
17		*Raorchestes spp.*	Bush Frog Variety	Least Concern
18		*Rhacophorus malabaricus*	Malabar Gliding Frog	Least Concern

VIII. Reptiles

Reptiles have a major role in the food chain and food web. In most ecosystems, reptiles are the vital part of food chains and they play an important role both as the prey species and the predators in ecosystems. Particularly in the agriculture sector, many serious agricultural pests like insects and rodent populations are controlled by reptiles. The snake's venom is used in manufacturing of modern life saving medicines. Some species of reptiles are declining due to habitat destruction, variations in the environmental factors and other threats. Serious efforts are required to analyse the effects of effluents and coal particles released by the Thermal Power Plants and other hazardous pollutants released by industries. Hence the long term monitoring and further detailed study is very essential. Following Table 4.14 gives the list of reptiles documented from the study area.

Table 4.14: List of Reptiles

Sl No	Family	Scientific Name	Common Name	Schedule WLPA	IUCN Status
1	Agamidae	*Calotes versicolor*	Oriental Garden Lizard	-	LC
2		*Psammophilus dorsalis*	Peninsular Rock Agama	-	LC
3	Chamaeleonidae	*Chamaeleo zeylanicus*	Indian Chameleon	Sch - II	LC
4	Cheloniidae	*Lepidochelys olivacea*	Olive Ridley Sea Turtle	Sch - I	VU
5	Colubridae	*Ptyas mucosa*	Common Rat Snake	Sch - II	LC
6		*Amphiesma stolatum*	Buff- Stripped Keelback	-	LC
7		*Xenochrophis piscator*	Checkered Keelback	Sch - II	LC
8		*Ahetulla nasuta*	Green Vine Snake	-	LC
9		*Lycodon aulicus*	Common Wolf Snake	-	NE
10		*Boiga trigonata*	Common Cat Snake	-	LC
11		*Coelognathus helena*	Common Trinket Snake	-	NE
12		*Sibynophis subpunctatus*	Dumeril's Black-headed Snake	-	NE
13		*Dendrelaphis tristis*	Common Bronzeback Tree Snake	-	-
14	Geomydidae	*Melanochelys trijuga*	Indian Black Turtle	-	NT
15	Elapidae	*Naja naja*	Spectacled Cobra	Sch - II	LC
16		*Bungarus caeruleus*	Common Indian Krait	-	-
17		*Hydrophis schistosus*	Hook-nosed Sea Snake	-	LC
18	Erycidae	*Eryx whitakeri*	Whitaker's Boa	-	-
19	Gekkonidae	*Hemidactylus frenatus*	Asian House Gecko	-	LC
20	Mabuyidae	*Eutropis carinata*	Common Keeled Skink	-	LC
21	Pythonidae	*Python molurus*	Indian Rock Python	Sch - I	NT
22	Trionychidae	*Lissemys punctata*	Indian Flapshell Turtle	Sch - I	VU
23	Typhlopidae	*Indityphlops braminus*	Common Worm Snake	-	LC
24	Varanidae	*Varanus bengalensis*	Bengal Monitor Lizard	Sch - I	NT
25	Viperidae	*Trimeresurus malabaricus*	Malabar Pit Viper	-	LC
26		*Daboia russelii*	Russell's Viper	Sch - II	LC
27		*Hypnale hypnale*	Hump-nose Pit Viper	-	-

IX. Mammals

Mammals are important members of food chains and food webs, as grazers and predators play a key role in maintaining a healthy ecosystem. They keep the populations of other animals in check and protect important plant species, thereby facilitating carbon sequestration and protection of water bodies. Mammals also interact with other species in many symbiotic relationships. Most of the mammals documented during the study are with direct sightings and indirect sightings. There are some globally threatened species in the study area. Illegal poaching, hunting, habitat loss are the main reasons. Hence more preference has to be given in the conservation of these threatened species. The following Table 4.15 gives the list of mammals documented from the study area.

Sl No	Family	Scientific Name	Common Name	Schedule WLPA	IUCN Status
1	Bovidae	*Bos gaurus*	Gaur	Sch- I	VU
2	Canidae	*Canis aureus*	Jackal	Sch- II	
3	Cercopithecidae	*Macaca radiata*	Bonnet Macaque	Sch- II	
4	Cercopithecidae	*Semnopithecus spp.*	Gray Langur	Sch- II	
5	Cervidae	*Rusa unicolor*	Sambar	Sch- III	VU
6	Cervidae	*Muntiacus muntjak*	Indian Muntjac	Sch- III	
7	Cervidae	*Axis axis*	Spotted Deer	Sch- III	
8	Felidae	*Panthera pardus*	Leopard	Sch- I	VU
9	Herpestidae	*Herpestes edwardsii*	Grey Mongoose	Sch- II	
10	Suidae	*Sus scrofa*	Indian Wild Boar	Sch- III	
11	Sciuridae	*Ratufa indica*	Indian Giant Squirrel	Sch- II	
12	Sciuridae	*Funambulus palmarum*	Three-striped Palm Squirrel	-	
13	Pteropodidae	*Pteropus giganteus*	Indian Flying Fox	Sch- IV	
14	Pteropodidae	*Rousettus leschenaultii*	Fulvous Fruit Bat	Sch- IV	
15	Muridae	*Rattus rattus*	Black Rat	Sch- V	
16	Lorisidae	*Loris lydekkerianus*	Slender Loris	Sch- I	NT
17	Leporidae	*Lepus nigricollis*	Indian Hare	Sch- IV	
18	Manidae	*Manis crassicaudata*	Indian Pangolin	Sch- I	E
19	Viverridae	*Paradoxurus hermaphroditus*	Common Palm Civet	Sch- II	
20	Tragulidae	*Moschiola indica*	Indian Chevrotain	-	
21	Hystricidae	*Hystrix indica*	Indian Crested Porcupine	-	

X.   Different Habitats in the Study Area

During the field visits, the study team have documented various flora and fauna as discussed in the previous chapters. The following are the images depicting different habitats and critical ecosystems in the study area which needs more conservation priorities. Figure 4.17: Shambhavi Riverine Ecosystem, 4.18: Mangrove Ecosystem, 4.19: Lake Ecosystem, Figure 4.20: Wetland Ecosystem, Figure 4.21: Estuarine Ecosystem, Figure 4.22: Pilarkan Reserve Forest.

Figure 4.17: Shambhavi Riverine Ecosystem

Figure 4.18: Mangrove Ecosystem

Figure 4.19: Lake Ecosystem

Figure 4.20: Wetland Ecosystem.

Figure 4.21: Estuarine Ecosystem.

Figure 4.22: Pilarkan Reserve Forest

4.7 Traffic Volume Survey

Traffic Volume Count is counting of number of vehicles passing through a road over a period of time. It is usually expressed in terms of Passenger Car Unit (PCU) and measured to calculate Level of Service of the road and related attributes like congestion, carrying capacity etc. The emission not only from industries but also from vehicular movement contributes to the air pollution; hence collection of vehicle movement data helps us in evaluating carrying capacity.

4.8 Industries

Though agriculture is a predominant activity in the district, industries in this district is fast developing. There are only few major industries in the district. However, the district is making all efforts to improve the small-scale industries in the region. The traditional industries around Udupi are tile manufacturing, beedi rolling, and cashew curing. Recently the industrial units comprising of few textiles, chemicals and engineering units are seen in the district. Besides these, off late other units like automobile, electrical and electronics, chemicals, ferrous and nonferrous, food and intoxicants, glass and ceramics, leather, paper and printing, rubber and plastics and other small-scale industrial units, which have registered their growth.

Chapter-5

ENVIRONMENTAL INDICATORS

Environmental indicators are the main components of the carrying capacity study; the environmental indicators are fixed based on the available resources in the study area. Few of the indicators are suggested in the CPCB methodology and few more were considered by the team based on their significance. The following are the main environmental indicators evaluated for carrying capacity.

1. Air emissions
2. Water use
3. Water available
4. Urban Land
5. Noise levels
6. Biodiversity- Forestry, flora and fauna
7. Traffic volume counts
8. Solid waste

Main pollution from coal and lignite based thermal power plants are classified as air emission, liquid waste, soil pollution and noise pollution.

5.1 Air emissions

The air emissions are generated due to the coal burning which are emitted through the stack apart from fly ash. The common air emissions from the coal based thermal power plants are as follows. Sulphur Dioxide (SO_2), Carbon Monoxide (CO), Oxides of Nitrogen (NOx), Ozone (O_3), Suspended Particulate Matter (SPM), Heavy metals like Mercury and Lead, Non-Methane Hydrocarbons, Carbon Dioxide (CO_2), Carbonaceous material (soot).

Source: Impacts of Power Plants | Thermal Watch

With respect to carrying capacity the level of air pollution is evaluated to understand, whether the region has carrying capacity or not. In other words, it is to determine the amount of fresh air supply in to the region is sufficient to dilute the polluted air or not.

Dispersion models are deterministic models, based upon physical theories that use source emission data, meteorology, and topography to create models of pollutant concentrations. Such models can be used to predict source-specific exposures.

The basic Gaussian plume-diffusion model is steady-state and hypothesizes that all meteorological, aerographic and surface parameters are uniform and constant throughout the air layer into which the pollutants are discharged. The pollutants are released at a height above the ground that is given by the physical stack height and the rise of the plume due to its momentum and buoyancy.

The degree of dilution is inversely proportional to the wind speed also the pollutant material reaching the ground level is reflected back into the atmosphere. The pollutant field is conservative; thus, it does not undergo any chemical reactions, transformation or decay. AERMOD is a steady-state plume dispersion model for the assessment of pollutant concentrations from point, volume, and area sources. The model employs hourly sequential pre-processed meteorological data to estimate concentrations by averaging times from one hour to one year. AERMOD employs continuous variables to characterize atmospheric conditions, rather than a fixed number of categories as used by traditional Gaussian models.

AERMOD is recommended by the EPA as the preferred dispersion model for general industrial modeling scenarios. Its performance was evaluated against observed concentrations for impacts emitted from UPCL stack, Udupi. For the present case simulations, the required source data input includes source type, emission rate, and location, stack height, stack gas exit velocity, stack inside diameter, stack gas temperature and elevation.

The AERMOD modeling system consists of two pre-processors and a core dispersion model. AERMET is the meteorological pre-processor for the AERMOD while AERMAP is the terrain pre-processor that characterizes the terrain, generates receptor grids, and facilitates the generation of hill height scales. Input data is collected from hourly cloud cover observations, surface meteorological observations, upper air sounding may include parameters and several vertical profiles of atmosphere. The model is very sensitive to land use parameters and complex coastal terrains.

The detailed procedure and assumptions in the study are given in the **Annexure 1.**

5.2 Water

Water is the basic necessity for human and animal consumption, Irrigation, fisheries, hydropower and industrial activities also demand water. The water use, that is the water demand for various purposes such as domestic, agricultural, industrial, livestock etc. in the region was evaluated. The obtained water demand was compared with the carrying capacity of the given region.

The total water availability including ground, surface and other sources of water was determined. Both surface and groundwater experiences the seasonal fluctuations, and details on these seasonal variations are mentioned in the inventory chapter.

The obtained water availability results are then compared with the carrying capacity to understand whether the study area can accommodate further usage of water resources or not. The Effluents are generated due to the Coal sludge, also known as slurry. The leachate from the coal yard is due to water sprinkling to avoid the fire catch. Coal sludge contains toxins such as Non-Methane hydrocarbons, heavy metals, and coal cleaning chemicals. The general heavy metal pollutants produced from the thermal

power plant are Lead, Mercury, Nickel, Tin, Cadmium, Antimony, Arsenic, Radio isotopes of thorium and strontium.

5.3 Land degradations

The soil near the coal based thermal power plant region gets contaminated due to coal dust deposition, fugitive emission, leachate and stack emission. The soil contaminants are Lead (Pb), Cadmium (Cd), Chromium (Cr), Arsenic (As), Copper (Cu), Zinc (Zn), Nickel (Ni) and Iron (Fe).
Source: Heavy metal accumulation in agricultural soils around a coal fired thermal power plant (Farakka) in India - PubMed (nih.gov)

The land is an essential environmental indicator in this study, as UPCL desires to expand their capacity. The land to be available for any developmental activities is calculated using an appropriate formula prescribed by CPCB. By using this result, it can be interpreted whether the study area has carrying capacity with respect to land or not. The following Table 5.1 shows the various environmental attributes that have been considered for arriving at the environmental carrying capacity.

Table 5.1: Various Environmental Attributes

Sl. No	Attribute	Parameter	Source of Data
1	**Land Use**	Trend of land use change for different categories	Digitized LULC 2019 layers using 2019- LISS-iv from NRSC 2002- LISS-iii + PAN from NRSC 2019- LULC layer from KSRSAC
2	**Water Quality**	Physical, Chemical and Biological parameters	Water samples are collected at different locations during this study period
3	**Ambient Air Quality**	PM2.5, PM10, NOx & SOx,	Secondary data from Karnataka State Pollution Control Board (KSPCB)
4	**Noise Levels**	Leq in dB(A)	Field data and Secondary data from Karnataka State Pollution Control Board (KSPCB)
5	**Ecology**	Existing terrestrial flora and fauna within the 10 Km radius of the study site.	Field survey and secondary sources from KFD.
6	**Geology**	Geological history	Secondary sources
7	**Soil**	Soil types and samples analysed for physical and chemical Parameters.	Field samples and secondary sources
8	**Socio - economic Aspects**	Socio-economic characteristics of 36 different villages	Based on field survey

5.4 Noise levels

The noise can cause adverse effects on human's mental and physical health The noise levels are one of the indicators to be focused in view of carrying capacity. It is crucial to evaluate the present noise levels and comparing it with the future noise levels after many developmental activities. The Ambient Noise Quality Standards as per Noise Pollution (Regulation and Control) Rules, 2000 was as followed:

Category of Area/Zone	Limits in dB(A) Leq	
	Day Time	Night Time
Industrial area	75	70
Commercial area	65	55
Residential area	55	45
Silence Zone	50	40

5.5 Biodiversity

5.5.1 Forests

Geographically the region is separated from the rest of south interior peninsula by the towering heights of the Western Ghats. The slopes of the Western Ghats are clothed with dense forests containing valuable timber species. The heavy rainfall in this area stimulates the growth of the forests, which sometimes, begin with a few kilometres of the seacoast. Generally, dense forest begins about 30 to 40 km. from the coast. Six types of forests are found in the State. The Udupi district is naturally blessed with evergreen, semi-evergreen and moist forests. Dense forest areas are more in Kundapura and Karkala Taluks.

5.5.2 Flora

The climatic and the edaphic factors of the district have promoted the spontaneous growth of plants and trees in all through the districts. The slopes of Western Ghats are covered with dense vegetation. In the coastal belt however, the tree-growth is somewhat sparse. The chief timber trees are the teak, rosewood, kiralbhogi, Matti and Kada halasu. The flora is luxuriant as well as complex and includes species like casuarinas, cashew trees, mango trees, etc. Climbers, reeds and canebrakes are found in abundance on the slopes of Western Ghats in the district. Turmeric is chiefly found in the Karkala taluk but is grown in small patches all over the district. Ginger, cardamom, plantains, pepper are some of the cash crops which are grown in the district.

5.5.3 Fauna

A large extent of forest lands in the district offers a safe home to all types of wild animals generally found in Southern India. Indian Leopard, Indian Guar, Sambar, Spotted deer, Wild Boars, Monkeys, Langurs, Porcupine, Mongoose, Giant Squirrels, etc. are amongst the important types of animals found in the district. Among the reptiles, Cobras, Python, Rat Snakes and the harmless green whip snakes are found in all parts of the district. The rivers, streams and the sea hosts variety of aquatic creatures. Among the insects, butterflies, odonates and moths are prominent. The number of leaf insects and the stick insects are also seen. The only economically valuable insect is the bee, which builds its nest on the higher branches of the lofty trees or in the clefts of rocks. Birds such as Peafowl, Jungle fowl and Spur fowl are seen in the forests. Partridges are not very common but Pigeons of several kinds are found.

5.6 Traffic volume

As per the information given by the National Highway Authority of India (NHAI), the following Tables 5.2, 5.3 and 5.4 shows the vehicle movements with in the study area.

Table 5.2: The Vehicle Movement Data for the year 2019

2019		
Sl.No	Month	Traffic Count
1	Jan-19	561379
2	Feb-19	481850
3	Mar-19	497866
4	Apr-19	543904
5	May-19	599410
6	Jun-19	473934
7	Jul-19	441929
8	Aug-19	423929
9	Sep-19	419665
10	Oct-19	518615
11	Nov-19	510404
12	Dec-19	533320
Total		**6006205**

Table 5.3: The Vehicle Movement Data for the year 2020

Sl.No	Month	Traffic Count
2020		
1	Jan-20	513765
2	Feb-20	503919
3	Mar-20	355549
4	Apr-20	34609
5	May-20	192221
6	Jun-20	313620
7	Jul-20	257897
8	Aug-20	374408
9	Sep-20	411738
10	Oct-20	491000
11	Nov-20	527191
12	Dec-20	600785
Total		**4576702**

Table 5.4: The Vehicle Movement Data for the year 2021

Sl.No	Month	Traffic Count
2021		
1	Jan-21	491000
2	Feb-21	527191
3	Mar-21	600785
4	Apr-21	515857
5	May-21	227642
Total		**2362475**

5.7 Solid Waste

The total solid waste generation in the district is required to throw a light on carrying capacity. The total solid waste generation was calculated. Out of total waste generated, fraction of the waste is collected and transported to Recycling, Re-using, Reprocessing and incineration and remaining was sent to dumping landfill site. Solid waste carrying capacity will be analysed from the waste generation and management potential and public perception. As per the sources available, the total solid waste generation in Udupi district is 107.6 T/D.

Chapter-6

ASSESSMENT OF CARRYING CAPACITY

Carrying capacity is an indicator of regional sustainability, and achieving regional sustainability is important because social institutions and ecological functions are closely linked at this scale (Graymore 2009). The concept of a sustainable carrying capacity is defined by a regional ecosystem's characteristics based on two premises. First, it must be possible to sustain the regional ecosystem's normal operations. Therefore, researchers usually calculate the quantity of resources and environmental capacity required to sustain these functions. Second, it is necessary to evaluate the regional population and intensity of activities that the natural resources can support after considering the needs of the ecosystem. The theory of environmental carrying capacity has been widely applied in environment planning and management. The carrying capacity depends strongly on environmental resources. However, there have also emerged some theoretical studies of carrying capacity based on various regional resources, owning the fact that carrying capacity is most often included within the larger theory of sustainable development.

$$\text{Carrying Capacity} = f \begin{cases} \text{Environmental impacts and natural resources;} \\ \text{Infrastructure and urban services;} \\ \text{Public Perception;} \\ \text{Institution Setting;} \\ \text{Society Supporting Capacity} \end{cases}$$

The Study area of Udupi Taluk is part of the Udupi district. As the impacts of this development activity of UPCL goes beyond the geographical boundaries and hence Udupi district as a whole is also being discussed in this chapter. Udupi district is bordered by the Arabian Sea on the West and Western Ghats on the east. The rivers in the districts mostly originate in the Western Ghats and the main drainage of the district is westwards. A range of urban settlements and development activities are located in or near the coastal zone which includes urban areas and many scattered settlements; large scale industries like UPCL; many small and medium scale industries, fishing and harbours like Malpe; infrastructure including NH17 and Konkan Railway.

6.1 Population

The 2011 census data of population is already mentioned in the previous chapter, the growing population leads to more demand for use of natural resources, and hence in view of carrying capacity, it is important to save the natural resources for the future generations, the developmental activities should not degrade the natural resources. Hence it is necessary to consider the population data in calculating carrying capacity for the region.

6.2 Coastal Zone

The coastal region of the district represents the highly dynamic ecosystems. Both landmass and wetland regions support enormous biodiversity due to unique ecological conditions. The coastal zone is under tremendous pressure from the population growth, industries, discharge of municipal and industrial waste. The coastal zone in addition comprises of many important estuaries, mangroves and wetlands with comprehensive flora and fauna. It is rich in marine biological resources. Human interventions intensify the marine pollution; hence it is very important aspect to study coastal zones while conducting carrying capacity.

6.3 Forest

The Udupi District has a biodiversity rich forest area with the forest cover of 2283.38 Sq.km and the geographical area of 3582 Sq. Km with very dense forest cover of 214.96 Sq.km, moderate forest cover of 1,405.09 Sq.km and open forest of 663 Sq.km. with unique flora and fauna. The Pilarkan Reserve forest is within the study area of 10 kms radius. The district is a unique biodiversity hotspots of the world. Though the forest resources are quite rich, they are also deeply fragile, and hence any disturbance will lead to ecological imbalance. Thus it is vital component for studying carrying capacity.

6.4 Rivers

As the Western Ghats are located on the eastern part of the district, the rivers and streams of this district necessarily flow from east to west. Varahi, Gangolli, Sitanadi, Swarna and Shambhavi are the important rivers in the district. In the monsoon season, all the rivers and streams swell due to heavy rains and some of them overflow to their banks, inundating the surrounding areas. These rivers on their journey towards the sea, get polluted. Heavy discharges of municipal sewage and industrial effluents pollute these rivers. Thus it is crucial to maintain the river drains very clean as rivers are important element in carrying capacity study.

6.5 Fisheries

Udupi is one of the coastal districts supporting many fishermen communities in the state. The rapid urbanization and industrialization have serious impacts on seas and marine life; hence it is very solemn aspect to be focussed while conducting carrying capacity studies.

6.6 Industries

There are 6 Large Scale Industries, 6 Medium Scale Industries and 11,283 Small-scale Industries in the district. Presently there are four major industrial areas viz Manipal, Nandikoor, Belapu and Miyar industrial areas. Two more industrial areas (Bola) and (Mulladka) are proposed to be set up and they are under progress. (Source: District at a Glance 2016). The industries in the study area contribute significantly towards the deterioration of the quality of air, water and soil. It is important to know about all the industries including UPCL that are present in the study area, to assess their contribution towards the environmental pollution.

6.7 Parameters evaluated

Carrying capacity of the region will be evaluated to assess the:
- Land use Land Cover Changes
- Qualitative analysis of soil
- Urban Land Carrying Capacity
- Monitoring and Analysis of Ambient Air
- Source Dispersion Modeling
- Assessment of Carrying capacity of Air
- Analysis of Water
- Assessment of Water resources carrying capacity
- Noise monitoring results
- People's Perception Survey
- Human Animal Conflict
- Observations

6.8 Analysis and results

The LULC classification is carried out for the year 2002 and 2019 by visual interpretation technique. This chapter briefs the results and outputs obtained from overlay analysis and change detection analysis.

6.9 LULC Change Detection Analysis outcomes

6.9.1 LULC Change between 2002 and 2019

The statistics generated from GIS analysis for the year 2002 to 2019 shows that Agricultural land is decreased by 1342 hectares with the difference of 7.55 %, whereas built up is increased by 2000.83 hectares with the difference of 56.08%. Forest area is decreased by 0.27%. Wasteland is decreased by 20.63% accounting to 656.52 hectares. Water bodies are decreased by 1.9 hectares with the difference of 0.31%. The detailed analysis LU/LC changes from 2002 to 2019 of level 1 and level 3 classifications is tabulated in the Table 6.1 and Figures 6.1 and 6.2.

Table 6.1: LULC Change between 2002 and 2019

	Landuse - Landcover (Level-I and III) changes between 2002 and 2019				
LULC Category		Area			% difference
		2002(Ha)	2019(Ha)	Difference(Ha)	
Level-I	**Agricultural Land**	**19149.14**	**17774.51**	**-1374.62**	**-7.73 Decrease**
L-III	Agricultural Plantation	6654.78	9197.13	2542.35	27.64 Increase
L-III	Aquaculture/pisciculture	0	4.66	4.66	100.00 Increase
L-III	Crop land	12494.36	8572.73	-3921.63	-45.75 Decrease
Level-I	**Built up**	**1570.24**	**3574.67**	**2004.44**	**56.07 Increase**
L-III	Built up (Rural)	92.16	261.15	168.98	64.71 Increase
L-III	Built up (Urban)	265.24	497.64	232.4	46.70 Increase
L-III	Hamlets and dispersed household	159.66	355.59	195.94	55.10 Increase
L-III	Mining/ Industrial	11.02	315.66	304.65	96.51 Increase
L-III	Mixed Settlement	374.9	1474.41	1099.51	74.57 Increase
L-III	Transportation	360.14	361.92	1.78	0.49 Increase
L-III	Village	307.12	308.3	1.18	0.38 Increase
Level-I	**Forest**	**144.66**	**144.48**	**-0.19**	**-0.13 Decrease**
L-III	Forest	144.66	144.48	-0.19	-0.13 Decrease
Level-I	**Waste land**	**3833.35**	**3181.54**	**-651.81**	**-20.49 Decrease**
L-III	Barren rocky	332.7	279.5	-53.2	-19.03 Decrease
L-III	Salt affected	19.96	14.09	-5.87	-41.66 Decrease
L-III	Sandy areas	16.8	14.81	-1.99	-13.44 Decrease
L-III	Scrub land Dense	948.48	875.15	-73.33	-8.38 Decrease
L-III	Scrub land Open	2507.03	1986.18	-520.84	-26.22 Decrease
L-III	Waterlogged	8.39	11.81	3.42	28.96 Increase
Level-I	**Waterbodies**	**595.55**	**617.73**	**22.19**	**3.59 Increase**
L-III	Lakes/Ponds	1.22	1.65	0.43	26.06 Increase
L-III	Reservoir/Tanks	13.3	26.45	13.15	49.72 Increase
L-III	River/Stream/Drain	581.03	589.63	8.61	1.46 Increase
Grant Total		**25292.94**	**25292.94**		
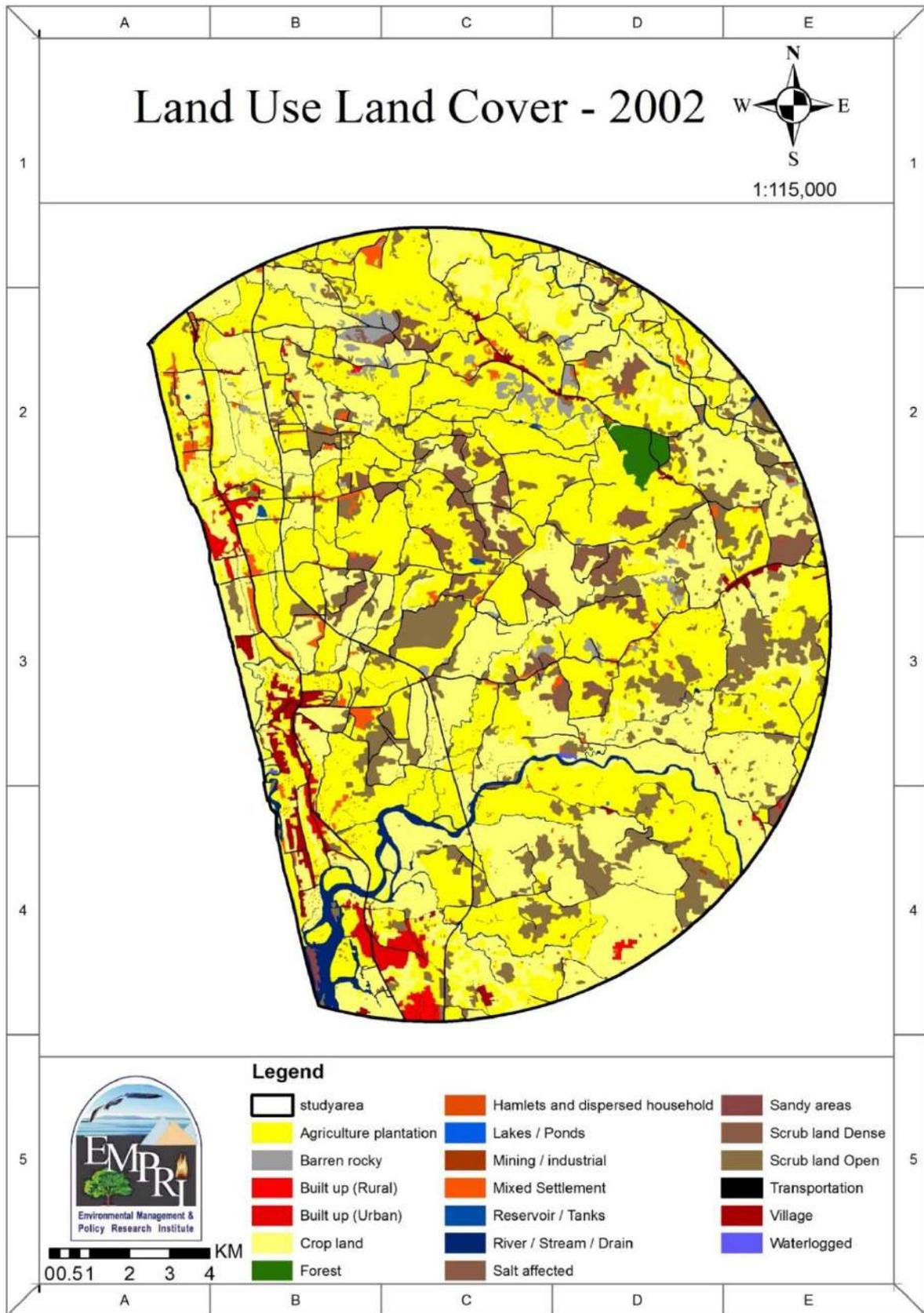
Figure 6.1: Land Use/ Land Cover Map – 2002
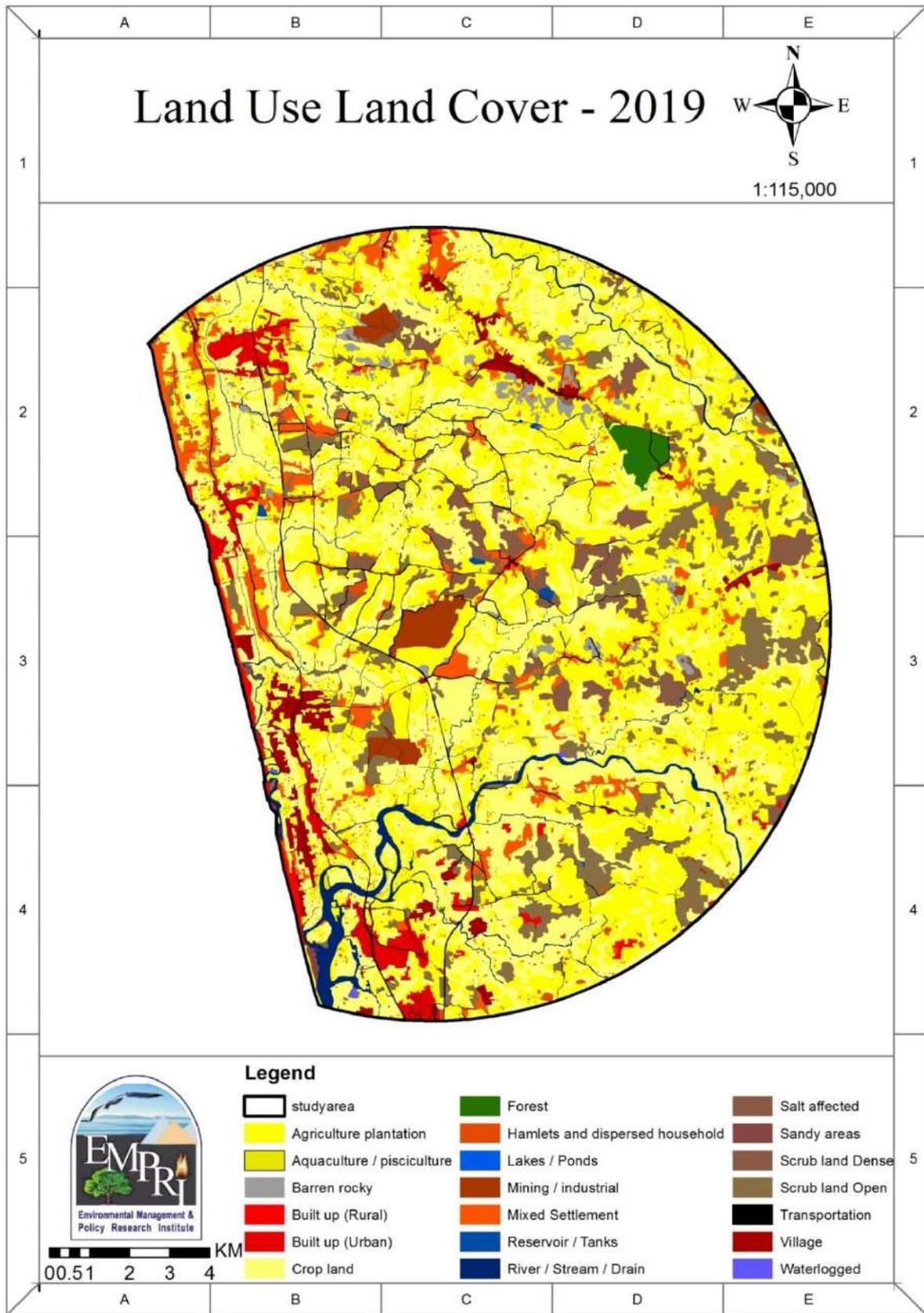
Figure 6.2: Land Use/ Land Cover Map – 2019

6.9.2 Overlay analysis

To estimate the land transformation from one class to another class overlay analysis is carried out. In the current study two sets of vector feature classes such as 2002 and 2019 LULC are considered to analyse the spatial relationship and change detection in the study area. Using the following attribute information, the change detection was analysed to trace the transformation in LULC. The statistical representation of Individual Class indicates the conversion of particular LULC (to and from various other classes) is detailed below.

1) **Agricultural Land:** Agricultural land has two major sub classes namely
   - Agricultural Plantation and
   - Crop land

With the observation the agricultural land has been decreased by conversion into other LULC classes

      a. Agricultural Plantation

The detail conversion of the agricultural plantation into other classes, that is totally 1224.86 hectares of agricultural plantation has been converted in the entire study area from 2002 to 2019, majorly into built up. The details are tabulated in the Table 6.2 (from 2002 to 2019).

Table 6.2: Distribution of LULC Classes in Agricultural Plantation (2002-2019)

Year	LULC Classes	Area in Ha
2002	Agriculture plantation	6654.78
Unchanged Area		
2019	Agriculture plantation	5429.92
Agriculture Plantation to other classes		
2019	Barren rocky	3.78
2019	Built up (Rural)	41.70
2019	Built up (Urban)	68.32
2019	Crop land	364.20
2019	Hamlets and dispersed household	52.47
2019	Lakes / Ponds	0.43
2019	Mining / industrial	4.02
2019	Mixed Settlement	659.38
2019	River / Stream / Drain	0.01
2019	Salt affected	0.02
2019	Sandy areas	0.00
2019	Scrub land Dense	2.13
2019	Scrub land Open	28.20
2019	Transportation	0.21
	Total	**1224.86**

b. Crop Land

The changes occurred in crop land are tabulated in Table 6.3, which indicates the distribution in crop land about 4320.91 hectares of crop land is converted to other classes.

Table 6.3: Distribution of LULC Classes in Crop Land (2002-2019)

Year	LULC Classes	Area in Ha
2002	Crop land	12494.36
Unchanged Area		
2019	Crop land	8173.44
Crop land to other classes		
2019	Agriculture plantation	3546.84
2019	Aquaculture / pisciculture	4.66
2019	Barren rocky	0.01
2019	Built up (Rural)	176.45
2019	Built up (Urban)	110.46
2019	Hamlets and dispersed household	82.65
2019	Mining / industrial	29.95
2019	Mixed Settlement	344.17
2019	Reservoir / Tanks	3.80
2019	River / Stream / Drain	3.19
2019	Scrub land Dense	9.02
2019	Scrub land Open	2.86
2019	Transportation	0.02
2019	Village	1.04
2019	Waterlogged	5.80
Total		**4320.91**

1. Built up

Built up has 7 major sub classes namely Built up (Rural), Built up (Urban), Hamlets and dispersed household, Mining/ Industrial, Mixed Settlement, Transportation and Village. However, there are no changes in Built up to various other LU/LC classes.

2. Forest

There are no significant changes observed in forest area around 0.19 hectares of forest area is converted into Hamlets and dispersed household from 2002 to 2019. The detailed tabulation is shown in the Table 6.4 below.

Year	LULC Classes	Area in Ha
2002	Forest	**144.66**
Unchanged Area		
2019	Forest	144.48
Forest to other classes		
2019	Hamlets and dispersed household	0.19
	Total	0.19

3. Water bodies

There are three major sub classes namely

- Lakes / Ponds
- River / Stream / Drain
- Reservoir / Tanks

There are no changes from Lakes / Ponds and Reservoir / Tanks to various other LU/LC classes. However, the changes observed from River / Stream / Drain is tabulated as below in Table No. 6.7.

4. Waste land

There are six major sub classes namely:
  a. Barren rocky
  b. Salt affected
  c. Sandy areas
  d. Scrub land Dense
  e. Scrub land Open

Changes from waste land to various other LU/LC classes are identified only from Scrub Land Open and Scrub Land Dense. And no changes observed in other classes of waste land.

a. Barren Rocky

The detail conversion of barren rocky into other classes, that is totally 73.58 hectares of barren rocky has been converted to other classes in the entire study area from 2002 to 2019 majorly into Mining/industrial. The details are tabulated in Table 6.5.

Year	LULC class	Area In Ha
2002	Barren rocky	332.70
Unchanged Area		
2019	Barren rocky	259.12
Barren rocky to other classes		
2019	Agriculture plantation	0.01
2019	Hamlets and dispersed household	0.57
2019	Mining / industrial	53.55
2019	Mixed Settlement	11.29
2019	Scrub land Dense	2.72
2019	Scrub land Open	5.43
	Total	73.58

b. Salt Affected Area:

The Table 6.6 shows the detail conversion of salt affected area into other classes. Totally 5.88 hectares of the salt affected area has been converted to other Land-use Classes as tabulated below.

Table 6.6: Distribution of LULC Classes in Salt Affected Area (2002-2019)

Year	LULC class	Area In Ha
2002	**Salt affected**	**19.96**
Unchanged Area		
2019	Salt affected	14.07
Salt affected to other classes		
2019	Hamlets and dispersed household	0.49
2019	Mixed Settlement	0.82
2019	Scrub land Open	4.58
	Total	**5.88**

c. Sandy Area

The Table 6.7 shows that the 1.99 hectares of sandy area is converted to River / Stream / Drain.

Table 6.7: Distribution of LULC Classes in Sandy Area (2002-2019)

Year	LULC Classes	Area in Ha
2002	Sandy areas	16.80
Unchanged Area		
2019	Sandy areas	14.81
Sandy areas to other classes		
2019	River / Stream / Drain	1.99
	Total	1.99

d. Scrub Land Open

The changes occurred in Scrub Land Open are tabulated in Table 6.8 below. It infers that 568.72 hectares of Scrub Land Open is converted to other classes from 2002 to 2019 mainly to build up area.

Table 6.8: Distribution of LULC Classes in Scrub Land Open (2002-2019)

Year	LULC Classes	Area in Ha
2002	Scrub land Open	2507.03
Unchanged Area		
2019	Scrub land Open	1938.31
Scrub land Open to other classes		
2019	Agriculture plantation	93.27
2019	Barren rocky	16.59
2019	Built up (Rural)	2.94
2019	Built up (Urban)	0.07
2019	Crop land	29.55
2019	Hamlets and dispersed household	43.94
2019	Mining / industrial	213.55
2019	Mixed Settlement	83.85
2019	Reservoir / Tanks	0.89
2019	River / Stream / Drain	3.17
2019	Scrub land Dense	79.21
2019	Transportation	1.54
2019	Village	0.14
	Total	**568.72**

e. Scrub land Dense

The changes occurred in Scrub Land Dense are tabulated in Table 6.9 below, which indicates that 166.43 hectares of scrub land Dense is converted to other classes from 2002 to 2019 mainly to Agricultural plantation and followed by build-up area.

Table 6.9: Distribution of LULC Classes in Scrub Land Dense (2002-2019)

Year	LULC Classes	Area in Ha
2002	Scrub land Dense	948.48
Unchanged Area		
2019	Scrub land Dense	782.05
Scrub land Dense to other classes		
2019	Agriculture plantation	127.10
2019	Built up (Urban)	1.45
2019	Crop land	5.53
2019	Hamlets and dispersed household	15.63

2019	Mining / industrial	3.58
2019	Mixed Settlement	0.00
2019	Reservoir / Tanks	8.46
2019	River / Stream / Drain	0.00
2019	Scrub land Open	4.67
	Total	**166.43**

6.10 Soil Sampling and Analysis

Soil testing is an essential component of soil resource management. The results obtained from the laboratory analysis depends on the sampling precision. So each sample collected must be a true representative of the area under the study. Hence, collection of large number of samples is advisable so that sample of desired size can be obtained by sub-sampling. For soil survey work, samples are collected from a soil profile representative to the soil of the surrounding area.

The Sampling Locations are shown in a Google map given below.
Reference: EPA 3051 and EPA 3051A
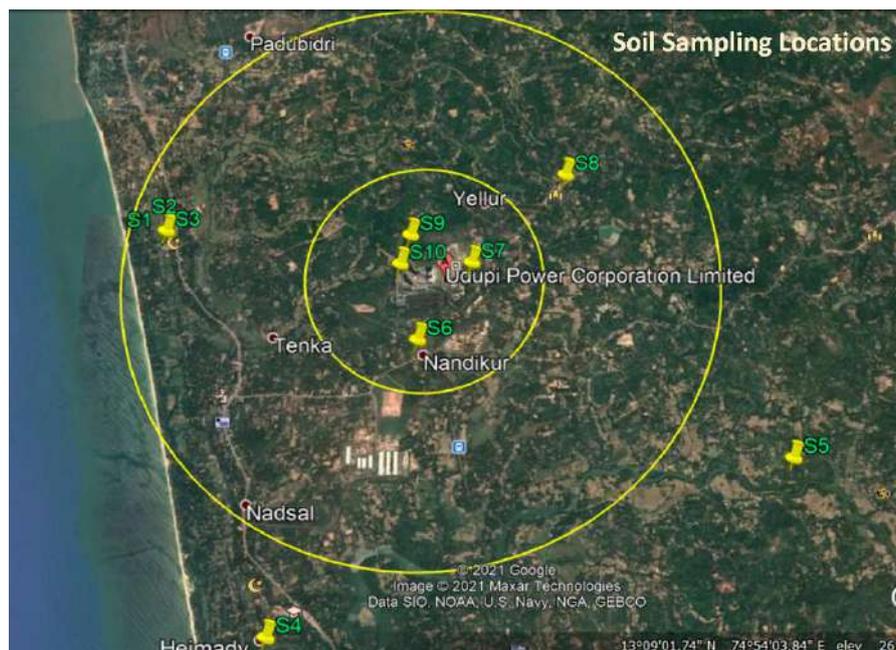
Figure 6.3: Soil Sampling Locations

S1 = Pump House Seawater Sedimentation Tank -1
S2 = Pump House Seawater Sedimentation Tank -Ii
S3 = Pump House
S4 = Hejamady Village
S5 = Inna Village
S6 = Nandikoor Village
S7 = Near Fire Station
S8 = Mudarangadi Village
S9 = R & R Adamar Village
S10 = Ullooru

Table 6.10: Consolidated results of Soil Sample Analysis from 10 locations: (by GLENS)

S. No	Pollutant	PH Sed Tank – I	PH Sed Tank - II	Pump House	Hejamady Village	Inna Village	Nandikoor Village	Near Fire Station	Mudarangadi Village	R & R Adamar Village	Ullooru-1
					Results of Soil Samples Analysis All Units in mg/ Kg						
1	Antimony (Sb)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)
2	Arsenic (As)	2.84	9.48	4.19	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	8.0	3.00	4.14
3	Zinc (Zn)	10.89	30.52	114.01	8.54	17.97	13.13	5.14	77.03	13.37	7.57
4	Cobalt (Co)	2.82	7.22	6.44	BLQ (LOQ:2.0)	2.58	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	3.58	4.30	BLQ (LOQ:2.0)
5	Cadmium (Cd)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)
6	Molybdenum (Mo)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	11.03	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	2.07	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)
7	Nickel (Ni)	6.57	28.8	16.84	5.08	10.63	6.53	3.21	9.44	9.46	4.83
8	Chromium (Cr)	20.31	75.05	59.5	19.22	69.25	31.73	43.1	92.95	29.56	79.08
9	Mercury (Hg)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)	BLQ (LOQ:2.0)
10	Copper (Cu)	3.58	14.35	78.35	4.75	18.28	7.59	7.37	20.72	10.2	7.99
11	Hexavalent Chromium (Cr^{6+})	BDL (DL:5.0)	BDL (DL:5.0)	BDL (DL:5.0)	BDL (DL:5.0)	BDL (DL:5.0)	BDL (DL:5.0)	BDL (DL:5.0)	BDL (DL:5.0)	BDL (DL:5.0)	BDL (DL:5.0)
12	Iron (Fe)	7761.9	24595.3	25880.83	7027.96	17878.38	5094.5	17163.08	394060.76	21130.16	17981.21
13	Lead (Pb)	2.98	9.63	23.91	3.55	9.3	7.04	5.13	14.09	9.26	6.61
14	Manganese as Mn	104.35	154.78	118.92	17.41	24.83	15.05	25.48	271.23	145.11	18.52

Note:

1. BLQ -Below the limit of Quantification

Table 6.11: Physico-Chemical Analysis sampled during the month of April 2021. (By EMPRI)

S. No	Parameter	PH Sed Tank - I	PH Sed Tank - II	Inna Village	Nandikoor Village	Pump House	Hejamady Village	Near Fire Station	Mudarangadi Village	R & R Adamar Village	Ullooru -1
	Results of Soil Samples Analysis **All Units in mg/ Kg (except pH, EC & Temperature)**										
1	pH	7.26	6.81	6.30	5.7	5.05	6.21	6.60	6.23	6.83	5.73
2	EC µS/cm	2400	261	31	48	357	141	102	71	171	168
3	Temperature ^{0}c	25.8	25.9	25.9	26	26.2	25.9	25.8	26	25.9	25.8
4	Available Sodium	1250.00	1390.00	100.00	320.00	880.00	620.00	830.00	180.00	420.00	330.00
5	Available Potassium	180.00	210.00	370.00	130.00	540.00	100.00	200.00	830.00	230.00	430.00

The levels of heavy metals in the soil were highest for Fe and Mn followed by Zn, Cr and Cu.

In the soil samples,

Fe content ranged from 5094.5 to 394060.76 mg/kg dry soil,

Mn ranged from 15.05 to 271.23,

Zn ranged from 5.14 to 114.01 mg/kg,

Cr ranged from 19.22 to 92.95 mg/kg and

Cu ranged from 3.58 to 78.35 mg/kg.

Following heavy metals in the soil were lowest for Ni followed by Pb, Mo, As and Co. In the soil samples, the

Ni content ranged from 3.21 to 28.80 mg/kg,

Pb ranged from 2.98 to 23.91 mg/kg,

Mo ranged from 2.07 to 11.03 mg/kg,

As ranged from 2.98 to 23.91 mg/kg

Co ranged from 3.21 to 28.8 mg/kg.

Table 6.12: Consolidated results of Soil Sample Analysis (by GLENS)
Soil Sample from 6 locations. Date of visit (15-03-2021 to 18-03-2021)

	Results of Soil Samples Analysis All Units in mg/ Kg (except pH, EC& Temperature)						
S. No	Parameter	Inna Village AAQMS- 2	Nandikoor Village	Hejamady Village AAQMS- 1	Ullooru - 1	Mudarangadi Village	R & R Adamar Village
1	pH	5.99	6.15	8.15	6.03	7.72	7.41
2	EC for 1 hr.	94	72	136	667	54	24
3	EC for 24 hr.	84	78	147	734	46	24
4	Temp ^{0}c	25.3	25.1	25.5	25.1	25.2	25.2
5	Available Copper	30.97	26.57	4.46	26.14	97.87	14.99
6	Available Iron	1525.08	1468.45	1434.52	1530.75	1528.58	1534.36
7	Available Zinc	40.28	47.53	10.75	39.03	207.08	24.39

Table 6.13: Results of Soil Sampling in the month of December 2020.

	Results of Soil Samples Analysis All Units in mg/ Kg (except pH, EC & Temperature)						
S. No	Parameter	S. S. 1	Ash Pond	N. H. P	T.Y. 1	Nandikoor	T.Y-B
1	pH	8.05	8.63	8.68	8.31	8.71	7.44
2	EC µS/cm	594	861	160	1104	750	1000
3	Temperature ^{0}c	23.2	23	23.1	22.9	23	22.5
4	Available Copper	1.88	39.87	3.75	9.32	20.84	27.44
5	Available Iron	1329.04	1519.38	1456.21	1516.86	1485.64	1536.51
6	Available Zinc	208.96	70.06	137.44	23.15	36.83	86.07

6.11 Soil

The levels of metals in the soil were highest for Fe and Mn followed by Zn, Cr and Cu. In the soil samples, the Fe content ranged from 5094.5 to 394060.76 mg/kg dry soil, Mn ranged from 15.05 to 271.23, Zn from 5.14 to 114.01 mg/kg, Cr ranged from 19.22 to 92.95 mg/kg and Cu ranged from 3.58 to 78.35 mg/kg. Heavy metals in the soil were lowest for Ni followed by Pb, Mo, As and Co. In the soil samples, the Ni content ranged from 3.21 to 28.80 mg/kg, Pb ranged from 2.98 to 23.91 mg/kg, Mo ranged from 2.07 to 11.03 mg/kg, As ranged from 2.98 to 23.91 mg/kg and Co ranged from 3.21 to 28.8 mg/kg. This shows some heavy metal concentration in the soil in this region. For any further expansion of industries or new industries, the aspect of soil contamination should be looked into.

6.12 Monitoring & Analysis of Ambient Air

The monitoring of air is an essential component in the assessment of carrying capacity. It is crucial to identify the level of pollutants in the region and to evaluate the carrying capacity of air. Here the major pollutants analysed were **PM$_{2.5}$, PM$_{10}$, SOx** and **NOx**.

a) **Siting requirement**

Samplers have been sited to meet the goals of the specific monitoring requirement. For this study, sampling was carried out to determine the compliance with the National Ambient Air Quality Standards (NAAQS) and sampler sitting as described in CPCB guidelines. The monitoring has been done outside the zone of influence of sources located within the designated zone of representation for the monitoring site.

b) **Sampling and analysis of Particulate Matter**

The National ambient air quality standards for PM$_{2.5}$, PM$_{10}$, SOx and NOx.

Sampling and Analysis of PM10 in ambient air (Gravimetric Method):

Table 6.14: The National Ambient Air Quality Standards for PM$_{10}$

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)
Particulate Matter, PM10, μg/m^3	Annual *	60	60
	24 Hours **	100	100

*   Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 8 hourly or 1 hourly monitored value, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

Reference: IS 5182 Part 23 Method of Measurement of Air Pollution: Respirable Suspended Particulate Matter (PM10) Cyclonic Flow Technique.

The detailed methodology for the Monitoring and Sampling including the Principle, Calculation formula, Quality Control are given in **Annexure – 1.**

Sampling and Analysis of PM2.5 in ambient air (Gravimetric Method)

Table 6.15: The National Ambient Air Quality Standards for PM$_{2.5}$

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)
Particulate Matter, PM2.5, µg/m^3	Annual *	40	40
	24 Hours **	60	60

* Annual Arithmetic mean of minimum104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

* 24 hourly or 8 hourly or 1 hourly monitored value, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

Reference: 40 CFR Parts 53 and 58 Revised Requirements for Designation of Reference and Equivalent Methods for PM2.5 and Ambient Air Quality Surveillance for Particulate Matter; PM2.5 Gravimetric Analysis - Revision 7, August 14, 2003, Page 2 of 24 RTI (Research Triangle Institute, US). The detailed methodology for the Monitoring and Sampling including the Principle, Calculation formula, Quality Control is given in the Glens report.

a) Sampling and Analysis of Sulphur Dioxide in Ambient Air
(Improved West and Geake Method)

Table 6.16: The National Ambient Air Quality Standards for Sulphur dioxide

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)
Sulphur Dioxide (SO2), µg/m^3	Annual *	50	20
	24 Hours **	80	80

* Annual Arithmetic mean of minimum 104 measurements in a year, at a particular site, taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

Reference: IS 5182 Part 2 Method of Measurement of Air Pollution: Sulphur Dioxide.

The detailed methodology for the Monitoring and Sampling including the Principle, Calculation formula, Quality Control are given in **Annexure – 1.**

b) Sampling and Analysis of Nitrogen Dioxide in Ambient Air
(Modified Jacob and Hochheiser Method)

Table 6.17: The National Ambient Air Quality Standard for Nitrogen dioxide

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)
Nitrogen Dioxide (NO2), µg/m^3	Annual *	40	30
	24 Hours **	80	80

* Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

The Ambient Air Quality Monitoring Locations with the reference to the UPCL is given in the Figure No. 6.4 as shown below.
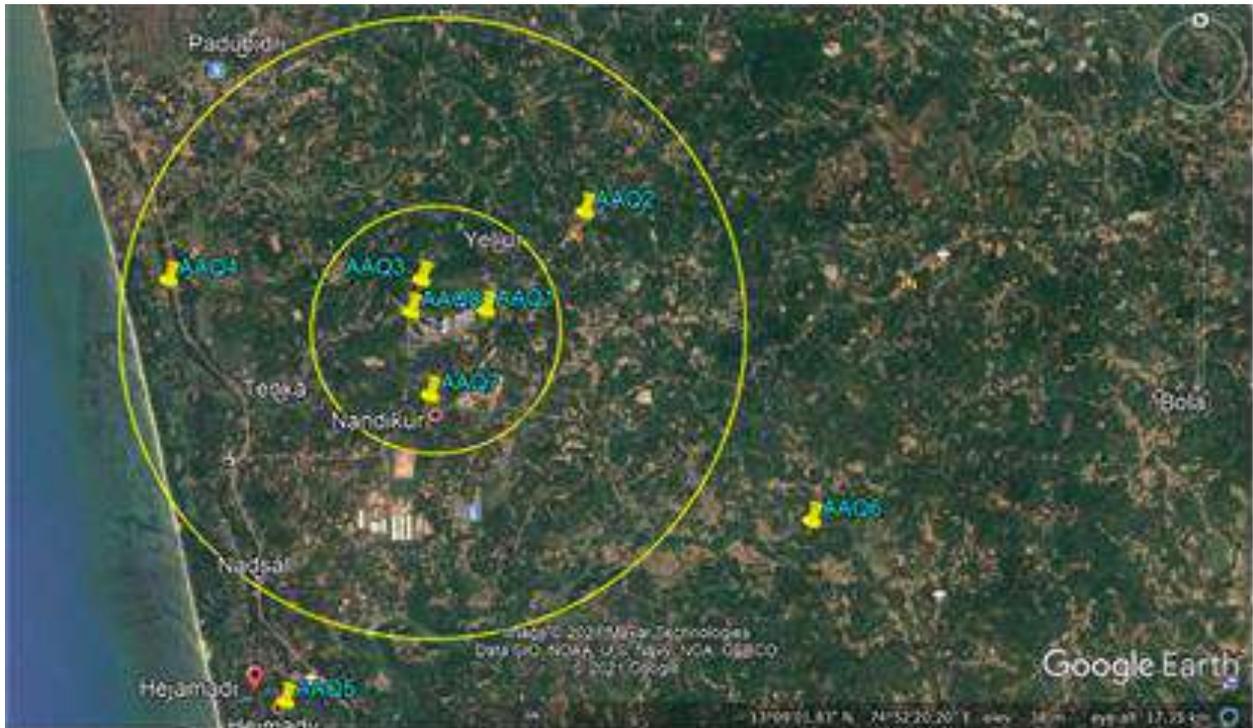
Figure 6.4: Google Earth Map – Ambient Air Quality Monitoring Locations

Ambient Air Monitoring was carried out in the following Locations:

AAQMS No 1: Top of the fire Station

AAQMS No 2: Mudarangadi Village

AAQMS No 3: R&R Colony, Adamar Village

AAQMS No 4: UPCL Seawater pump house (Tenka – Yermal Village)

AAQMS No 5: Hejamady village

AAQMS No 6: Inna Village

AAQMS No 7: Nandikoor Village

AAQMS No 8: Ullooru Village

6.13 Results & Discussions

6.13.1 Ambient Air Quality Monitoring Results

For the Ambient Air Quality Monitoring, eight sampling locations were identified to assess the Ground Level Concentration (GLC) of point source emission of Gaseous and Particulate matter.

The consolidated results of Ambient Air Quality Monitoring for the 1st day during 2nd to 3rd April 2021 for all the eight locations are tabulated in the Table 6.18 as given below.

Wind Direction: WNW

Ambient Temperature: In the range between 25 – 33.3°C

Relative humidity: In the range between 49 – 85 %.

The height of the Sampler in all the locations was at 5.0 metres from the ground.

Table 6.18: AAQM Consolidated Monitoring Results

Day:1 AAQM Consolidated Monitoring Results [02.04.2021 to 03.04.2021] Unit of measurement is μg/m³				
Sampling Location	**SO_2**	**NO_2**	**PM_{10}**	**$PM_{2.5}$**
Top of the Fire Station	12.4	15.5	54.5	23.5
Mudarangadi Village	6.7	11.7	52.7	22.1
R&R Colony, Adamar Village	9.2	13.3	45.5	16.4
UPCL Seawater Pump House	12.1	14.6	47	17.7
Hejamady Village	9.7	12.4	50.3	18.8
Inna Village	10	12	51.1	20
Nandikoor Village	11	12.8	49.4	18.9
Ullooru Village	10.3	12.7	48.7	18.5

The values in graphical presentation are given in the following page for Day 1 of monitoring viz 2nd to 3rd April 2021.

Day:1 AAQM Consolidated Monitoring Results

DAY:1 AAQM CONSOLIDATED MONITORING RESULTS
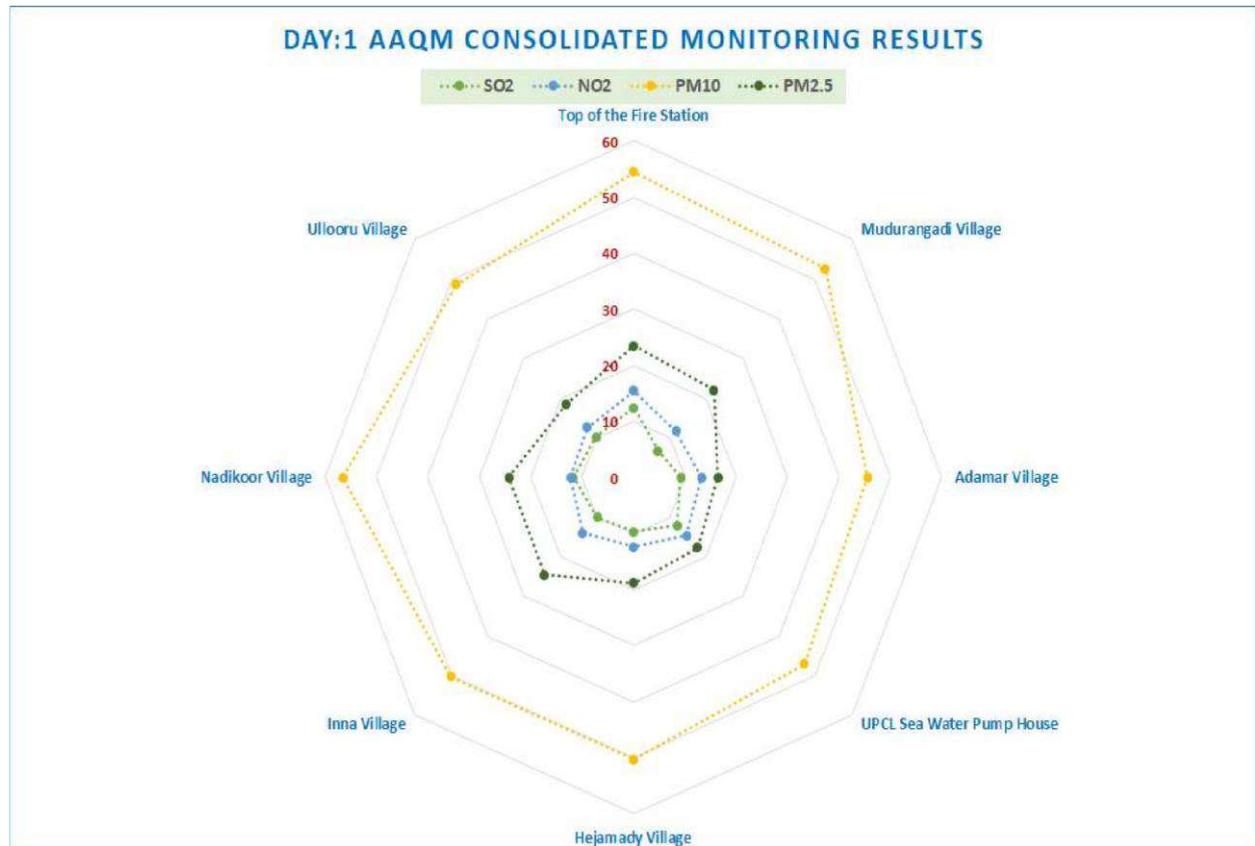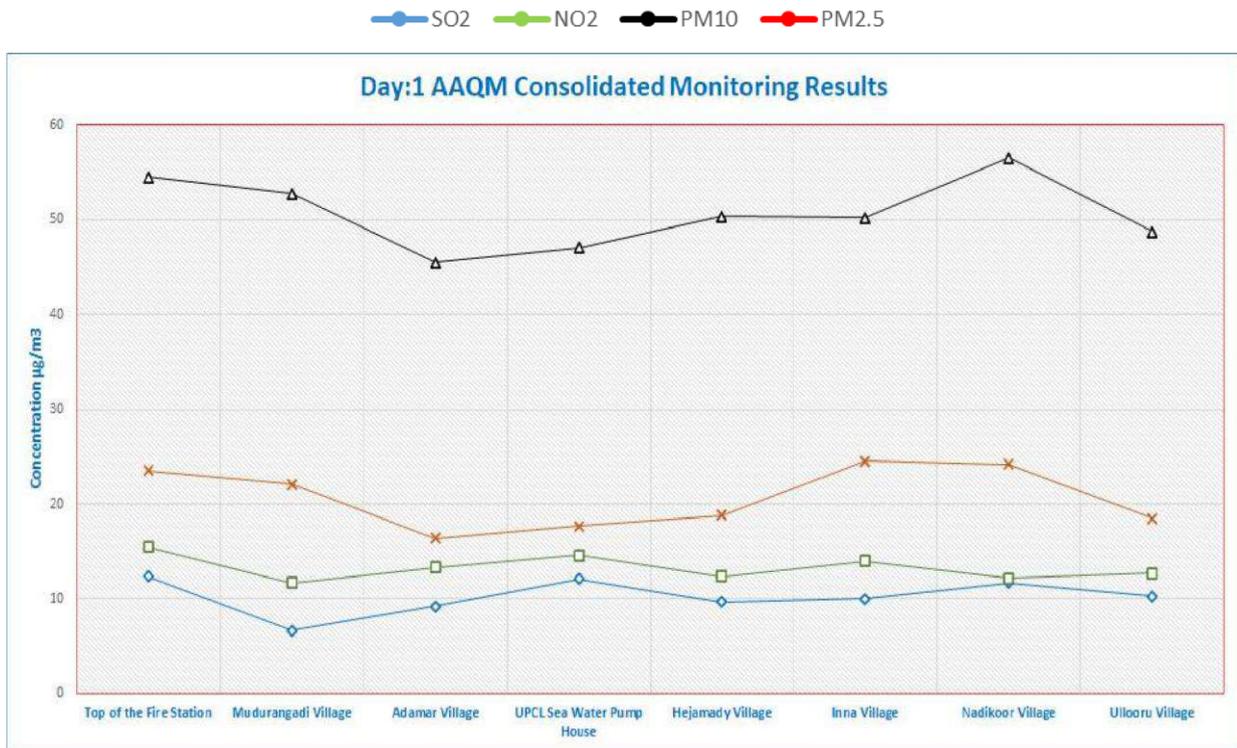
The consolidated results of Ambient Air Quality Monitoring for the 2nd day during 3rd to 4th April 2021 at all the eight locations are tabulated in the Table 6.19 as given below.

Wind Direction: WNW

Ambient Temperature: In the range between 25 – 32.8°C

Relative humidity: In the range between 49 – 82 %.

The height of the Sampler in all the locations was at 5.0 metres from the ground.

Table 6.19: Day 2 AAQM Consolidated Monitoring Results

Day:2 AAQM Consolidated Monitoring Results [03.04.2021 to 04.04.2021] Unit of measurement is µg/m³				
Sampling Location	**SO2**	**NO2**	**PM10**	**PM2.5**
Top of the Fire Station - UPCL	13.2	13.8	58.8	26.4
Mudarangadi Village	7.3	11.1	50.9	26.6
R&R Colony, Adamar Village	8	9.5	52.5	20.7
UPCL Seawater Pump House	9.7	11	51.4	19.4
Hejamady Village	10.4	14.2	53	21.1
Inna Village	10	12	51.1	20
Nandikoor Village	11	12.8	49.4	18.9
Ullooru Village	11.8	14.5	51.7	21.3

The values in graphical presentation are given in the following page for Day 1 of monitoring viz 3rd to 4th April 2021.

Day:2 AAQM Consolidated Monitoring Results

DAY:2 AAQM CONSOLIDATED MONITORING RESULTS

Environmental Carrying Capacity study for expansion of 2X600 MW Udupi Power Plant   82
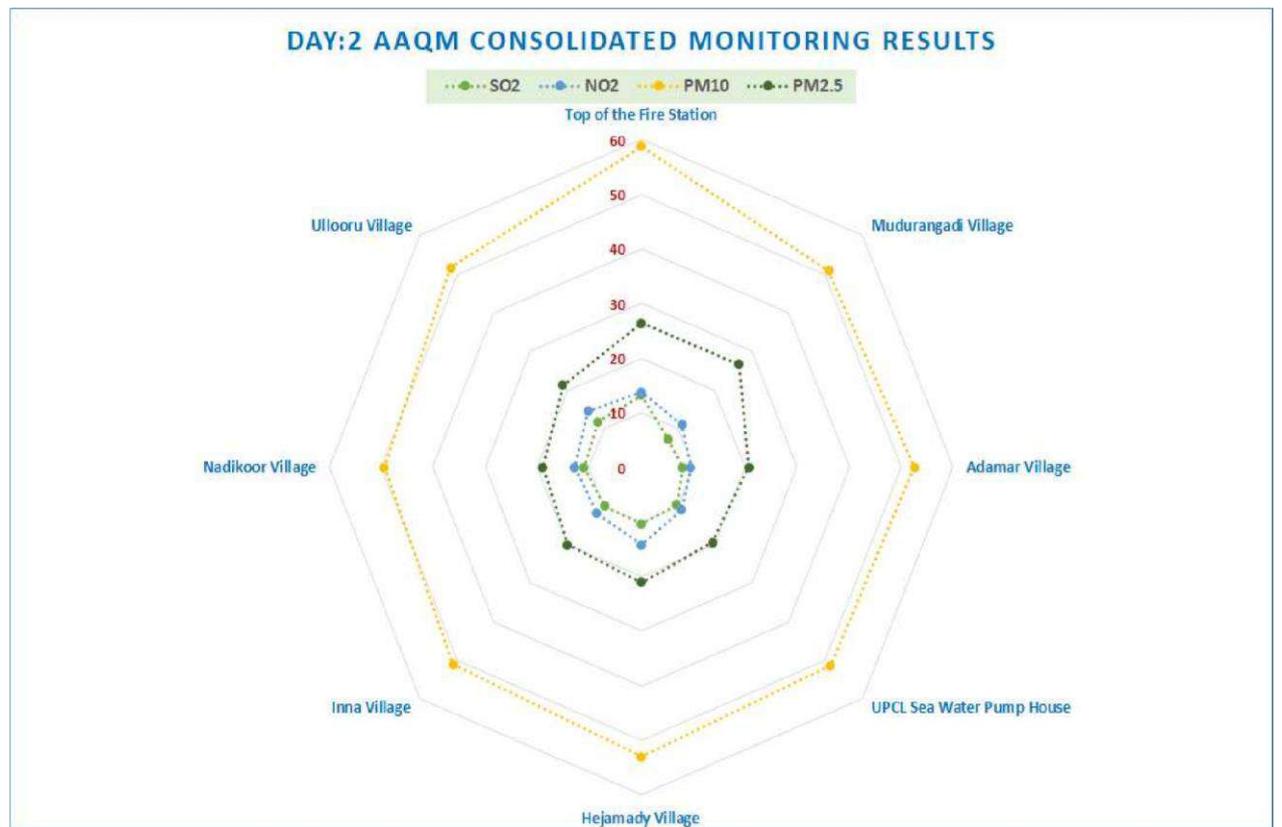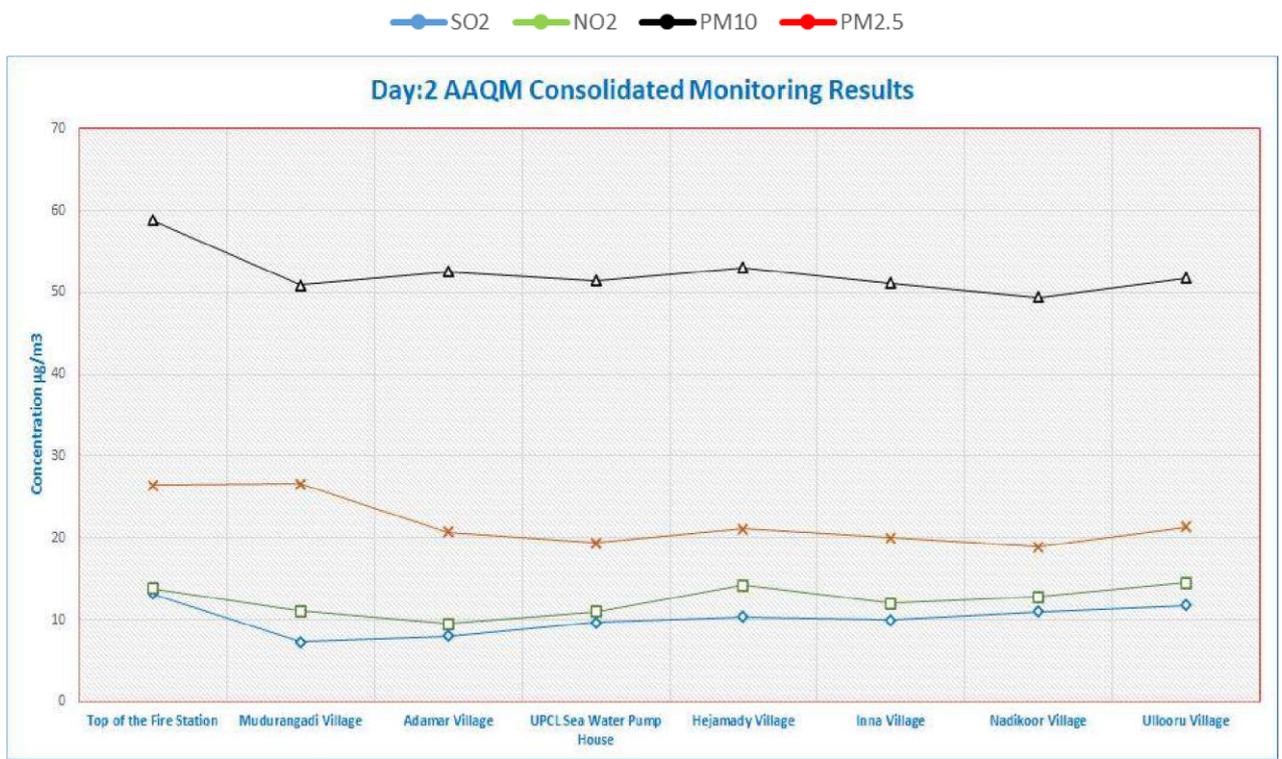
Considering the Monitoring and Analysis of Ambient Air carried out in eight different locations from 2nd to 4th April 2021, the following conclusive observations are drawn:

- *Sulphur dioxide as SO₂:* Ambient Air Quality measurement values of SO_2 were ranging from 6.7 to 13.2 µg/m³.

- *Nitrogen dioxide as NO₂:* Ambient Air Quality values of NO_2 were ranging from 9.5 to 15.5 µg/m³.

- *Particulate Matter (PM₁₀):* Ambient Air Quality values of PM_{10} were ranging from 45.5 to 58.8 µg/m³.

- *Particulate Matter (PM₂.₅):* Ambient Air Quality values of $PM_{2.5}$ were ranging from 16.4 to 26.4µg/m3.

6.14 Stack monitoring:

The assessment was carried out for technical and quality aspects to meet the requirements of standard test steps are shown in the below diagram.
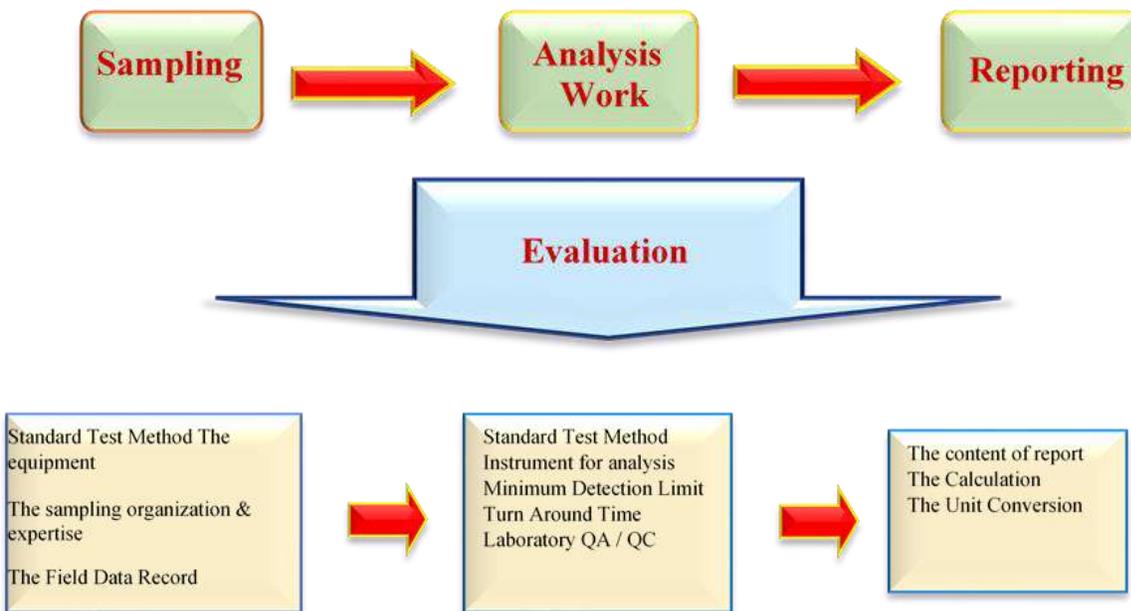
The evaluation is based on the activities of stack measurement. The activity consists of 3 steps of work: Sampling Work, Analysis Work and Reporting. Each step contributes to the accuracy of the results obtained.

Both the boilers were in operation and the Stacks were monitored accordingly on the given dates. The detailed methodology for Monitoring and Sampling including the Principle, Calculation formula, Quality Control are given in **Annexure –1.**

6.14.1 Stack Emission Results of both Boilers:

Table 6.20: Thermal Boiler Unit -1; Plant running at a Load Factor of 82.44 %

Date of Monitoring: 3rd April 2021

S.No	Pollutant	Unit	Result at Effective Oxygen Level	Result at 6% Oxygen Level	As Per CPCB Limit
	LOCATION –THERMAL BOILER UNIT-I				
1	Stack Temperature	K	401	NA	NA
2	Velocity	m/sec	6.5	NA	NA
3	Volume of Gas Discharge	Nm^3/hr	627475	NA	NA
4	Oxygen as O_2	%	9.5	NA	NA
5	Carbon Monoxide as CO	mg/Nm^3	75	NA	NA
6	Carbon Dioxide as CO_2	%	10.8	NA	NA
7	Particulate Matter	mg/Nm^3	25.9	34	50
8	Sulphur Dioxide as SO_2	mg/Nm^3	679	886	600
9	Oxides of Nitrogen as NO_2	mg/Nm^3	267	348	600

The Pollution Control Equipment in the System is the Electro Static Precipitator (ESP) which is used for the removal of Particulate Matter. Further, it is followed by the Flue Gas Desulphurisation (FGD) to desulphur the Flue Gas.

Thermal Boiler Unit-1: Emission of Particulate Matter concentration is 25.9 mg/Nm^3 and is dispersed at the effective stack height of 275 m (Stack height 275 m + Plume Height 3.0m) with exit velocity of 6.5 m/sec and the flue gas temperature was 25ºC. Emission of Sulphur dioxide concentration was 679 mg/Nm^3, Oxides of Nitrogen as NO_2 was 267 mg/Nm^3 and Carbon Monoxide was 75 mg/ Nm^3. The concentration of Carbon Dioxide is 10.8 %. All these are emitted at the effective stack height of 275 m plus a Plume Height of about 3.0 m.

Table 6.21: Thermal Boiler Unit - II; Plant running at a Load Factor of 85.91 %
(Date of Monitoring: 3rd April 2021)

S.NO	Pollutant	Unit	Result at Effective Oxygen Level	Result at 6% Oxygen Level	As Per CPCB Limit
Location –Thermal Boiler Unit-II					
1	Stack Temperature	K	339	NA	NA
2	Velocity	m/sec	6.8	NA	NA
3	Volume of Gas Discharge	Nm^3/hr	776388	NA	NA
4	Oxygen as O_2	%	11.2	NA	NA
5	Carbon Monoxide as CO	mg/Nm^3	70	NA	NA
6	Carbon Dioxide as CO_2	%	9.2	NA	NA
7	Particulate Matter	mg/Nm^3	30	46	50
8	Sulphur Dioxide as SO_2	mg/Nm^3	779	1192	600
9	Oxides of Nitrogen as NO_2	mg/Nm^3	341	522	600

The Pollution Control Equipment in the System is the Electro Static Precipitator (ESP) was used for the removal of Particulate Matter. Further, it is followed by the Flue Gas Desulphurisation (FGD) to desulphur the Flue Gas.

Thermal Boiler Unit-II: Emission of Particulate matter concentration is 30.0 mg/Nm3 and dispersed at the effective stack height of 275 m (Stack height 275 m + Plume Height 3.0m) with exit velocity of 6.5 m/sec and the flue gas temperature are 25°C.Emission of Sulphur Dioxide concentration is 779 mg/Nm3, Oxides of Nitrogen as NO_2 is 341 mg/m3 and Carbon Monoxide as 70 mg/m3. The concentration of Carbon Dioxide is 9.2 %. All these are emitted at the effective stack height of 275 m plus a Plume Height of about 3.0 m.

6.14.2 Dispersion Modeling Results for Boiler I & II:

Stack Emission Dispersion Modeling – UPCL Thermal Boiler Unit-1 @ 2 & 5 KM – Particulate Matter

Concentration at Source (Milligm/m^3)	Distance Travelled to reach GLC (km)	Maximum GLC (Microgm/m^3)	Average Concentration at 2 km (Microgm/m^3)	Average Concentration at 5 km (Microgm/m^3)
25.9	0.8	5.64	0.76	0.00878

UPCL Thermal Boiler Unit-1: Emission of Particulate matter concentration is 25.9 mg/m3 and dispersed at the effective stack height of 275m (Stack height 275 m + Plume Height 3.0 m) with exit velocity of 6.5m/sec and the flue gas temperature is 25°C. All the modeling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively uniform emission rates. Based on the dispersion parameters the Ground Level Conc. (GLC) reached at 0.8 km at the concentration of 5.64 μg/m3 at 2 km dispersion Particulate matter is 0.76 μg/m3 and at 5 km dispersion Particulate matter is 0.00878 μg/m3 and the predominant wind direction is WNW.

Stack Emission Dispersion Modeling – UPCL Thermal Boiler Unit-1 @ 2 & 5KM – Sulphur Dioxide

Concentration at Source (Milligm/m^3)	Distance Travelled to reach GLC (km)	Maximum GLC (Microgm/m^3)	Average Concentration at 2 km (Microgm/m^3)	Average Concentration at 5 km (Microgm/m^3)
679	0.83	149	2.34	0.289

UPCL Thermal boiler unit-1emission of Sulphur Dioxide concentration is 679 mg/m3 and dispersed at the effective stack height of 275m (Stack height 275m + Plume Height 3.0 m) with exit velocity of 6.5m/sec and the flue gas temperature are 25°C. All the modeling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.83 km at the concentration of 149 µg/m3 at 2 km dispersion Sulphur Dioxide is 2.34 µg/m3 and at 5 km dispersion Sulphur Dioxide is 0.289 µg/m3 and the predominant wind direction is WNW.

Stack Emission Dispersion Modeling – UPCL Thermal Boiler Unit-1 @ 2 & 5KM – Nitrogen Dioxide

Concentration at Source (Milligm/m^3)	Distance Travelled to reach GLC (km)	Maximum GLC (Microgm/m^3)	Average Concentration at 2 km (Microgm/m^3)	Average Concentration at 5 km (Microgm/m^3)
267	0.81	58.1	0.89	0.0989

UPCL Thermal boiler unit-1: Emission of Nitrogen Dioxide concentration is 267 mg/m3 and dispersed at the effective stack height of 275m (Stack height 275 m + Plume Height 3.0 m) with exit velocity of 6.5 m/sec and the flue gas temperature are 25°C. All the modeling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively uniform emission rates. Based on the dispersion parameters the GLC reached at 0.81 km at the concentration of 58.1 μg/m3 at 2 km dispersion Nitrogen Dioxide is 0.89 μg/m3 and at 5 km dispersion Nitrogen Dioxide is 0.0989 μg/m3 and the predominant wind direction is WNW.

Stack Emission Dispersion Modeling – UPCLThermal Boiler Unit-1 @ 2 & 5KM – Carbon monoxide

Concentration at Source (Milligm/m^3)	Distance Travelled to reach GLC (km)	Maximum GLC (Microgm/m^3)	Average Concentration at 2 km (Microgm/m^3)	Average Concentration at 5 km (Microgm/m^3)
75	0.77	100.02	1.21	0.123

UPCL Thermal boiler unit-1: Emission of Carbon monoxide concentration is 75 mg/m3 and dispersed at the effective stack height of 275 m (Stack height 275 m + Plume Height 3.0 m) with exit velocity of 6.5 m/sec and the flue gas temperature are 25°C. All the modeling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively uniform emission rates. Based on the dispersion parameters the GLC reached at 0.77 km at the concentration of 100.02 µg/m3 at 2 km dispersion Carbon monoxide is 1.21 µg/m3 and at 5km dispersion Carbon monoxide is 0.123 µg/m3 and the predominant wind direction is WNW.

Concentration at Source (Milligm/m^3)	Distance Travelled to reach GLC (km)	Maximum GLC (Microgm/m^3)	Average Concentration at 2 km (Microgm/m^3)	Average Concentration at 5 km (Microgm/m^3)
30	0.86	8.1	2.21	0.24

UPCL Thermal boiler unit-II: Emission of Particulate matter concentration is 30 mg/m3 and dispersed at the effective stack height of 275 m (Stack height 275 m + Plume Height 3.0 m) with exit velocity of 6.8 m/sec and the flue gas temperature are 25°C. All the modeling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively uniform emission rates. Based on the dispersion parameters the GLC reached at 0.86 km at the concentration of 8.1 µg/m3 at 2 km dispersion Particulate matter is 2.21 µg/m3 and at 5 km dispersion Particulate matter is 0.24 µg/m3 and the predominant wind direction is WNW.

Stack Emission Dispersion Modeling – UPCL Thermal Boiler Unit-II @ 2 & 5KM – Sulphur Dioxide

Concentration at Source (Milligm/m^3)	Distance Travelled to reach GLC (km)	Maximum GLC (Microgm/m^3)	Average Concentration at 2 km (Microgm/m^3)	Average Concentration at 5 km (Microgm/m^3)
779	0.81	210	12.11	0.897

UPCL Thermal boiler unit-II emission of Sulphur Dioxide concentration is 779 mg/m3 and dispersed at the effective stack height of 275 m (Stack height 275 m + Plume Height 3.0 m) with exit velocity of 6.8 m/sec and the flue gas temperature are 25°C. All the modeling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.81 km at the concentration of 210 µg/m3 at 2 km dispersion Sulphur Dioxide is 12.11 µg/m3 and at 5 km dispersion Sulphur Dioxide is 0.897 µg/m3 and the predominant wind direction is WNW.

Concentration at Source (Milligm/m^3)	Distance Travelled to reach GLC (km)	Maximum GLC (Microgm/m^3)	Average Concentration at 2 km (Microgm/m^3)	Average Concentration at 5 km (Microgm/m^3)
341	0.76	91.8	14.11	6.76

UPCL Thermal boiler unit-II: Emission of Nitrogen Dioxide concentration is 341 mg/m3 and dispersed at the effective stack height of 275 m (Stack height 275 m + Plume Height 3.0 m) with exit velocity of 6.8 m/sec and the flue gas temperature are 25ºC. All the modeling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.76 km at the concentration of 91.8μg/m3 at 2km dispersion Nitrogen Dioxide is 14.11 μg/m3 and at 5 km dispersion Nitrogen Dioxide is 6.76 μg/m3 and the predominant wind direction is WNW.

STACK EMISSION DISPERSION MODELING–UPCL Thermal Boiler Unit-II@ 2 & 5KM – Carbon monoxide

Concentration at Source (Milligm/m^3)	Distance Travelled to reach GLC (km)	Maximum GLC (Microgm/m^3)	Average Concentration at 2 km (Microgm/m^3)	Average Concentration at 5 km (Microgm/m^3)
70	0.84	18.8	0.38	0.0871

UPCL Thermal boiler unit-II: Emission of Carbon monoxide concentration is 70 mg/m^3 and dispersed at the effective stack height of 275 m (Stack height 275m + Plume Height 3.0m) with exit velocity of 6.8m/sec and the flue gas temperature are 25°C. All the modeling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively uniform emission rates. Based on the dispersion parameters the GLC reached at 0.84 km at the concentration of 18.8 µg/m^3 at 2km dispersion Carbon monoxide is 0.38 µg/m^3 and at 5 km dispersion Carbon monoxide is 0.0871 µg/m^3 and the predominant wind direction is WNW.

Based on the results of Stack Monitoring Emission and considering all the modeling parameters like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate, the Ground Level Concentration (GLC) at 2.0 Km and 5.0 Km was calculated. These stacks typically operate on a continuous basis with relatively uniform emission rates. The Consolidated GLC observed is shown in the Table 6.22 below.

Table 6.22: Consolidated GLC for both Boiler Emissions

Sl. No.	Parameter	Boiler I			Boiler II		
		GLC	@ 2.0 Km in $\mu g/m^3$	@ 5.0 Km in $\mu g/m^3$	GLC	@ 2.0 Km in $\mu g/m^3$	@ 5.0 Km in $\mu g/m^3$
1	Particulate Matter	0.8 Km @ 5.64 $\mu g/m^3$	0.76	0.00878	0.86 Km @ 8.1 $\mu g/m^3$	2.21	0.24
2	Sulphur Di-Oxide as SO_2	0.83 Km @ 149 $\mu g/m^3$	2.34	0.289	0.81Km @ 210.0 $\mu g/m^3$	12.11	0.897
3	Nitrogen Di-Oxide as NO_2	0.81 Km @ 58.1 $\mu g/m^3$	0.89	0.0989	0.76 Km @ 91.8 $\mu g/m^3$	14.11	6.76
4	Carbon Monoxide as CO	0.77 Km @ 100.02 $\mu g/m^3$	1.21	0.123	0.84 Km @ 18.8 $\mu g/m^3$	0.38	0.0871

6.15 Assessment of Carrying Capacity of Air

The assessment of carrying capacity of Air is explained through the Dispersion model. The UPCL has 2 Thermal boilers i.e. units 1 and 2. The emissions of Sulphur dioxide, Nitrogen dioxide, Carbon Monoxide and Particulate Matter are dispersed at the effective stack height of 275m (Stack height 275m + Plume Height 3.0m) with exit velocity of 6.5m/sec and the flue gas temperature of 25°C.

The outcome of this study showed the following impact of UPCL on the - air pollution:

UPCL is presently operating two coal fired boilers with the installed capacity of 2 X 600 MW. UPCL Thermal Boiler Unit-1 has installed ESP and FGD to control Particulate Matter and SO^2 emissions respectively. During the study it was found at the outlet of Air Pollution Control Device (APCD) the emission of Particulate matter concentration was 25.9 mg/Nm3 on the date of monitoring with exit velocity of 6.5 m/sec and the flue gas temperature at 66 $^{\circ}$C. The mass flow rate of particulate matter is 55.96 kg/Hr or 1343 kg/day. Dispersion around the GLC at 0.8 km, the concentration of Particulate Matter was 5.64 µg/m3 and at 2 km dispersion Particulate Matter was 0.76 µg/m3 and at 5 km dispersion Particulate Matter was 0.00878 $µg/m^3$. Due to this stack emission, the ambient air quality monitoring at 0.8 km distance was only 5.64 µg/m3. But the dust load to the atmosphere per day is 1343 kg/day (1.343Tons/day) per boiler and the same will impact the nearby villages, farming and social life at the vicinity of power plants. It has also been observed that there was a lot of fly ash deposition on the flora and agricultural farmland. It has come to the notice of the team that there were number of public complaints on the fly ash deposition on their houses and that farmer's crop yield is decreasing predominantly every year. Fly ash dust can get deposited on topsoil increasing the pH and affecting the plants and animal ecosystems.

UPCL Thermal Boiler Unit-1: emission of Sulphur dioxide was 679 mg/m3 on the date of monitoring with the same stack dimensions and characteristics. In the dispersion model the maximum GLC reached at 0.83 km at the concentration of 149 µg/m3 at 2 km dispersion Sulphur dioxide was 2.34 µg/m3 and at 5 km dispersion Sulphur dioxide was 0.289 µg/m3. The impact on the ambient atmosphere up to 1km radius was more than NAAQM standard and this impact was very high due to sulphur dioxide. The mass flow rate of Sulphur dioxide is 1,462 kg/Hr (1.462Tons/Hr) or 35,092 kg/day (35.092Tons/day). Also, UPCL was exceeding the CPCB emission limit values of 600 mg/Nm3 at 6% O_2 in the source on the date of monitoring.

Sulphur dioxide enters the leaves mainly through the stomata (microscopic openings) and the resultant injury is classified as either acute or chronic. Acute injury is caused by absorption of high concentrations of Sulphur dioxide in a relatively short time. The symptoms appear as 2-sided (bifacial) lesions that usually occur between the veins and occasionally along the margins of the leaves. The colour of the necrotic area can vary from a light tan or near white to an orange-red or brown depending on the time of year, the plant species affected and ambient weather conditions.

Expanded leaves usually are most sensitive to acute Sulphur dioxide injury, the very youngest and oldest leaves are somewhat relatively resistant.

UPCL Thermal Boiler Unit-1: Emission of Nitrogen dioxide concentration was 267 mg/m3 with the same stack dimensions and characteristics. In the dispersion model the maximum GLC reached at 0.81 km at the concentration of 58.1μg/m^3 and at 2 km dispersion Nitrogen dioxide was 0.89 μg/m3 and at 5 km dispersion Nitrogen dioxide was 0.0989 μg/m3. The impact on the ambient atmosphere up to 1 km radius was more than NAAQM standard and the impact is very high due to Nitrogen Oxides. The mass flow rate of Nitrogen Oxides was 575 kg/Hr (0.575 ton/Hr) or 13,799 kg/day (13.799Tons/day).

Excessive levels of Nitrogen dioxide in the atmosphere can cause damage to the leaves of many agricultural crops and even cause death.

6.15.1 for Two Boilers

Particulate Matter

Particulate Emission Concentrations	=	55.9 mg/Nm3
Gaseous Discharge	=	14,03,863 Nm3/Hr
Max. GLC @ 0.8km	=	13.74 μg/m3
Mass Emission Load	=	111.92 kg/hour or 2686.08 kg/day

(2.69 Tons/day)

Sulphur Dioxide

SO2 Emission Concentrations	=	1458 mg/Nm3
Gaseous Discharge	=	14,03,863 Nm3/Hr
Max. GLC @ 0.8km	=	359 μg/m3
Mass Emission Load	=	70184 kg/day (70.184 Tons/day)

Nitrogen Oxides

NOx Emission Concentrations	=	608 mg/Nm3
Gaseous Discharge	=	14,03,863 Nm3/Hr
Max. GLC @ 0.8km	=	149.9 μg/m3
Mass Emission Load	=	27598 kg/day (27.598 Tons/Day)

Based on results from the study, the carrying capacity by UPCL to ambient atmosphere of SO$_2$ [359 μg/m3] was exceeding the National Ambient Air Quality standards [80 μg/m3] as well as mass emission load of SO$_2$ emissions [70184 kg/day (70.184 Tons/day)] were too high. This can affect nearby habitant's health as well as agricultural growth. Similarly, for NOx [149.9 μg/m3] concentration in the atmosphere also exceeds the National Ambient Air Quality standards [80 μg/m3] as well as mass emission load of NOx emissions [27598 kg/day (27.598 Tons/Day)] was too high which has deleterious effect on the ecosystem.

The cumulative particulate matter emissions from UPCL through stacks is 55.9 mg/m3. The average ground level concentration achieves at an average distance of 0.83km and the sum of PM concentration at GLC is 13.74 µg/m3 which includes both the boiler stacks at UPCL. The residential areas are more than 2km radius and the expected ground level concentration will be further less than maximum GLC. It clearly indicates the PM contribution to the nearby residential areas are minimum and it is well below within the National Ambient Air Quality Standards.

The cumulative Nitrogen Oxides emissions from UPCL through stacks is 608mg/m3. The average ground level concentration achieves at an average distance of 0.78km and the sum of Nitrogen Oxides concentration at GLC is 149.9µg/m3 which includes both the boiler stacks at UPCL and this GLC is exceeding the NAAQM standard. The residential areas are more than 2km radius and the expected ground level concentration will be further less than maximum GLC. It clearly indicates the NO2 contribution to the nearby residential areas are minimum and it is well below within the National Ambient Air Quality Standards.

The cumulative Sulphur dioxide emissions from UPCL through stacks is 1458mg/m3. The average ground level concentration achieves at an average distance of 0.82km and the sum of Sulphur dioxide concentration at GLC is 359 µg/m3 which includes both the boiler stacks at UPCL and it is exceeding the NAAQM standards. The residential areas are more than 2km radium and the expected ground level concentration will be further less than maximum GLC. It clearly indicates the SO2 contribution to the nearby residential areas are maximum and it is not below within the National Ambient Air Quality Standards.

6.15.2 FLY ASH Management and Impact

The fly ash collected in the ESP is evacuated and disposed to the Silos through Pressurized Dense-Phase Fly Ash Conveying System (PDFACS) and from the Silos the fly ash is utilised for further beneficial use.

The heavier particle called the Bottom Ash which comprises traces of combustibles are embedded in forming clinkers and is collected at the Bottom of the furnace. The same is quenched and disposed in the form of slurry to Ash Pond located at a distance of 2 to 3 km away from the Power Plant.

Mercury and other heavy metals (As, Hg, Cr, and Pb etc.) are usually monitored in the bottom ash as also in the effluents emanating from the existing ash pond. UPCL has not mentioned the data and it is presumed that this analysis might not be carried out. Piezometric wells are available across the dyke pond but UPCL could not produce the heavy metals analysis reports on this water samples.

Ash Content in Coal	=	6 - 15%
Coal Consumption per Hour	=	456 TPH (Tons per Hour) (Both Units)
Theoretical Ash Content per Hour	=	28.04 TPH (Tons per Hour)
ESP Bottom Ash Qty per Hour	=	3.08 TPH (Tons per Hour)
ESP Fly Ash Qty per Hour	=	24.96 TPH (Tons per Hour)
Particulate Matter Load (kg/Hr)	=	0.055 TPH (Tons per Hour)

As per the above it seems UPCL doesn't have the proper fly ash / bottom ash inventorization and hence indicates improper fly ash management. The team could not find the reuse of fly ash and bottom ash and its records. The present dyke ponds are not being properly maintained and the depth of dyke ponds are low and no overflow water collection facility was evidenced during the heavy rainy period. In view of this, there is a possibility of overflow of water from dyke pond into the nearby villages and agricultural farms. The present ash generation per day 673 Tons and per year (considering 235 days' operation) is 1,58,146 Tons.

There is no evidence of the present ash generation being put to productive reuse by the UPCL. Hence, with further additional units the ash generation would be almost double and is not likely to be able to reuse. This leads to accumulation and the entire quantity of ash in the dyke pond will drastically increase. The overflow during rainy season also proportionately increases given the present management practices.

Fly ash is ultra-fine, the UPCL dyke ponds are in dry state and there is possibility of fly ash becoming air borne into the nearby environment. Long-term exposure to fly ash in the air can lead to serious pulmonary illnesses like bronchitis, silicosis, fibrosis, pneumonitis, etc. The ash contains toxic heavy metals too that are known carcinogens.

So with respect to management of fly ash at UPCL, the present generation of fly ash and bottom ash has not been put to proper reuse or storage which leads to groundwater contamination. The nearby farmers have complained on decrease in the crop yield and deposition of fly ash due to airborne particles. By adding additional expansion facilities in the plant, it may further impact the groundwater and soil would be prone to contamination.

6.15.3 Coal Storage and Handling

Coal should be stored in such a way that coal heap should not be higher than 5 meter and clear distance between two adjoining heaps at Ground level (G.L.) should be 5 meters. But the dust suppression due to sprinkling water, leachate as well as rain water collection trenches are fully blocked with soil. Presently the leachate generated in the coal yard is not flowing through these trenches and it is bypassing directly into the collection pond. From collection pond it is discharged into the sea and other water bodies. Moreover, UPCL is not following the CPCB /

KSPCB coal handling guidelines and physically. It has been observed that the black colour leachate water is being pumped into the cooling tower blow down water collection pond and the photograph of the same is given below;

Figure 6.5: UPCL Coal Storage Area / Coal Yard is not matching CPCB Standards

During the heavy wind blow, this coal dust which is airborne deposits in the surrounding environment and it is observed that there is a layer of black dust in the plants and agricultural crops. This indicates that the UPCL is not properly handling coal (continuous sprinkling) to prevent airborne dust into the environment. Water sprinkling is not being carried out at each and every stage of handling due to which there is lot of fugitive coal dust emissions into the atmosphere.

6.15.4 Cooling Tower Blowdown Water Discharges into Sea and Impact

Presently UPCL is using seawater in cooling tower and it passes through effluent discharge pipeline. The blowdown from cooling tower is collected into the intermediate storage sump to reduce the temperature and then discharged back into the sea at a distance of 650m. In the sea for better mixing/diffusion is attained. But the UPCL discharge pipe was broken long time back and presently the blowdown water is being discharged at the bay itself. UPCL has not yet installed online temperature sensor at the collection pond or at discharge point and hence has a complaint issue.

Marine organisms get affected by cooling water systems of thermal power plants. At the intakes, in the condensers and in the discharge system there is an increase in temperatures of the receiving waters as there is no proper management of the same. Firstly, the increase in seawater temperature directly affects the environmental temperature of marine organisms and secondly due to increase in seawater temperature, it causes seawater to stratify, which influences the foraging environment of marine organisms.

In view of the non-conformities as above it is desired that the expansion plans be revived in the above context and then decision taken.

6.15.5 People's perception

Many of the respondents expressed that they have lost their agricultural lands and houses due to UPCL. Many of them have expressed that UPCL has caused pollution in Air, Water and Soil. They also opined that their health has been adversely affected and most of them expressed their opinion against UPCL and its expansion. Also against other major industry in the region. Details of this study is given in the section 6.21.

Thus in this chapter, all aspects leading to the assessment of carrying capacity of Udupi taluk and the district has been discussed. All the above issues discussed indicate that the area does not have the capacity to withstand the present as well as the future pollution levels, loss of natural resources and agriculture for the expansion of the existing or the establishment of any new industry.

6.16 Water analysis

The monitoring and analysis which has been carried out was specific to this study area. The water samples were collected by two study teams viz EMPRI for analysing general water parameters and GLENS for analysing heavy metals and the results are compiled.

6.16.1 Water Sampling and Analysis

The Ground, Surface and Seawater Sampling Locations are shown in the Google Map results are given in the following page.
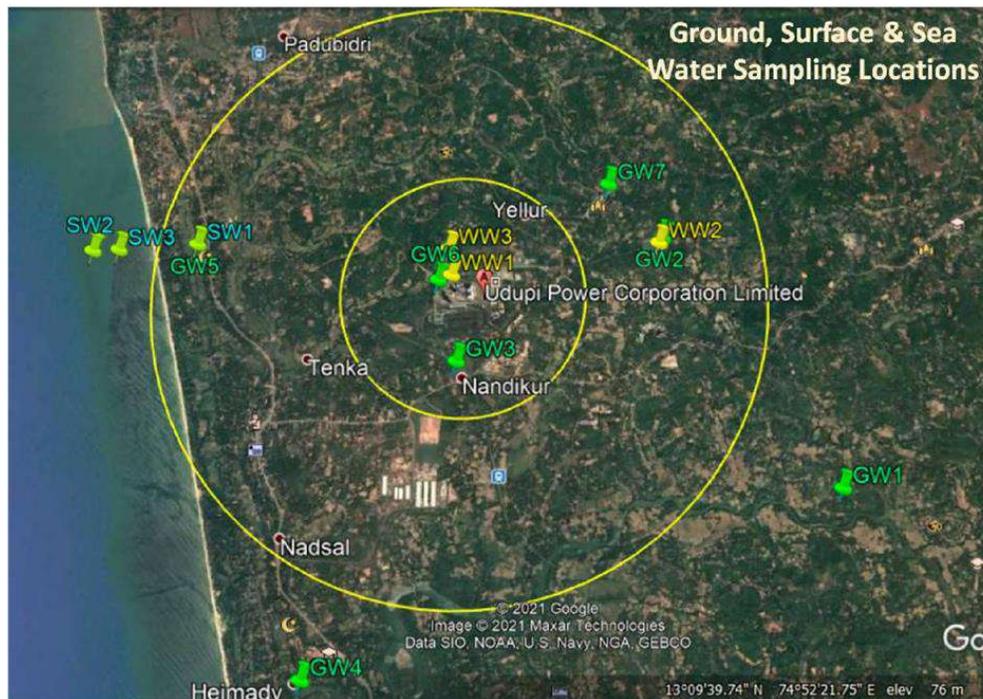
Figure 6.6: Water Sampling Locations

GW1 = INNA VILLAGE
GW2 = UPCL ASH POND
GW3 = NANDIKOOR VILLAGE
GW4 = HEJAMADY VILLAGE
GW5 = PUMP HOUSE
GW6 = ULLOORU
GW7 = MUDRANGADI VILLAGE
GW8 = R & R ADAMAR VILLAGE
SW1 = PUMP HOUSE – SEDIMENTATION TANK
SW2 = INTAKE SEAWATER
SW3 = OUT TAKE SEAWATER
WW1 = UPCL COOLING TOWER DISPOSAL WATER
WW2 = UPCL GUARD POND
WW3 = R & R ADAMAR VILLAGE

6.16.2 Analysis Results of Water Samples from the UPCL

The Physico-Chemical analysis including heavy metal analysis of water samples collected from the UPCL in the month of April 2021 are given in the following Tables.

Table 6.23: The Physico Chemical analysis of water samples
Samples collected from the UPCL in the month of April 2021 by EMPRI

		Results of Water Samples from the UPCL				As per IS 10500: 2012 Drinking water	
		All Units in mg/L (except pH & EC)					
S.NO	Parameter	Pump House – Sedimentation Tank	UPCL Ash Pond (groundwater)	Guard Pond - UPCL	Cooling Tower Disposal Water	Acceptable limit	Permissible limit in the absence of alternate source
1	pH at 25°C	4	6.6	6.6	8.16	6.5 to 8.5	No relaxation
2	EC µS/cm at 25°C	4,200	200	8,800	77,100	NS	NS
3	Total Suspended Solids at 105°C	15.2	86.2	65.8	133.2	NS	NS
4	Dissolved oxygen (DO)	4.6	Nil	5.6	Nil	-	-
5	Total Dissolved Solids at 180°C	2,519	141.8	6,143	70,271	500	2000
6	Chloride	1,245	10	2,949	31,740	250	1000
7	Total hardness (CaCO3)	350	45	985	11,300	200	600
8	Calcium (Ca)	46.1	6.01	98.2	921.8	75	200
9	Magnesium (Mg)	57.1	7.3	179.8	2,187	NS	NS
10	Alkalinity (CaCO3)	NA	45	45	210	200	600
11	Sulphate (SO4)	891	23.2	1,404	1,404	200	400

12	Fluoride (F)	1.14	1.28	0.82	0.16	1	1.5
13	Ammonia NH3-N	7	2.8	8.4	2.8	0.5	No relaxation
14	Phosphate (P)	BDL	36.72	BDL	0.59	NS	NS
15	Nitrate (NO3)	72.2	12.97	70.53	50.41	45	No relaxation
16	Nitrite (NO2)	BDL	BDL	8.56	0.14	NS	NS
17	Copper(Cu)	BDL	0.08	BDL	BDL	0.05	1.5
18	Iron(Fe)	0.67	12.35	0.52	1.03	0.3	No relaxation
19	Lead (Pb)	BDL	BDL	BDL	BDL	0.01	No relaxation
20	Manganese (Mn)	0.27	0.51	0.11	0.52	0.1	0.3
21	Zinc (Zn)	0.07	2.02	BDL	BDL	5	15

Note:

1. BDL-Below detection limit

2. NA: The sample was acidic in nature and hence not analysed for Alkalinity

Samples from Pump House – Sedimentation Tank, UPCL Ash Pond (groundwater), Guard Pond – UPCL and Cooling Tower Disposal Water were collected and analysed.

- Some of the parameters, such as pH, Ammonia, Nitrate (NO3), Iron. (Fe) Sulphate (SO4), Total Dissolved Solids at 180°C, Chloride, Total hardness (CaCO3), Ammonia NH3-N, Nitrate (NO3), Calcium (Ca) and Manganese (Mn) are exceeded the limits as per the Drinking Water Standards IS 10500: 2012 permissible limits in the absence of alternate sources.

- Phosphate (P), Nitrite (NO2), Copper (Cu), Lead (Pb), Zinc (Zn) are below detection limit.

- And Dissolved oxygen (DO) found nil for UPCL Ash Pond (groundwater), Cooling Tower Disposal Water,

- The intended use of these water sources is not for drinking purposes.

Table 6.24: The Heavy Metal analysis of water samples collected from the UPCL
(In the month of April 2021 by M/s GLENS)

Results of Water Samples from the UPCL All Units in mg/L					
S.NO	Pollutant	Cooling Tower Disposal Water	Pump House – Sedimentation Tank	Intake Seawater	Outtake Seawater
1	Arsenic (As)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)
2	Cadmium (Cd)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)

S.NO	Pollutant	Cooling Tower Disposal Water	Pump House – Sedimentation Tank	Intake Seawater	Outtake Seawater
		Results of Water Samples from the UPCL **All Units in mg/L**			
3	Copper (Cu)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)
4	Chromium (Cr)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)
5	Nickel (Ni)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)
6	Lead (Pb)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)
7	Mercury (Hg)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)
8	Selenium (Se)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)	BLQ (LOQ:0.005)
9	Zinc (Zn)	0.013	BLQ (LOQ:0.005)	0.014	BLQ (LOQ:0.005)
10	Hexavalent Chromium (Cr^{6+})	BLQ (LOQ:0.03)	BLQ (LOQ:0.03)	BLQ (LOQ:0.03)	BLQ (LOQ:0.03)

Note:

1. BLQ -Below the limit of Quantification

Seawater samples collected from three locations. The sampling locations are Pump House – Sedimentation Tank, Intake Seawater and Out Take Seawater.

- Zinc (Zn): Seawater sample measurement values of Zinc are ranging from 0.013 to 0.014 mg/L. Highest value of 0.014mg/L is obtained.

- Arsenic, Cadmium, Copper, Chromium, Nickel, Lead, Mercury, Selenium and Hexavalent Chromium metals are below detection limit.

<div align="center">

Table 6.25: Results of Water sampling and Physico chemical analysis
(December 2020 by EMPRI).

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Sl No.	Parameters	UPCL (Bore well Water)	UPCL Ash Pond (groundwater)	Guard Pond – UPCL	Acceptable limit	Permissible limit in the absence of alternate source
	Results of Water Samples from the UPCL				**As per IS 10500: 2012 Drinking water**	
	All Units in mg/L (except pH & EC)					
1	pH at 25°C	6.4	6.1	6.4	6.5 to 8.5	No relaxation
2	EC µS/cm at 25°C	151	115	-	NS	NS
3	Total Suspended Solids at 105°C	35	351.2	3.6	NS	NS
4	Total Dissolved Solids at 180°C	120.8	85.2	12,428	500	2000
5	Chloride	50.33	50.34	6,040	250	1000
6	Total hardness (CaCO3)	36	54	424.8	200	600
7	Calcium (Ca)	3.96	3.6	13.34	75	200
8	Magnesium (Mg)	6.34	10.93	96.1	NS	NS
9	Alkalinity (CaCO3)	94.5	52.5	63	200	600
10	Sulphate (SO4)	BDL	BDL	522.7	200	400
11	Fluoride (F)	0.91	0.91	0.74	1	1.5
12	Ammonia NH3-N	4.2	8.4	8.4	0.5	No relaxation
13	Phosphate (P)	1.94	3.26	BDL	NS	NS
14	Nitrate (NO3)	12.46	13.1	46.44	45	No relaxation
15	Nitrite (NO2)	BDL	BDL	8.61	NS	NS

Note:

1. BDL-Below detection limit

Samples from UPCL (Bore well Water), UPCL Ash Pond (groundwater) and Guard Pond – UPCL were collected and analysed.

- pH at 25°C, Total Dissolved Solids at 180°C, Chloride, Sulphate (SO4), Ammonia NH$_3$-N and Nitrate (NO3) are exceeded the limits as per the Drinking Water Standards IS 10500: 2012 permissible limits in the absence of alternate sources for the Guard Pond UPCL.

- Phosphate (P), Sulphate (SO4), and Nitrite (NO2) are below detection level.

6.16.3 Surface Water Sampling and Analysis:

Table 6.26: Results of Water sampling and analysis carried out by EMPRI
Date of visit (01-04-2021 to 06-04-2021)

S.NO	Parameter	Ullooru	Acceptable limit	Permissible limit in the absence of alternate source
	Results of Surface Water Samples All Units in mg/L (except pH & EC)		**As per IS 10500: 2012 Drinking water**	
1	pH at 25°C	3.7	6.5 to 8.5	No relaxation
2	EC µS/cm at 25°C	3,400	NS	NS
3	Dissolved oxygen (DO)	Nil	NS	NS
4	Total Suspended Solids at 105°C	21.8		
5	Total Dissolved Solids at 180°C	1,923	500	2000
6	Chloride	969.7	250	1000
7	Total hardness (CaCO3)	360	200	600
8	Calcium (Ca)	64.1	75	200
9	Magnesium (Mg)	48.6	NS	NS
10	Alkalinity (CaCO3)	NA	200	600
11	Sulphate (SO4)	534.8	200	400
12	Fluoride (F)	BDL	1	1.5
13	Ammonia NH$_3$-N	1.4	0.5	No relaxation
14	Phosphate (P)	2.75	NS	NS
15	Nitrate (NO3)	17.72	45	No relaxation
16	Nitrite (NO2)	BDL	NS	NS
17	Copper (Cu)	BDL	0.05	1.5
18	Iron (Fe)	7.9	0.3	No relaxation
19	Lead (Pb)	BDL	0.01	No relaxation
20	Manganese (Mn)	1.76	0.1	0.3
21	Zinc (Zn)	0.06	5	15

Note:

1. BDL-Below detection limit

Samples from Ullooru village was collected and analysed.

- Some of the parameters such as pH at 25°C, Sulphate (SO4), Ammonia NH3-N, Iron(Fe) are exceeded the limits as per the Drinking Water Standards IS 10500: 2012 permissible limits in the absence of alternate sources.
- Fluoride (F), Nitrite (NO2), Copper(Cu), Lead (Pb), Manganese Mn) are below detection level
- And Dissolved oxygen (DO) found nil for this village.

Table 6.27: Heavy Metal Analysis (By M/s GLENS)

S.No.	Pollutant	UPCL Guard Pond	R & R Adamar Village
	Surface Water Samples All Units in mg/L		
1	Arsenic (As)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)
2	Cadmium (Cd)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)
3	Copper (Cu)	0.003	0.003
4	Chromium (Cr)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)
5	Nickel (Ni)	BLQ (LOQ:0.002)	0.003
6	Lead (Pb)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)
7	Mercury (Hg)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)
8	Selenium (Se)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)
9	Zinc (Zn)	0.027	0.035
10	Hexavalent Chromium (Cr^{6+})	BLQ (LOQ:0.03)	BLQ (LOQ:0.03)

Note:

1. BLQ -Below the limit of Quantification

There are traces of Copper and Zinc in the water samples. 0.003 mg/L Nickel is found in the R&R Adamar village.

Table 6.28: Results of Physico Chemical Analysis of Surface Water on March 2021
(EMPRI)

S.NO	Parameter	Inna 2A	Ullooru 7	Ullooru 7A	Acceptable limit	Permissible limit in the absence of alternate source
	Results of Surface Water Samples All Units in mg/L (except pH & EC)				**As per IS 10500: 2012 Drinking water**	
1	pH at 25°C	6.4	3.6	3.5	6.5 to 8.5	No relaxation
2	EC µS/cm at 25°C	196	2900	7000	NS	NS
3	Total Suspended Solids at 105°C	97.6	180.4	49.2	NS	NS
4	Total Dissolved Solids at 180°C	106	1915	4,782	500	2000

	Results of Surface Water Samples All Units in mg/L (except pH & EC)				As per IS 10500: 2012 Drinking water	
S.NO	Parameter	Inna 2A	Ullooru 7	Ullooru 7A	Acceptable limit	Permissible limit in the absence of alternate source
5	Chloride	14.9	1149.6	2249.3	250	1000
6	Total hardness (CaCO3)	25	360	835	200	600
7	Calcium (Ca)	4	72.2	128.3	75	200
8	Magnesium (Mg)	3.6	43.7	125.1	NS	NS
9	Alkalinity (CaCO3)	25	NA	NA	200	600
10	Sulphate (SO4)	16.1	666.3	666.3	200	400
11	Fluoride (F)	BDL	BDL	BDL	1	1.5
12	Ammonia NH$_3$-N	9.8	7	5.6	0.5	No relaxation
13	Phosphate (P)	5.105	9.229	0.392	NS	NS
14	Nitrate (NO3)	15.79	7.33	8.87	45	No relaxation
15	Nitrite (NO2)	0.07	0.003	0.009	NS	NS
16	Copper (Cu)	BDL	BDL	BDL	0.05	1.5
17	Iron (Fe)	1.18	11.85	3.04	0.3	No relaxation
18	Lead (Pb)	0.04	0.11	0.14	0.01	No relaxation
19	Manganese (Mn)	BDL	1.88	2.32	0.1	0.3
20	Zinc (Zn)	0.37	0.07	0.2	5	15

Note:

1. BDL-Below detection limit

2. NA: The sample was acidic in nature and hence not analysed for Alkalinity

Samples from Inna 2A, Ullooru 7, and Ullooru 7A were collected and analysed.

- Some of the parameters such as pH at 25°C, Chloride, Sulphate (SO4), Ammonia NH3-N, Iron(Fe), Lead (Pb), Manganese (Mn), Total Dissolved Solids at 180°C, are exceeded the limits as per the Drinking Water Standards IS 10500 2012 permissible limits in the absence of alternate sources.

- Fluoride (F), Copper (Cu), Manganese (Mn) in (INNA-2A) are below detection level.

Table 6.29: Results of Water sampling and analysis by EMPRI

Results of surface Water Samples All Units in mg/L (except pH & EC)				As per IS 10500: 2012 Drinking water	
Sl No.	Parameters	Nandikoor	Ullooru Yelluru	Santhoor (Near Ash Tank)	Acceptable limit	Permissible limit in the absence of alternate source
1	pH at 25°C	5.6	3.3	7.7	6.5 to 8.5	No relaxation
2	EC µS/cm at 25°C	467	-	532	NS	NS
3	Total Suspended Solids at 105°C	11	21.8	1.8	NS	NS
4	Total Dissolved Solids at 180°C	324	2,930	427	500	2000
5	Chloride	95.64	2,214	201.4	250	1000
6	Total hardness (CaCO3)	270	180	59.4	200	600
7	Calcium (Ca)	5.05	23.08	8.65	75	200
8	Magnesium (Mg)	62.54	29.74	9.18	NS	NS
9	Alkalinity CaCO3)	21	BDL	73.5	200	600
10	Sulphate (SO4)	BDL	210.88	184	200	400
11	Fluoride (F)	0.91	0.91	0.91	1	1.5
12	Ammonia NH3-N	5.6	4.2	7	0.5	No relaxation
13	Phosphate (P)	12.27	1.54	0.38	NS	NS
14	Nitrate (NO3)	8.48	9.51	11.17	45	No relaxation
15	Nitrite (NO2)	BDL	BDL	0.21	NS	NS

Note:

1. BDL-Below detection limit

Sampling as carried out during the month of December 2020 to Jan 2021
Samples from Nandikoor, Ullooru-Yelluru, Santhoor (Near Ash Tank) were collected and analysed.

- Some of the parameters such as pH at 25°C, Total Dissolved Solids at 180°C, Chloride, Ammonia NH3-N, are exceeded the limits as per the Drinking Water Standards IS 10500: 2012 permissible limits in the absence of alternate sources.

- Alkalinity (CaCO3), Nitrite (NO2), Phosphate (P), Sulphate (SO4), are below detection level.

6.16.4 Consolidated results of Groundwater Analysis

Sampling and Analysis as carried out in the month of December 2020. Date of visit (26-12-2020 to 28-01-2021)

Table 6.30: Results of Water sampling and analysis by EMPRI

Sl No.	Parameters	Nandikoor (Well Water)	Ullooru-2 Yelluru (Well Water)	Ullooru-1 (Groundwater)	Acceptable limit	Permissible limit in the absence of alternate source
	Results of Groundwater Samples All Units in mg/L (except pH & EC)				As per IS 10500: 2012 Drinking water	
1	pH at 25°C	5.2	5.6	6.6	6.5 to 8.5	No relaxation
2	EC µS/cm at 25°C	1,080	-	1,779	NS	NS
3	Total Suspended Solids at 105°C	12.8	16	83.8	NS	NS
4	Total Dissolved Solids at 180°C	647	2,548	1,559	500	2000
5	Chloride	352.3	1,761	105.7	250	1000
6	Total hardness (CaCO3)	369	102.6	144	200	600
7	Calcium (Ca)	5.41	18.03	18.03	75	200
8	Magnesium (Mg)	86.38	13.99	24.05	NS	NS
9	Alkalinity (CaCO3)	21	31.5	168	200	600
10	Sulphate (SO4)	16.88	BDL	BDL	200	400
11	Fluoride (F)	0.91	0.91	0.91	1	1.5
12	Ammonia NH$_3$-N	5.6	22.4	2.8	0.5	No relaxation
13	Phosphate (P)	BDL	3.16	BDL	NS	NS
14	Nitrate (NO3)	8.23	10.67	11.69	45	No relaxation
15	Nitrite (NO2)	BDL	BDL	0.3	NS	NS

Note:

1. BDL-Below detection limit

Samples from Nandikoor (Well Water), Ullooru-2- Yelluru (Well Water) Ullooru-1 (Groundwater) were collected and analysed.

- Some of the parameters such as pH at 25°C, Ammonia NH3-N, Total Dissolved Solids at 180°C are exceeded the limits as per the Drinking Water Standards IS 10500 2012 permissible limits in the absence of alternate sources.

- Phosphate (P), Sulphate (SO4), Nitrite (NO2) are below detection level

Table 6.31: Results of Water sampling and analysis by EMPRI

Sampling and Analysis carried out in the month of March 2021. Date of visit (15-03-2021 to 18-03-2021)

S. No	Parameter	Mudarangadi Village 3A	Mudarangadi Village 3B	R and R Adamar 4	Ullooru-2	Hejamady Village 1	Inna 2	Nandikoor Village 5	Tenka Yermal 8	Tenka Yermal 8B
	Results of Groundwater Samples from the UPCL All Units in mg/L (except pH & EC)									
1.	pH at 25°C	5.7	6.2	5.2	5.3	6.96	6.3	5.0	7.2	6.6
2.	EC µS/cm at 25°C	102	71	51	2800	303	125	628	382	445
3.	Total Suspended Solids at 105°C	70	2.6	1.4	1.6	290.8	89	0.8	83.6	72.6
4.	Total Dissolved Solids at 180°C	73	52.8	18.2	1,743	212	87	373	265	253.8
5.	Chloride	29.9	9.9	9.9	894.7	7.49	12.5	154.9	15.0	32.5
6.	Total hardness (CaCO3)	10	20	BDL	310	105	25	55	200	220
7.	Calcium (Ca)	4.0	2.0	BDL	84.2	38.08	8.0	10.0	76.2	70.1
8.	Magnesium (Mg)	BDL	3.6	BDL	24.3	2.4	1.2	7.3	2.4	10.9
9.	Alkalinity (CaCO3)	10	40	5.0	10.0	90	35	10	185	205
10.	Sulphate (SO4)	5.7	16.8	1.6	18.2	49.8	8.2	145.6	24.2	10.8
11.	Fluoride (F)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
12.	Ammonia NH_3-N	9.8	7	7.0	7.0	7.0	8.4	4.2	5.6	7.0
13.	Phosphate (P)	1.374	70.889	20.422	2.552	95.632	50.860	1.374	85.028	6.283
14.	Nitrate (NO3)	137.46	6.44	6.05	6.17	32.85	14.77	8.23	60.54	14.38
15.	Nitrite (NO2)	0.003	0.003	0.009	0.013	0.15	0.01	0.003	0.22	0.013
16.	Copper(Cu)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
17.	Iron(Fe)	0.47	0.94	0.42	0.54	0.97	0.27	0.80	0.90	1.0
18.	Lead (Pb)	0.03	0.08	0.08	0.15	0.01	0.07	0.09	0.18	0.19
19.	Manganese (Mn)	0.08	0.07	0.09	0.55	0.29	BDL	0.14	BDL	0.12
20.	Zinc (Zn)	1.96	0.40	BDL	BDL	BDL	BDL	BDL	0.05	BDL

Note:

1. BDL-Below detection limit

The samples from Mudarangadi Village 3A, Mudarangadi Village 3B, R and R Adamar 4, Ullooru-2, Hejamady Village, Inna, Nandikoor Village, Tenka Yermal 8, and Tenka Yermal 8B were collected and analysed.

- Some of the parameters such as Iron(Fe), Ammonia NH3-N, pH at 25°C, Iron(Fe), Lead (Pb), Nitrate (NO3), Manganese (Mn), Ammonia NH3-N, are exceeded the limits as per the Drinking Water Standards IS 10500 2012 permissible limits in the absence of alternate sources.

- Fluoride (F), Copper (Cu), Zinc (Zn), Manganese (Mn), Total hardness (CaCO3), Calcium (Ca), Magnesium (Mg) are below detection level.

Table 6.32: Results of Water sampling and analysis by EMPRI

Sampling and Analysis as carried out in the month of April 2021. Date of visit (01-04-2021 to 06-04-2021)

Results of Groundwater Samples from the UPCL **All Units in mg/L (except pH & EC)**								
S.NO	Parameter	Mudarangadi Village 8	Mudarangadi Village 8B	R and R Adamar	Ullooru-2	Hejamady Village	Inna	Nandikoor Village
1.	pH at 25°C	6.1	6.4	6.0	6.5	6.6	6.6	6.6
2.	EC μS/cm at 25°C	137	74	1,290	2,400	312	240	557
21.	Dissolved oxygen (DO)	2.5	3.8	4.2	2.11	4.6	5	3.6
3.	Total Suspended Solids at 105°C	3.0	0.6	1.4	4.2	1.6	2.8	112.2
4.	Total Dissolved Solids at 180°C	90.6	49	862	1,687	238	193	321
5.	Chloride	15	5.0	345	685	35	15	154.95
6.	Total hardness (CaCO3)	15	15	85	585	115	40	55
7.	Calcium (Ca)	4.0	4.0	20.04	164.3	38.08	8.02	12.02
8.	Magnesium (Mg)	1.22	1.22	8.51	42.5	4.86	4.86	6.08
9.	Alkalinity (CaCO3)	10	25	15	115	85	30	10
10.	Sulphate (SO4)	24.07	20.6	259.23	92.04	34.85	8.17	75.7
11.	Fluoride (F)	BDL	BDL	0.19	0.19	BDL	BDL	BDL

12.	Ammonia NH₃-N	1.4	1.4	4.2	1.4	1.4	1.4	2.8
13.	Phosphate (P)	3.53	16.3	BDL	BDL	45.36	BDL	BDL
14.	Nitrate (NO3)	30.67	15.92	62.97	19.26	33.1	34.25	17.08
15.	Nitrite (NO2)	BDL	BDL	BDL	BDL	0.03	BDL	BDL
16.	Copper(Cu)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
17.	Iron(Fe)	0.82	1.77	0.66	2.09	0.45	0.54	0.41
18.	Lead (Pb)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
19.	Manganese (Mn)	0.20	0.29	0.5	1.16	0.09	0.17	0.18
20.	Zinc (Zn)	0.21	0.25	0.15	BDL	BDL	BDL	BDL

Note:

1. BDL-Below detection limit

Mudarangadi Village -8, Mudarangadi Village 8B, R and R Adamar, Ullooru-2, Hejamady, Village, Inna, Nandikoor Village

- Some of the parameters such as Iron (Fe), Ammonia NH3-N, pH at 25°C, Nitrate (NO3), Manganese (Mn) pH at 25°C are exceeded the limits as per the Drinking Water Standards IS 10500: 2012 permissible limits in the absence of alternate sources.

- Zinc (Zn), Fluoride (F), Copper (Cu), Nitrite (NO2), Lead (Pb), Phosphate (P) are below detection level.

Table 6.33: Groundwater Samples analysis by M/s GLENS
Results of analysis of Heavy Metal Parameters in the month of April, 2021

Results of Groundwater Samples All Units in mg/L								
S.NO	**Pollutant**	**Inna Village**	**UPCL Ash Pond**	**Nandikoor Village**	**Hejamady Village**	**Pump House**	**Ullooru**	**Mudarangadi Village**	**R&R Adamar Village**
1	Aluminium (Al)	0.035	0.021	0.07	0.114	4.797	0.009	0.034	BLQ (LOQ:0.002)
2	Barium (Ba)	0.063	0.054	0.158	0.107	0.218	0.380	0.053	0.095
3	Boron (B)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	0.067	0.015	0.104	0.02	BLQ (LOQ{.002)	0.042
4	Copper (Cu)	BLQ (LOQ:0.002)	0.081	0.004	0.007	0.012	BLQ (LOQ:0.002)	0.007	BLQ (LOQ:0.002)
5	Manganese	0.178	0.424	0.160	0.133	0.278	1.003	0.234	0.095

S.NO	Pollutant	Inna Village	UPCL Ash Pond	Nandikoor Village	Hejamady Village	Pump House	Ullooru	Mudarangadi Village	R&R Adamar Village
					Results of Groundwater Samples All Units in mg/L				
	(Mn)								
6	Selenium (Se)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	0.006	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)
7	Silver (Ag)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)
8	Zinc (Zn)	0.028	3.868	0.025	0.035	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	0.152	0.006
9	Cadmium (Cd)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)
10	Lead (Pb)	BLQ (LOQ:0.002)	0.041	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)
11	Molybdenum (Mo)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)
12	Nickel (Ni)	0.006	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	0.003	0.013	BLQ (LOQ:0.002)	0.004	BLQ (LOQ:0.002)
13	Arsenic (As)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)
14	Chromium (Cr)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	0.003	0.005	BLQ (LOQ:0.002)	0.004	BLQ (LOQ:0.002)
15	Iron (Fe)	BLQ (LOQ:0.002)	0.041	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	0.003	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)	BLQ (LOQ:0.002)
16	Magnesium (Mg)	2.0	5.0	10	6.5	56	16	4.0	9.0

Note:

1. BLQ -Below the limit of Quantification

The levels of heavy metals in the Groundwater were highest for Mg and Al followed by Zn, Mn, Ba and B. In the Groundwater samples,

Mg content ranged from 2 to 56 mg/L
Al ranged from 0.009 to 4.797mg/L
Zn ranged from 0.006 to 3.868 mg/L
Mn ranged from 0.095 to 1.003 mg/L
Ba ranged from 0.053 to 0.38 mg/L
B ranged from 0.015 to 0.104 mg/L

Following heavy metals in the Groundwater were lowest for Cu followed by Fe, Pb, Ni, Se and Cr. In the Groundwater samples, the

Cu content ranged from 0.004 to 0.081 mg/L
Fe ranged from 0.003 to 0.041 mg/L
Pb ranged from 0.041 to 0.041 mg/L
Ni ranged from 0.003 to 0.013 mg/L
Se ranged from BLQ to 0.006 mg/L
Cr ranged from 0.003 to 0.005 mg/L

6.16.5 Measurement of Toxicity Characteristic Leaching Procedure (TCLP)

Sampling and Analysis Coal and Fly Ash: Four samples were collected to co-relate with contamination if any at other locations and for the purpose of material balance.

Coal – UPCL Coal Yard
Coal – UPCL Bottom Ash Bin
Fly Ash – UPCL Fly Ash
Fly Ash – UPCL Pond Ash

From the time of sample collection until after analysis, samples must be refrigerated at 4 ± 2 degrees Celsius (°C) for periods specified by the EPA.

6.16.6 Consolidated results of TCLP of Ash and Coal Samples

TCLP analysis of Ash and Coal Samples from 04 locations

Table 6.34: The analysis results of the Soil Samples for the Toxicity, by M/s GLENS.

Soil Sample Analysis Results All Units in mg/ Kg					
S.NO	Pollutant	Coal Yard	Bottom Ash Bin	Fly Ash	Pond Ash
1	Arsenic (As)	BLQ (LOQ:0.1)	3.15	6.77	7.29
2	Barium (Ba)	3.92	6.37	1.57	6.41
3	Cadmium (Cd)	BLQ (LOQ:0.1)	BLQ (LOQ:0.1)	BLQ (LOQ:0.1)	BLQ (LOQ:0.1)
4	Chromium (Cr)	BLQ (LOQ:0.1)	0.37	0.44	3.04
5	Mercury (Hg)	BLQ (LOQ:0.1)	BLQ (LOQ:0.1)	BLQ (LOQ:0.1)	BLQ (LOQ:0.1)
6	Copper (Cu)	BLQ (LOQ:0.1)	1.48	2.96	0.12

Soil Sample Analysis Results All Units in mg/ Kg					
S.NO	Pollutant	Coal Yard	Bottom Ash Bin	Fly Ash	Pond Ash
7	Cobalt (Co)	0.18	0.64	1.18	1.24
8	Lead (Pb)	BLQ (LOQ:0.1)	BLQ (LOQ:0.1)	BLQ (LOQ:0.1)	BLQ (LOQ:0.1)
9	Nickel (Ni)	0.2	2.12	1.85	14.35
10	Zinc (Zn)	0.21	51.60	1.52	1.47
11	Manganese (Mn)	11.92	26.13	18.73	17.25
12	Iron (Fe)	41.2	39.79	1.78	0.81
13	Fluoride (F)	27.97	10.31	9.40	0.70

Note:

1. BLQ -Below the limit of Quantification

The levels of heavy metals in the TCLP were highest for Zn and Fe followed by F, Mn and Ni. In the TCLP samples

Zn content ranged from 0.21 to 51 mg/L

Fe ranged from 0.81 to 41.2,

F ranged from 0.7 to 27.97 mg/L

Mn ranged from 11.92 to 26.13 mg/L

Ni ranged from 0.2 to 14.35 mg/L

Following heavy metals in the TCLP were lowest for 'As' followed by Ba, Cr, Cu and Co. In the Ash Samples,

As content ranged from 3.15 to 7.29 mg/L

Ba ranged from 1.57 to 6.41 mg/L

Cr ranged from 0.37 to 3.04 mg/L

Cu ranged from 0.12 to 2.96 mg/L

Co ranged from 0.18 to 1.24 mg/L

6.17: Groundwater characteristics of Udupi district

As per the report "Assessment of Groundwater Quality in Udupi District, Karnataka" the Udupi district was selected as the study area. 106 Water sample were collected throughout the area. The Samples were tested for different water quality parameters such as pH, Total Dissolved Solids, Total Hardness, Fluoride, Chloride, Nitrate, Iron, Sulphate and Bicarbonate etc., and prioritizing the area based on quality.

Each and every groundwater samples that were collected in the study area were tested for many different parameters. The minimum, maximum and mean values of each parameter is listed below. (Kotian et al., 2018)

Table 6.35: Groundwater Quality of entire Udupi District

Parameter	Minimum	Maximum	Mean	Percentile Variation	IS 10500:2012
pH	5.01	7.6	6.305	81.132	6.5-8.5
TH (mg/l)	12	220	116	0.94	200
Ca^{2+} (mg/l)	7	88	47.5	0.94	75
Mg^{+} (mg/l)	0	132	66	7.547	30
HCO_3 (mg/l)	40	300	170	3.773	200
Cl^{-} (mg/l)	0	99.95	49.75	0	250
TDS (mg/l)	126.17	586.98	356.57	0.94	500
F^{-} (mg/l)	0.2	2.35	1.275	31.13	1
Mn^{+} (mg/l)	1	14	7.5	100	0.1
NO_3^{-} (mg/l)	0	9	4.5	0	45
Fe^{2+} (mg/l)	0	4.2	2.1	54.71	0.3
SO_4^{-} (mg/l)	2	25	13.5	0	200
Turbidity (NTU)	1.2	13.6	7.4	100	1
Conductivity	253.16	1196.8	725.2	0	-
K	1	16	8.5	0	-
Na^{+}	3	110	56.5	0	-

The obtained results from our study with respect to the groundwater (Open dug well) analysis was compared with the above referred report, to see the major differences between the water parameters. It is found that from both the results, the exceeded parameters are likely to be similar.

6.18 Assessment of Carrying Capacity of Water for Udupi District

In this section, the study is to assess the carrying capacity of Water resources, distribution network and water use applications incorporating all usage of water like drinking and domestic use, irrigation, fisheries, hydropower and industry. To develop such a holistic perspective, an assessment of geology and hydrology of the district, water resource availability at both, surface, groundwater and other resources, present usage for various purposes, potential demand and demand supply gap was required. This chapter therefore focuses on water resource scenario in Udupi District from this perspective.

6.18.1 Water Resource Carrying Capacity

The water resource carrying capacity is difference of total water availability in the region to the water demand for various purposes in the same region.

6.18.2 Water Availability

The water availability refers to the presence of groundwater and surface water in the district, where the total water availability includes surface water such as rainfall, river basins and groundwater in the region.

6.18.3 Water Demand

The water demand refers to the water required for meeting irrigation, domestic, livestock, industrial, power generation needs.

The Water resource carrying capacity can be calculated by using the following formula

WRCC=TWA/TWD

Where

WRCC= Water resource carrying capacity

TWA = Total water availability

TWD = Total water demand

The following Table no. 6.36 is adopted from the report 'Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) 2016' - District Irrigation Plan for Udupi District, which refers to the total water availability and total water requirement of the Udupi district.

To assess carrying capacity of water resource, we have referred to this report as source of secondary data.

Table 6.36: Taluk-wise Water Resource Carrying Capacity
(Water Availability, Water Demand, Water Balance)

Name of Blocks	Existing water availability (BCM)		Total (BCM)	Water Demand (BCM)		Water balance (BCM)		Water resource carrying capacity WRCC=TWA/TWD (BCM)	
	Surface water	Ground water		2016	Projected (2020)	2016	Projected (2020)	2016	Projected (2020)
Udupi	5.690	0.0545	5.7445	0.1649	0.3911	5.5795	5.3533	34.8342	14.6854
Karkala	3.031	0.0471	3.0781	0.0650	0.2474	3.0130	2.8306	47.3190	12.4387
Kundapura	7.774	0.1058	7.8798	0.0914	0.1073	7.7883	7.7724	86.1369	73.4302
Total	**16.495**	**0.2073**	**16.7024**	**0.3214**	**0.7459**	**16.3809**	**15.9564**	**51.9620**	**22.3907**

Source: Departments of Major and Minor Irrigation, Mines and geology and others

Note: The data on surface water availability for Udupi includes Karkala.

As against the total water availability of 16.38093 BCM, only 0.321435 BCM is at present used for various purposes in the district. It works out to be 2 percent of the total water available in the district. Even with the projected demand for water of 0.74594 BCM, the district will have water balance of 15.95642 BCM. With the projected increase in water demand, the percentage of water use in total water availability would increase to 6 percent.

In view of carrying capacity as per CPCB methodologies for assessment of carrying capacity, Widodo et al., 2015 stated that;

If,

WRCC <1 capacity is overshoot, **WRCC 1-3** capacity is conditionally safe, and

WRCC >3 capacity is safe

In this study the water resources carrying capacity (WRCC) is more than 3, hence it is concluded that water resources carrying capacity is safe.
Since the few heavy metals and other physicochemical parameters in the collected water samples were not meeting the standards when it is compared with IS-10500, though WRCC is safe it is necessary to focus on the qualitative aspects.

6.19 Assessment of Water Resources for the Study Area

6.19.1 Water Resources

The water resources available in the study area are computed in two parts viz., Groundwater and Surface water. Total Water available in the study area is the sum of available groundwater and Surface water and other available water resources if any.

Amount of available water resources (AWR) is estimated by the following equations:

$$AWR = AGWR + ASWR + OAWR$$

- AGWR is the available groundwater resource
- ASWR is the available surface water resource
- OAWR is the other available water resources, mainly wastewater reuse and collection of rainwater harvested.

6.19.2 Groundwater Availability

The groundwater availability for the state of Karnataka is published by Groundwater Directorate, Government of Karnataka and Central Groundwater Board (CGWB) south western region for every 4 years through publication "Dynamic Groundwater Resources of Karnataka". The publications are available for the years 2004, 2008, 2013 and 2017.

The current study area falls completely within nationally codified watershed code 5A3B5. The watersheds are categorized into Safe, Semi-critical, Critical and Over-exploited zones based on the stage of groundwater development. In this case, the study area has good groundwater prospects and is declared as "SAFE" category in the stage of groundwater development. The groundwater availability is computed as per the 'Groundwater Estimation Methodology – 1997' published by CGWB. From the data given in the annexures of published reports of 2008, 2013 and 2017. The statistics of the groundwater potential in this watershed and study area is as tabulated in below Table no. 6.37.

Table 6.37: Groundwater Potential of the Study area

Description	2008	2013	2017
Watershed area	99,200 ha		
Groundwater recharge worthy area (After deducting slope >20% in Hilly areas)	98,600 ha		
Rainfall infiltration factor	4%		
Net Annual GW Availability ha-m	10,925 ha-m	10,436 ha-m	10,444 ha-m
Study area	25,293 ha	25,293 ha	25,293 ha
GW Availability for Study area ha-m	**2,802 ha-m**	**2,667 ha-m**	**2,679 ha-m**

Hence on an average over decade (2008-2017), the available groundwater resource (AGWR) may be taken as 2,716 ha-m or 27.16 million cubic meters (MCM).
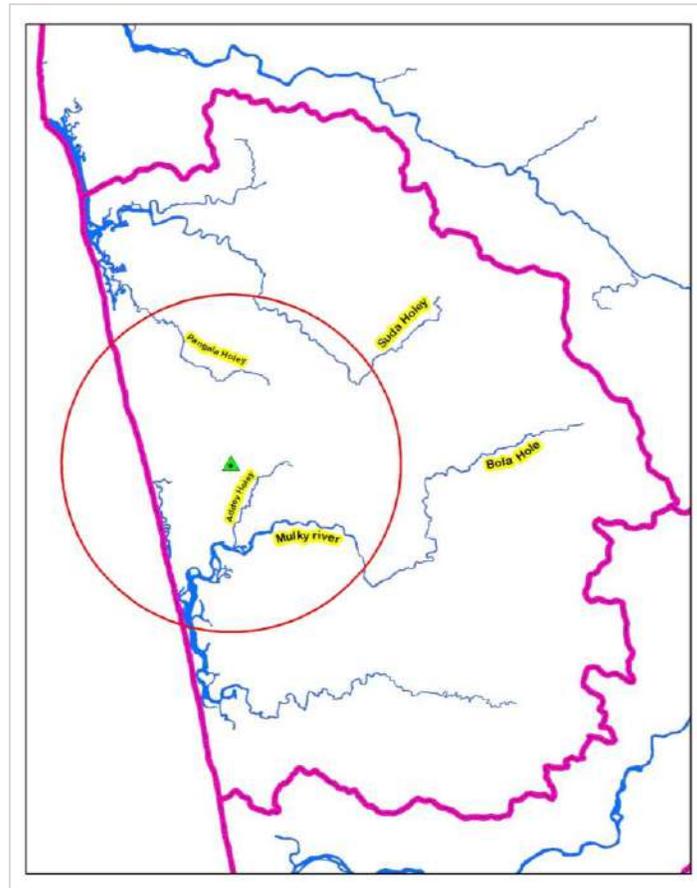
Figure 6.7: Map showing the watershed 5A3B5 which encompasses the study area

6.19.3 Surface Water Availability

The Surface water availability has been computed using Soil Water and Assessment Tool (SWAT). SWAT is a hydrological model used to assess the monthly and annual surface water potentials for catchments. The SWAT model has been developed to predict the hydrological response of various un-gauged catchments to natural inputs as well as manmade interventions in India. Water and sediment yields can be assessed using this program. The tool uses Landuse-Landcover, Soil and Slope aspects to compute the water balance components. The following data products have been used in this study.

Table 6.38: Data products used for computation for Surface water availability

Sl.No	Data Product	Year	Source
1.	Landuse- Landcover	2019	1: 50,000 scale Landuse Landcover data from KSRSAC
2.	Soil	2003	FAO/UNESCO. Digital Soil Map of the World and Derived Soil Properties. Rev. 1. (CD Rom), 2003.
3.	Digital Elevation Model (DEM) CartoDEM v.3	2015	The Cartosat-1 Digital Elevation Model (CartoDEM) is a National DEM developed by the Indian Space Research Organization (ISRO). It is derived from the Cartosat-1 stereo payload launched in May 2005.
4.	Rainfall	1989 – 2020 (32 years)	The daily rainfall data has been collected from Directorate of Economics and Statistics, Govt. of Karnataka
5.	Temperature	1989 – 2020 (32 years)	IMD High resolution 1by1 degree gridded daily temperature data.
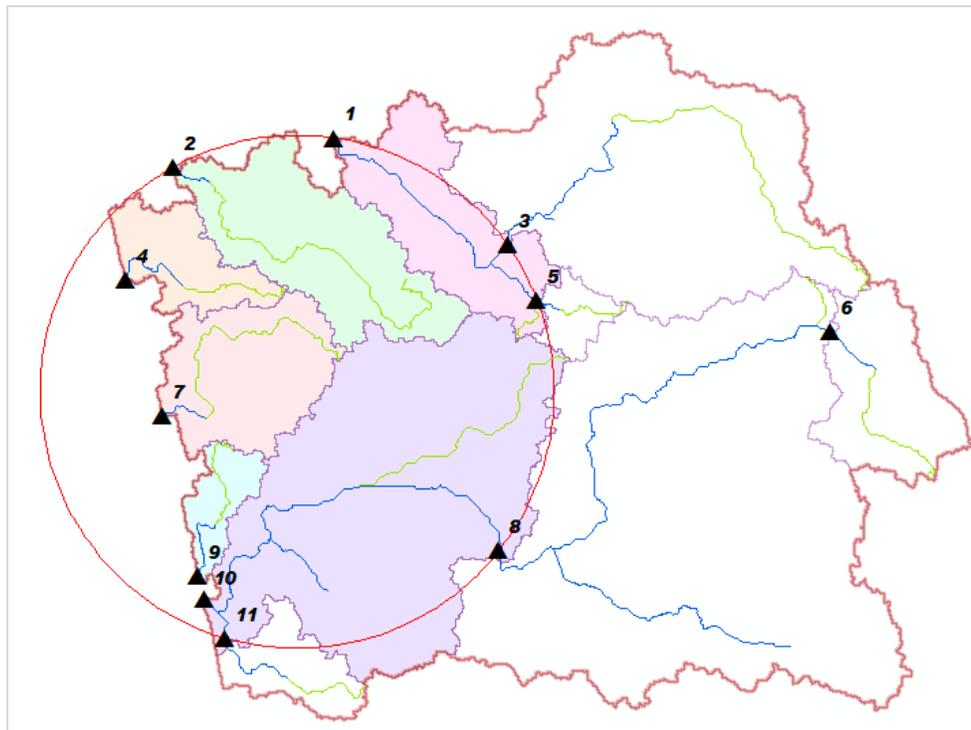
Figure 6.8: Map showing hydrological boundary catchments (sub-basins) for the study area
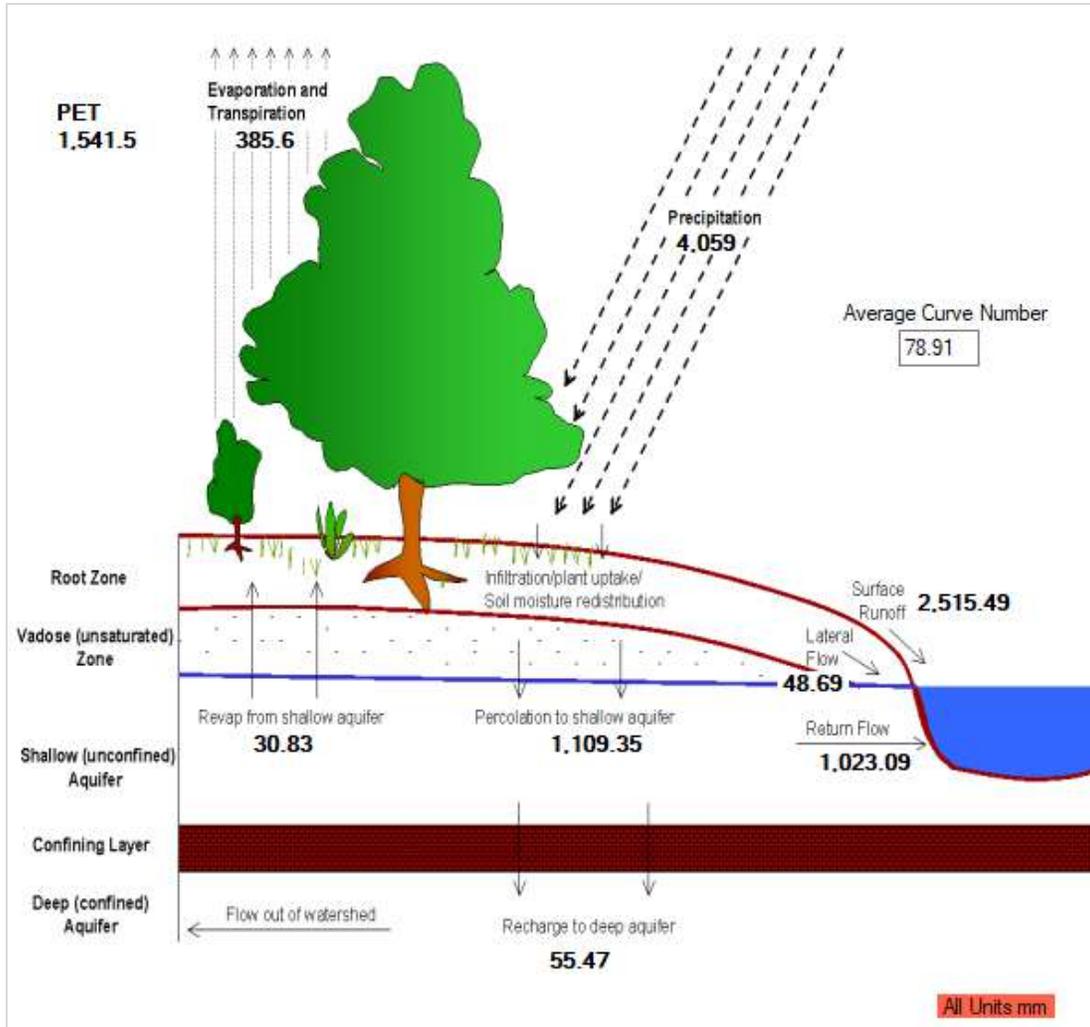
Figure 6.9: Schematic diagram showing average water balance components

Figure 6.10: Model output showing the average water balance ratios for entire catchment

Table 6.39: Year-wise computation of Surface Water Availability
(For the buffer zone study area)

Year	Rainfall in mm	ASWR… ha-m
1994	5,255	92,602
1995	4,416	75,580
1996	3,296	52,581
1997	4,199	72,942
1998	4,127	66,811
1999	3,619	53,099
2000	3,048	46,802
2001	4,255	68,778
2002	3,134	45,518
2003	3,560	57,148
2004	3,922	61,458
2005	3,157	46,965
2006	2,990	43,629
2007	3,700	56,477

Year	Rainfall in mm	ASWR… ha-m
2010	4,688	77,117
2011	4,162	65,174
2012	3,544	56,090
2013	3,821	57,840
2014	2,977	41,080
2015	3,049	43,860
2016	2,717	38,661
2017	2,439	33,441
2018	4,149	67,783
2019	4,317	67,823
2020	4,591	75,493
Average	3,695	57,964

Year	Rainfall in mm	ASWR… ha-m
2008	2,875	42,322
2009	3,763	57,963

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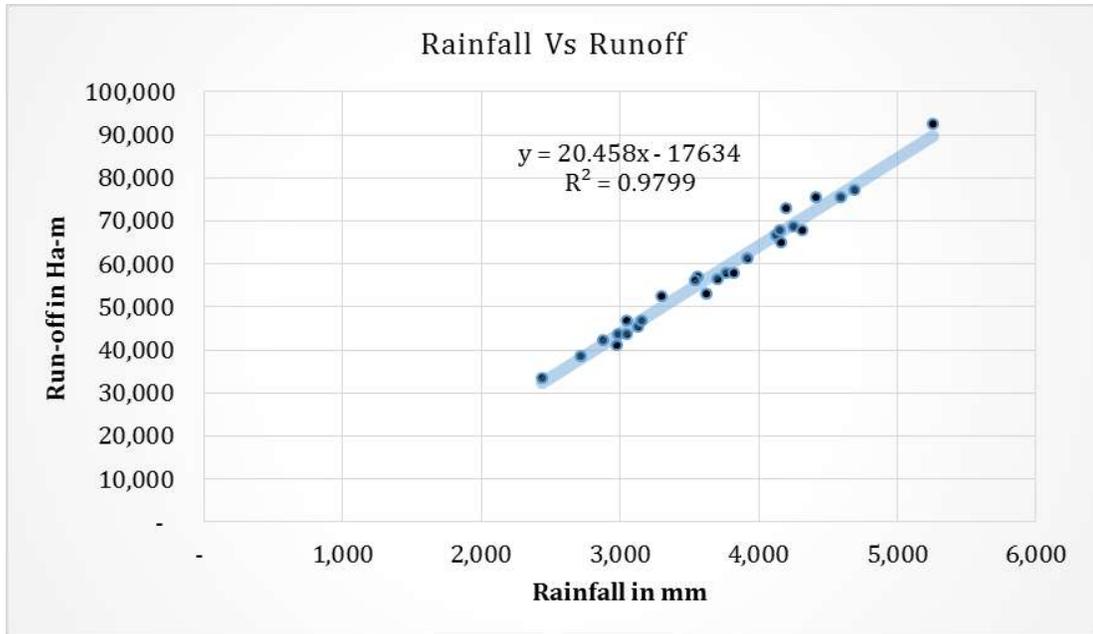
Figure 6.11: Rainfall – Run-off co-relation from the SWAT model for buffer zone study area.

Table 6.40: River stretch wise Surface water availability in the buffer zone study area

Gross Surface Water Availability		
River point	**River name**	**ASWR… ha-m**
1	Shirva Holey	8,185 ha-m
2	Pangala Holey	10,207 ha-m
4	Mulur stream	3,523 ha-m
7	Padubidri stream	7,155 ha-m
9		1,665 ha-m
10	Mulki River	27,230 ha-m
	Total	**57,964 ha-m**

Available water resources (AWR)

The Available water resources (AWR) are calculated using the following equation:

$$AWR = AGWR + ASWR + OAWR$$

The average AGWR is 2,716 ha-m

The average ASWR is 57,964 ha-m

OSWR is not applicable.

Hence, on an average the available water resources in the buffer zone study area is,

$$AWR = 2,716 + 57,964 = \textbf{60,680 ha-m per year or 606.80 MCM}$$

Definitions:

- **Watershed:** Based on the concept – ridge to valley – All India Soil and Land Use Survey has given 5-stage delineation (AIS&LUS, 1990). In this classification the lowest order delineation is Watershed having an area of 0.2 – 3 Lakh ha. (Table 3, Watershed Atlas of Karnataka, KSRSAC, Pg.3)

- **Hilly areas:** This sub-unit comprises of all portions of the groundwater assessment unit which have ground slopes greater than 20 percent. This sub-unit is characterised by practically negligible groundwater recharge, and hence no groundwater assessment is made for it. ("Detailed Guidelines for Implementing the Groundwater Estimation Methodology - 2009", CGWB Pg.9)

- **Net Groundwater Availability:** The Net Groundwater availability is the sum of groundwater recharge from all sources during monsoon and non-monsoon seasons deducting the provision for natural discharge.

- **Net Yield (Net Surface water availability):** The Net yield is defined as the available surface water in the outlet of a catchment deducting all the usages within the catchment.

- **Gross Yield (Gross Surface water availability):** The Gross yield is defined as the total surface water at the outlet of a catchment without any deductions or usage in the catchment.

- **Study area:** The study area is the 10 Km Buffer Zone from the UPCL.

- **Study area catchment:** the hydrological bounded catchment where the study area lies including the upper reaches where there is contribution of run-off.

6.20 Solid Waste Carrying Capacity

The Total Solid Waste is calculated as the total waste generated in the study area in tons per day (TPD) for the current year. Out of the total waste generated, the waste collected and transported to a dumping landfill site. Solid waste carrying capacity was analysed from the waste generation and management potential and public perception. Solid Waste Environment Carrying Capacity (SWECC) is assessed by using the following simple expression given in CPCB methodology.

$$SWECC = \frac{SWMef\ (tons) + RC\ (tons)}{SWG\ (tons)}$$

Where, SWECC = Solid Waste Environment Carrying Capacity

SWMef = Solid Waste Managed Environment-Friendly. Includes all SWM options (Recycling +Re-using +Reprocessing +Sanitary Land-filling +incineration in compliance with emission norms, etc.). Collection of waste is the foremost requirement before wastes are sent for land-filling, recycling, incineration, etc.

RC = Remaining Capacity, Capacity left/available for managing more SW.

SWG = Solid Waste Generated in tons.

The task is collection of the generated solid waste after which, the local authority can manage the waste by sending for recycling, land-filling or incineration etc. threshold for assessment;

According to CPCB,

If SWECC= 1 Carrying Capacity is on edge/break-point. CC may overshoot very soon. = SWECC> 1t Carrying Capacity exists. More the value, more the CC. SWECC<1: CC overshoot.

Carrying Capacity of Sewage management:

To calculate the total sewage generation in the region based on the present population scenario and for projected population for next 20 years and to evaluate the efficiency of the Treatment Plants Installed.

As per the available data from Udupi District Environment Plan, total waste generation including wet, dry, construction and demolishing waste (C & D), Street sweeping, drain silt, Domestic Hazardous Waste (DHW) and other waste is 107.6 tonnes per day. This includes the five local bodies consisting of Udupi City Municipal Council (CMC), Kundapura Town Municipal Council (TMC), Karkala TMC, Kaup TMC and Saligrama Town Panchayat (TP).

$$SWECC = \frac{79.64 (T/D) + 27.96 (T/D)}{107.6 (T/D)}$$

SWECC = 1.

The total solid waste generated in the district is 107.6 T/D. The Solid Waste Managed Environment-Friendly. Includes all SWM options (Recycling + Re-using + Reprocessing + Sanitary Land-filling + incineration in compliance with emission norms, etc.). Collection of waste is the foremost requirement. The wastes sent for land-filling, recycling, incineration, etc. is 79.64 MT/D and remaining capacity left for managing Solid waste is 27.96 T/D,

SWECC = 1: Carrying capacity on edge/break – point. Carrying capacity may overshoot very soon.

By the obtained results, it is concluded that the district has carrying capacity in view of Solid waste management, but it is at the edge, further load after expansion may lead to overshoot in the carrying capacity.

6.21: Noise monitoring results:

This section presents the results of noise monitoring conducted over August 2021 at the areas UPCL surrounding Udupi.

The purpose of the study was to:

- Monitor noise levels from the UPCL surrounding area and compare with ambient noise levels.
- Provide recommendations for environmental noise mitigation. If necessary, for noise from UPCL activities to meet norms.

A vicinity map showing the site, surrounding area, and sound measurement locations is presented in Figure no. 6.12.

The following are the key conclusions of the study

- Noise levels from the UPCL in typical operation currently meets daytime as well as night time ambient noise levels.
- During the study the plant was at half capacity and the continuous noise monitoring is suggested across the season when plant is running at full load capacity

6.21.1 Sound Level Descriptors:

Sound is measured as sound level in units of decibels, dB. The human ear responds differently to sounds at different frequencies. This is demonstrated by the fact that we hear higher pitched sounds more easily than lower ones of the same magnitude. To compensate the different "loudness" as perceived by humans, a standard weighting curve is applied to the measured sound levels. The weighting curve represents the frequency response of the human ear and is labelled as dBA ("A" weighted decibels).

People normally experience sound levels between 30 and 90 dBA, depending on their activities. Locations near highways or urban areas may be 70 dBA, whereas quiet rural areas may be 40 dBA.

Each 10 dB increase in sound level corresponds to a tenfold increase of sound energy, but is judged by a listener as only a doubling of loudness. The smallest changes in sound level considered just noticeable and are about 2 to 3 dBA.

When measuring noise that is fluctuating over time, it is common practice to use a descriptor called equivalent A-weighted sound level, Leq. The Leq is that constant sound level in dBA which contains the same amount of sound energy over a given time period as the measured fluctuating noise. The Leq is often determined for one-hour time periods.

Another descriptor used in this report is the Lmax. The Lmax is the highest instantaneous sound level for a given sound event or time period. Similarly, Lmin is the lowest instantaneous sound level for a given sound event or time period. (Source: SSA Acoustics).
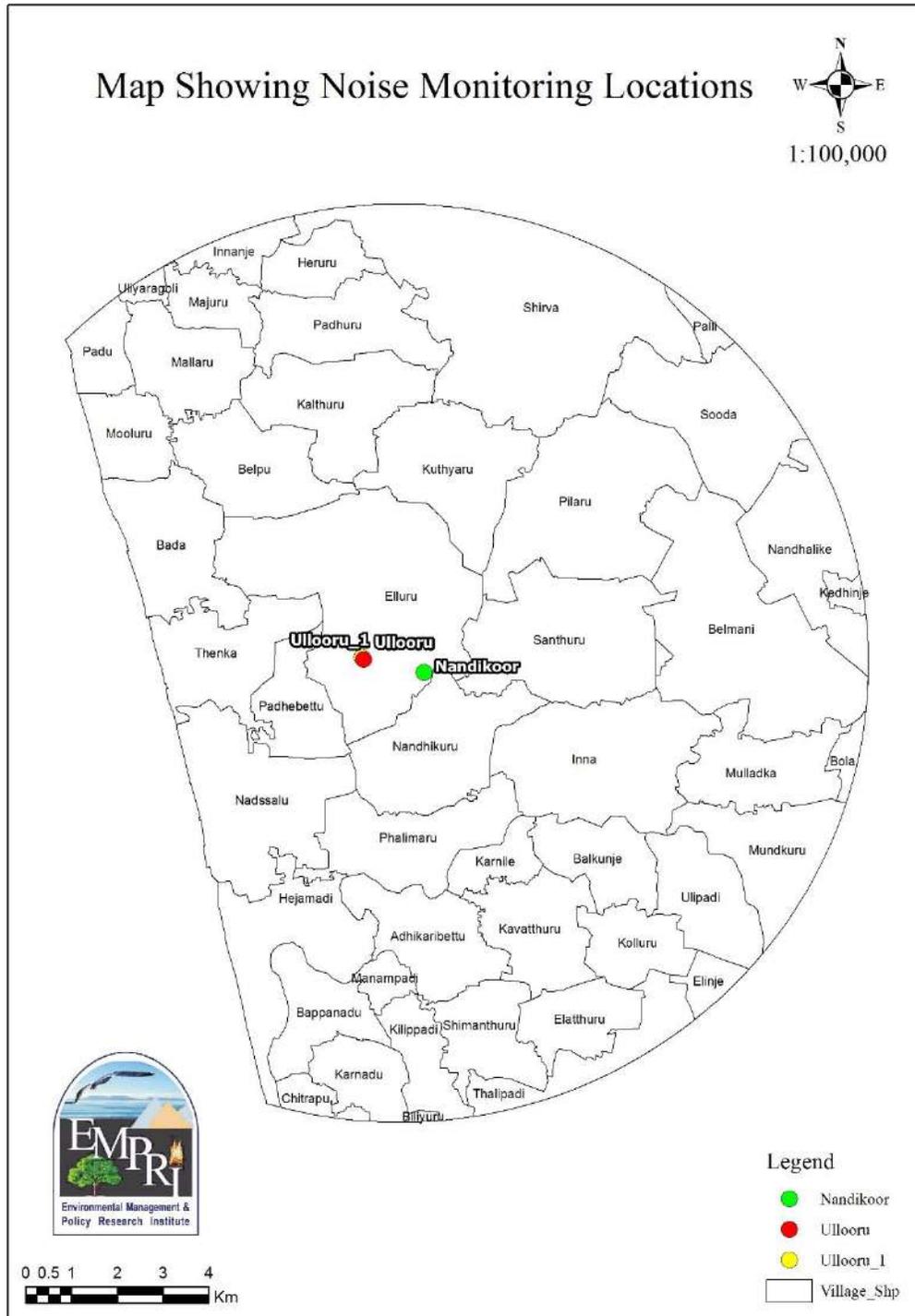
Figure 6.12: Map showing the Noise monitoring locations

Area Code	Category of Area/Zone	Limits in dB(A) Leq	
		Day Time	Night Time
(A)	Industrial area	75	70
(B)	Commercial area	65	55
(C)	Residential area	55	45
(D)	Silence Zone	50	40

The Study team carried out a Noise monitoring study in the month of August-2021, and the obtained results for 24 hours are as shown in the Table 6.42 below.

Table 6.42: Rainy Season Ambient Noise Level Results in the Study Area.
(In the month of August-2021)

Sl. No.	Monitoring Locations	GPS Co-ordinates	Rainy Season Aug-21		
			Maximum. dB	Minimum. dB	Leq dB(A)
1	Ullooru – Yelluru -1	13.160657 N 74.795357 E	73.47	16.4	34.74
2	Ullooru – Yelluru -2	13.160277 N 74.795692 E	65.47	4.95	36.21
3	Nandikoor	13.157673 N 74.807556 E	68.32	32.69	39.58

As per the Noise Pollution (Regulation and Control) Rules, 2000 the obtained results are within the limits. But it is observed that the plant was running in a half capacity during the time of monitoring. Hence the continuous monitoring is suggested across the season when plant running at a full capacity.

The below bar graphs are representing the ranges of noise data that is Leq Average, Maximum and Minimum for each location where monitored was carried out (Figure no's. 6.13, 6.14 & 6.15). and the below Figure no's. 6.16 and 6.17 depicts the instrument siting location and study team with device respectively.

1 Ullooru – Yelluru -1 13.160657 N 74.795357 E
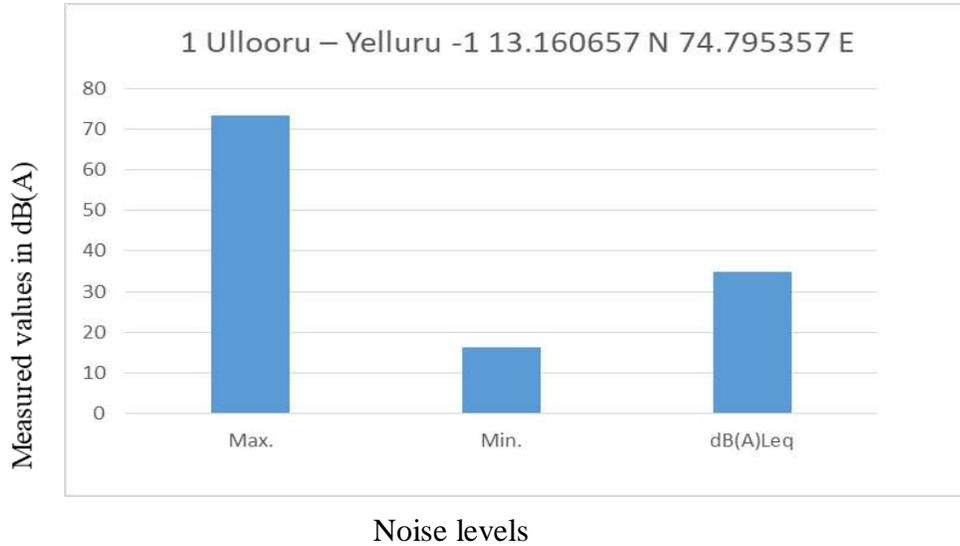
Figure 6.13: Bar graph showing the noise level as Max, Min and Leq (avg) values at location 1

2 Ullooru – Yelluru -2 13.160277 N 74.795692 E
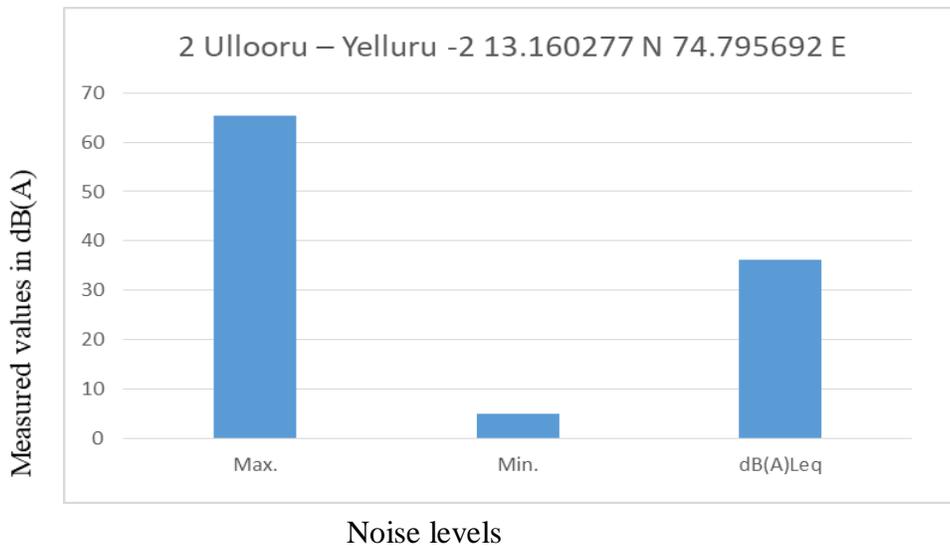
Figure 6.14: Bar graph showing the noise level as Max, Min and Leq (avg) values at location 2
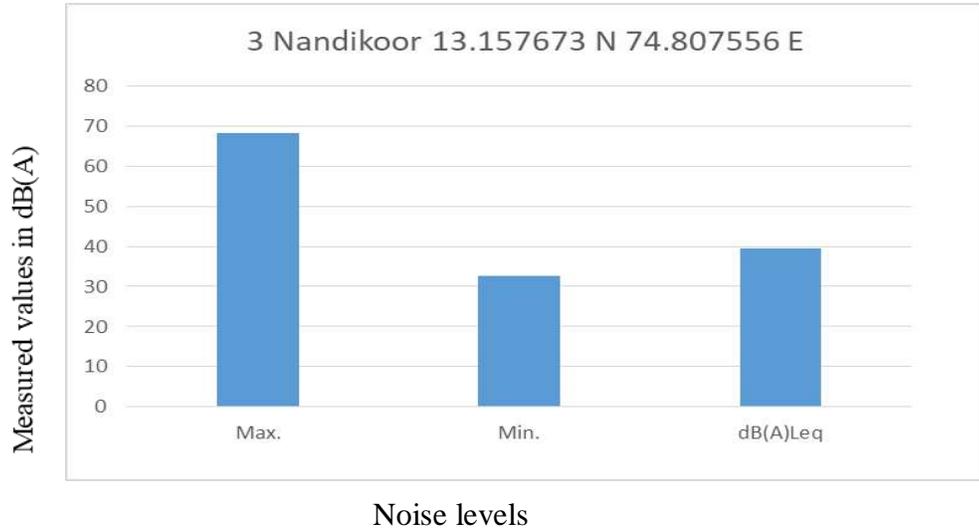
Figure 6.15: Bar graph showing the noise level as Max, Min and Leq (avg) values at location 3

Figure 6.16: Pictures showing Noise monitoring instruments at different locations

Figure 6.17: Study Team with Noise Monitoring Equipment

6.22 People's Perception Survey

A survey was conducted in the 36 villages surrounding the UPCL plant in Udupi district to know the socieo-economic, health, environment and ecological aspects of the respondents. The data was collected from a randomly selected 387 respondents in these villages in a prescribed questionnaire. The main objectives were

1. To know the socio-economic conditions of the residents
2. To elicit the opinion of the residents on the impact of the UPCL plant on their environment and their health conditions
3. To know their opinion on the expansion of UPCL plant and on setting up any new industry in the area

6.22.1 Methodology

A structured questionnaire in Kannada language was used to collect the information. A random sample of 36 villages within a radius of 10 Km was first selected. In the second stage a random sample of 387 families was selected from the 36 villages selected at the first stage. For determining the sample size for the study the small sample techniques as suggested by Robert V. Krejcie and Daryle W Morgan are adopted. The data collected in the prescribed questionnaire were further processed and tabulated using R software. A preliminary analysis is carried out. The summary Tables with actual numbers and percentages are presented and used for interpretation. A graphical summary of the Tables is also presented.

6.22.2 Results

The results are presented in different sub-sections as per the objectives listed above.

a) Socio-Economic conditions

Classification of respondents by gender is given in Table 6.43 and Figure 6.18, from this it is observed that 69% of the respondents were males and the remaining were females. Thus there is adequate representation for both genders and hence there may not be any gender bias in the results. In the next Table 6.44 and Figure 6.19 the distribution of respondents by the level of education. Only a small percent (1%) were illiterate. Rests had at least primary education. Occupational classification of respondents is given in Table 6.45 and Figure 6.20. A large proportion (69.25%) had Agriculture as their primary occupation. Fisheries were the occupation of 10.6%. Monthly income of 39.8% is found to be lesser than Rs. 10,000/- per month, while 50.6% had more than that and 10.8% did not disclose their income (Table 6.46 and Figure 6.21). Table 6.47 and Figure 6.22 shows the size distribution of landholdings in the sample. Many did not disclose the size of their landholdings (72.0%). Table 6.48 and Figure 6.23 shows Joint ownership of the property. It was observed that among 57.1% around 27.1% singly owned their property and 15.87% did not disclose the information.

Table 6.43: Distribution of respondents by gender

Gender	Number.	Percent
Male	268.00	69.25
Female	119.00	30.75
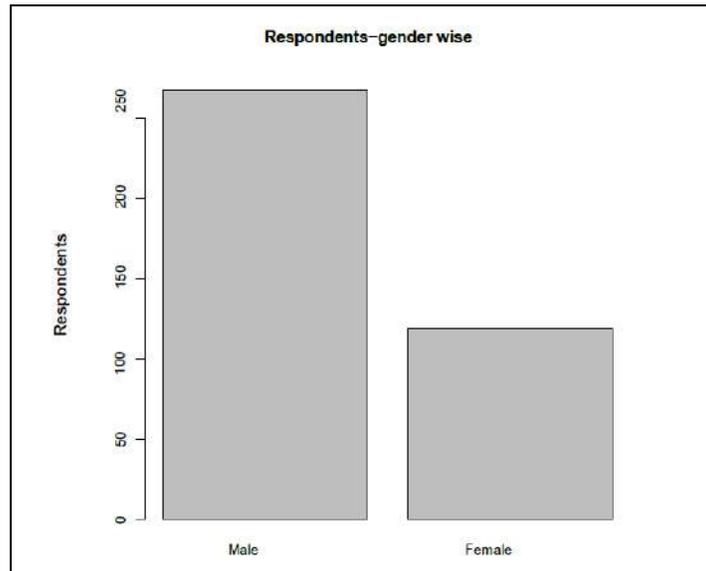
Figure 6.18: Distribution of respondents by gender

Table 6.44: Education level of Respondents

Education	Number.	Percent
Primary	104.00	26.87
High school	140.00	36.18
Pre university	56.00	14.47
Degree	64.00	16.54
Illiterate	5.00	1.29
NA	18.00	4.65
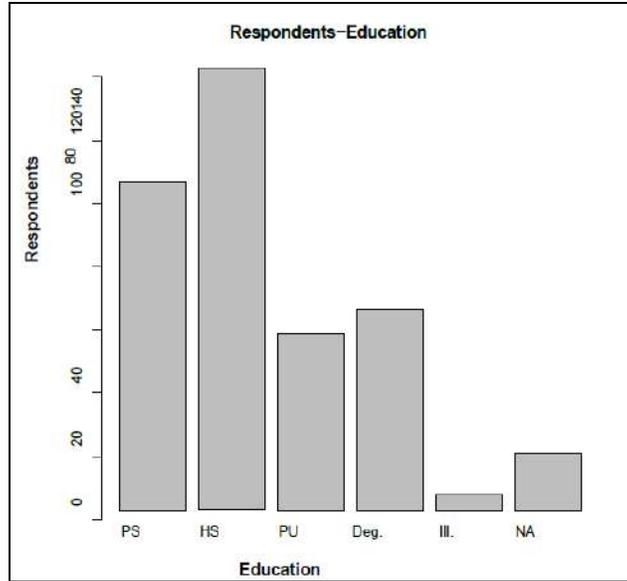
Figure 6.19: Education level of respondents

Table 6.45: Occupation of Respondents

Occupation	Number	Percent
Agriculture	268.00	69.25
Agri, Private job	4.00	1.03
Agri, private job, Fishery	1.00	0.26
Agri, Business	14.00	3.62
Agri, Fishery	4.00	1.03
Govt.job	7.00	1.81
Private job	22.00	5.68
Private job, Fishery	2.00	0.52
Business	16.00	4.13
Fishery	41.00	10.59
Other	1.00	0.26
NA	7.00	1.81

Figure 6.20: Occupation of Respondents

Table 6.46: Distribution of monthly income

	Income (Rs./month)	Number.	Percent
1	Lesser than 10000	154.00	39.79
2	More than 10000	196.00	50.64
3	NA	37.00	9.56
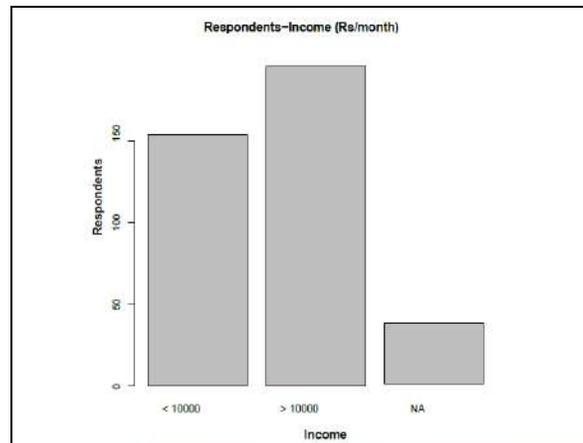
Figure 6.21: Respondents−Income

Table 6.47: Size of landholdings of respondents

	Size(Acres)	Number.	Percent
1	Less than 1	5.00	1.29
2	1-2	19.00	4.91
3	2-5	50.00	12.92
4	5-10	26.00	6.72
5	10-20	5.00	1.29
6	40	1.00	0.26
7	50	2.00	0.52
8	NA	279.00	72.09
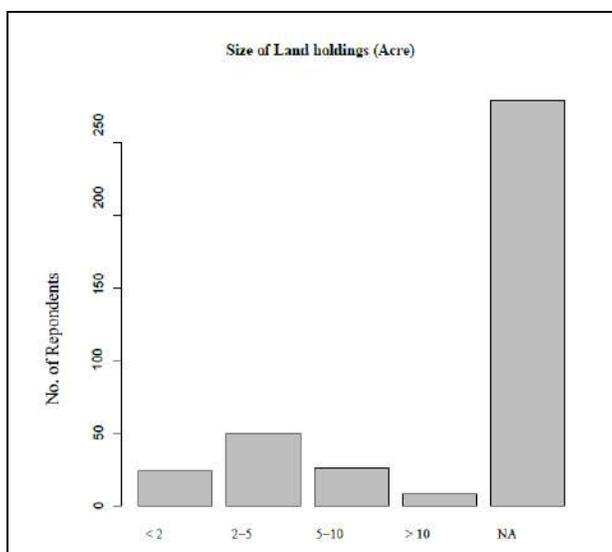
Figure 6.22: Landholding size in the study area

Table 6.48: Ownerships of Property by the respondents

Sl. No	Ownership	Number	Percent
1	Single	105.00	27.13
2	Joint	221.00	57.11
3	NA	61.00	15.76
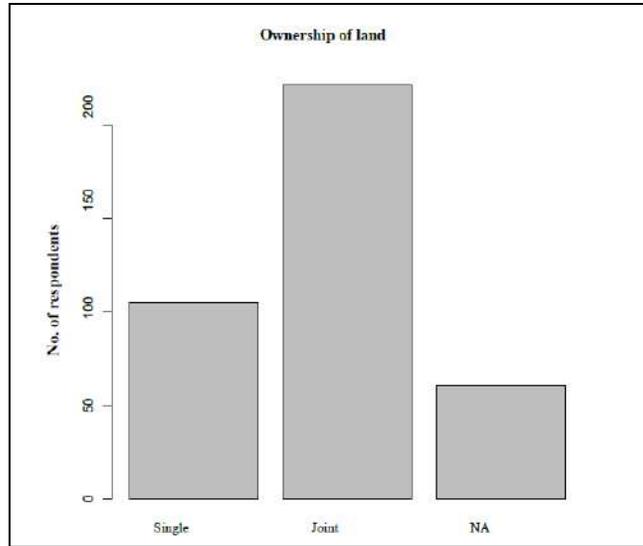
Figure 6.23: Ownership of lands in the study area

b) Impact of UPCL plant

From Table 6.50 and Figure 6.25, it is observed that 84.75% suffered loss of their Agricultural land, 9.56% lost their house and land, while 10.85% failed to part with the information. It is observed from Table 6.49 and Figure 6.24 that 93.5% expressed that there is no benefit from the UPCL plant, only 3.6% expressed on employment and a negligible 0.77% expressed improvement in infrastructure. From Table 6.51 and Figure 6.26, it is observed that 54.26% had multiple health problems due to UPCL, 39.3% had respiratory problems and 13.5% suffered from cough fever and head ache. From Table 6.52 and Figure 6.27, 54.8% expressed their basic needs of air, water and soil was adversely affected by UPCL plant. Some also expressed that their lands and buildings are also adversely affected. Regarding unemployment (Table 6.53 and Figure 6.28), 68.2% expressed that there is unemployment.

Table 6.49: Opinion on Benefits due to setting up UPCL

	Benefits	Number	Percent
1	Employment	14.00	3.61
2	Better infra	3.00	0.77
3	No benefits	363.00	93.56
4	Other	4.00	1.03
5	NA	4.00	1.03
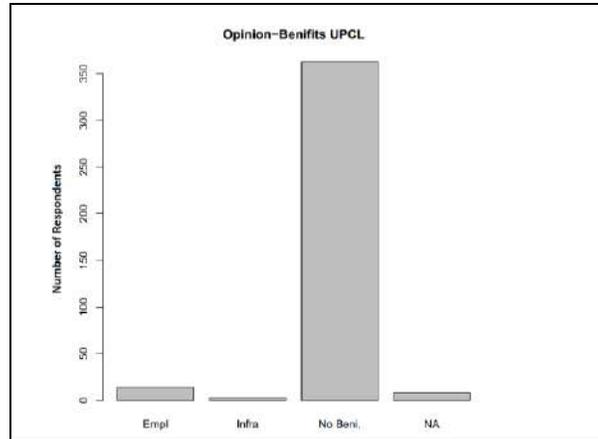
Figure 6.24: Opinion on Benefits due to setting up UPCL

Table 6.50: Effect of UPCL-LOSS

Sl no.	Items	Number.	Percent
1	Agri. Land	328.00	84.75
2	House	17.00	4.39
3	Land	20.00	5.17
4	Other	36.00	9.30
5	Fishery	17.00	4.39
6	NA	42.00	10.85
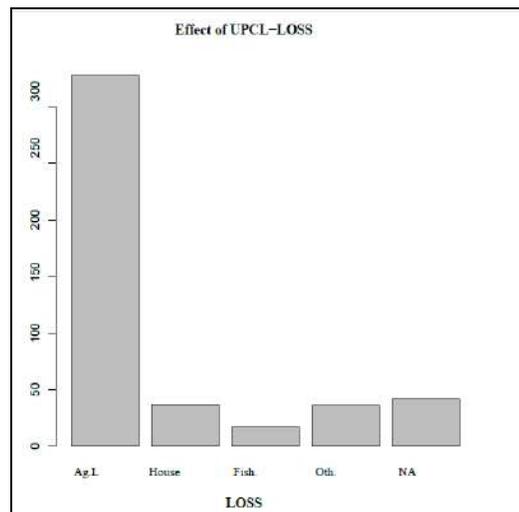
Figure 6.25: Represents the effect of Udupi power Corporation limited (UPCL) loss

Table 6.51: Health problems of the respondents due to UPCL

	Problems	Number	Percent
1	Cough	3.00	0.78
2	Fever	47.00	12.14
3	Headache	3.00	0.78
4	Breathing trouble	152.00	39.28
5	Others	41.00	10.59
6	Multiple problems	210.00	54.26
7	NA	11.00	2.84
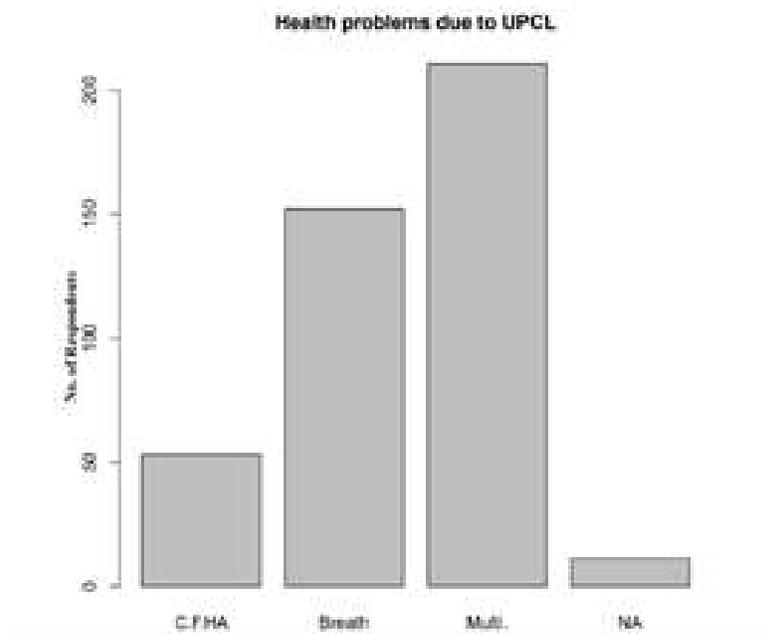
Figure 6.26: Health Problems due to UPCL

Table 6.52: Problems of Basic needs of respondents due to UPCL

(1: Air, 2: Water, 3: Soil, 4: Land, 5: Building)

	Problems	Number.	Percent
1	1	17.00	4.13
2	1,2	39.00	10.08
3	1,2,3	212.00	54.78
4	1,2,3,4	49.00	12.66
5	1,2,3,4,5	36.00	9.30
6	1,2,3,5	2.00	0.52
7	1,2,4	5.00	1.29
8	1,3	2.00	0.52
9	1,3,4	1.00	0.26
10	2	5.00	1.29
11	2,3,4	2.00	0.52
12	2,3,4,5	1.00	0.26
13	2,4,5	1.00	0.26
14	4	2.00	0.52
15	NA	13.00	3.36

Figure 6.27: Problems of Basic needs of respondents due to UPCL

(1: Air, 2: Water, 3: Soil, 4: Land, 5: Building)

Table 6.53: Opinion about Status of Unemployment due to UPCL

	Status	Number	Percent
1	Yes	264.00	68.22
2	No	1.00	0.26
3	Don't Know	122.00	31.52
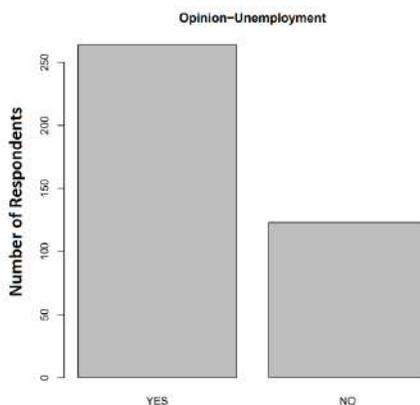
Figure 6.28: Opinion about Status of Unemployment due to UPCL

Table 6.54: Source of Cattle feed/fodder

(1: Natural grass, 2: Planted grass, 3: Feeds from Market, 4: Crop residues

	Source	Number.	Percent
1	1	72.00	18.60
2	1,2	28.00	7.24
3	1,2,3	41.00	10.59
4	1,2,3,4	74.00	19.12
5	1,2,4	13.00	3.36
6	1,3	45.00	11.63
7	1,3,4	8.00	2.07
8	1,4	10.00	2.58
9	2	7.00	1.81
10	3	3.00	0.78
11	NA	86.00	22.22

Figure 6.29: Source of Cattle feed/fodder

(1: Natural grass, 2: Planted grass, 3: Feeds from Market,4: Crop residues

c) Other facilities:

From Table 6.56 and Figure 6.31 it is observed that 80.1% resided in "Kutcha" houses while 19.9% in "Pucca" houses. Good quality drinking water is available for 84.75% and remaining 14.25% got polluted water unfit for drinking (Table 6.57 and Figure 6.32). Majority (89.7%) got their drinking water from open wells and a small percentage (1.55%) got tap water (Table 6.58 and Figure 6.33). The area grows crops mainly from rainfall (54%). Some (22.2%) also used bore wells and other sources for irrigation (Table 6.59 and Figure 6.34). Cattle are mainly fed with grass, both natural grass and planted grass. Crop residues and cattle feed from markets are also used (Table 6.54 and Figure 6.29). Among the list of important places include places of worship, lakes, seashore and forest (Table 6.55 and Figure 6.30).

Table 6.55: Opinion about Places of importance

(1: Places of worship, 2: Lake, 3: Seashore, 4: Forest, 5: Others)

Sl No	Places	Number	Percent
1	1	196.00	50.65
2	1,2	23.00	5.94
3	1,2,3	7.00	1.81
4	1,2,3,4	3.00	0.78
5	1,2,4	21.00	5.43
6	1,2,5	2.00	0.52

Sl No	Places	Number	Percent
7	1,3	30.00	7.75
8	1,4	23.00	5.94
9	1,4,5	2.00	0.52
10	1,5	37.00	9.56
11	2	5.00	1.29
12	3	20.00	5.17
13	4	2.00	0.52
14	5	5.00	1.29
15	NA	11.00	2.84

Places of Importance
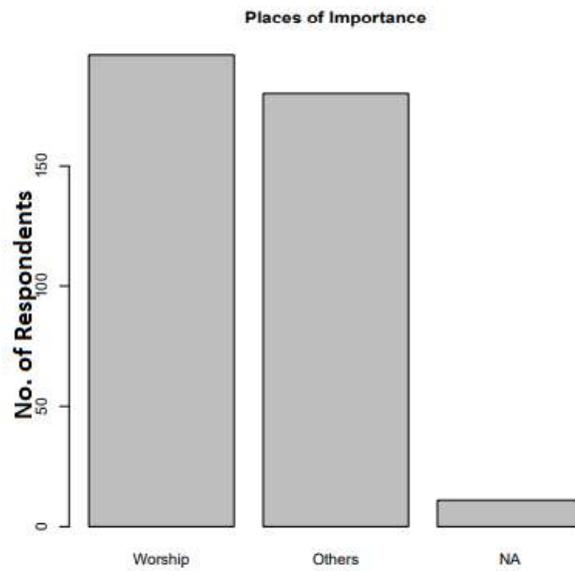
Figure 6.30: Opinion about Places of importance

(1: Places of worship, 2: Lake, 3: Seashore, 4: Forest, 5: Others)

Table 6.56: Condition of residential house of respondents

Sl. No.	Quality	Number	Percent
1	Pucca	77	19.90
2	Kutcha	310	80.10

Quality of houses

Pucca   Kutcha
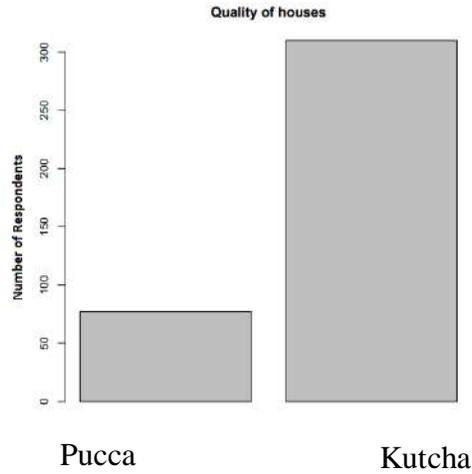
Figure 6.31: Condition of residential house of respondents

Table 6.57: Opinion about quality of Drinking water

	Quality	Number	Percent
1	Good	328.00	84.75
2	Polluted	33.00	8.53
3	Polluted, unfit	3.00	0.78
4	Unfit	23.00	5.94

Quality of Drinking water
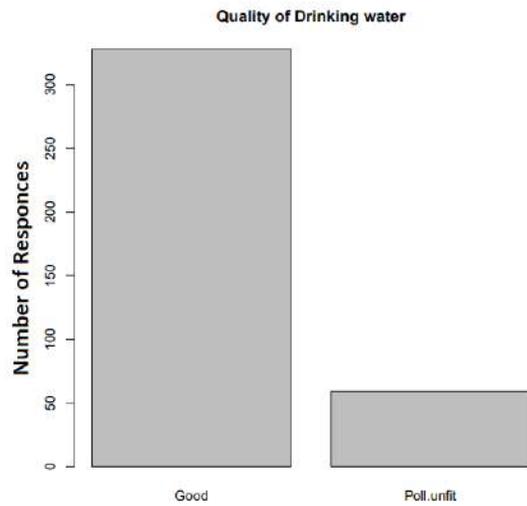
Figure 6.32: Opinion about quality of Drinking water

Table 6.58: Source of drinking water

Sl No	Source	Number	Percent
1	Bore well	8.00	2.07
2	Open well	347.00	89.66
3	Tap water	6.00	1.55
4	Bore/Open well	19.00	4.91
5	Other	4.00	1.03
6	NA	3.00	0.78
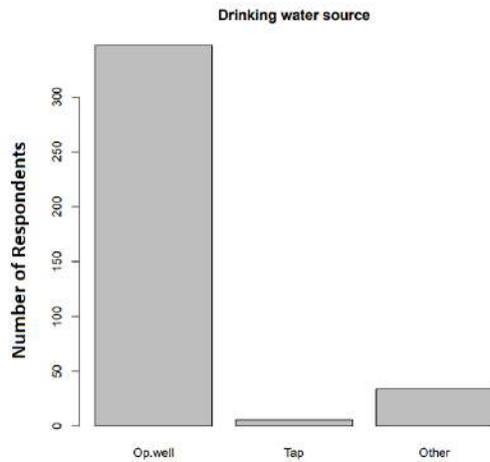
Figure 6.33: Source of drinking water

Table 6.59: Source of irrigation water
(1: Rain, 2: water, 3: Tanks, 4: Bore well, 5: Other)

Sl No	Source	Number.	Percent
1	1	203.00	52.45
2	1,2	4.00	1.03
3	1,2,3	4.00	1.03
4	1,2,5,	1.00	0.26
5	1,3	8.00	2.07
6	1,3,5	2.00	0.52
7	1,4	30.00	7.75
8	1,4,5	5.00	1.29
9	1,5	86.00	22.22
10	2	5.00	1.29
11	3	3.00	0.78
12	4	5.00	1.29
13	5	5.00	1.29
14	NA	26.00	6.72
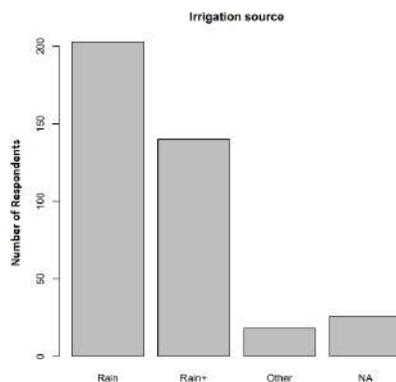
Figure 6.34: Source of irrigation water

(1: Rain, 2: Groundwater, 3: Tanks, 4: Bore well, 5: Other)

d) Environment condition

The opinion on general environmental condition is given in Table 6.60 and Figure 6.35. Opinion of 26.36% was water pollution, air pollution and health problems persisted. Problems of health, land/ soil erosion loss of trees in addition to air, water pollution was also observed (52.4%). Local environmental condition (Table 6.61 and Figure 6.36) was moderate (69.25%) and was healthy (21.45%). In Table 6.60 and Figure 6.37, 64.4% felt no health facility and 23.25% felt otherwise. From Table 6.63 and Figure 6.38 it is observed that 95% of respondents saw a change in the landscape of the district. Many did not respond (75%) regarding suffering from ill health in the family (Table 6.64).

Table 6.60: Opinion about Environmental pollution problems

(1: Water pollution, 2: Air pollution, 3: Health problem, 4: Land/ Soil erosion, 5: Loss of trees)

Sl No	Opinion	Number	Percent
1	1,2,3	102.00	26.36
2	1,2,3,4	54.00	13.95
3	1,2,3,4,5	203.00	52.45
4	2,3,4,5	24.00	6.20
5	NA	4.00	1.03

Envi.poln.(1:water,2:air,3:health,4:land/so,5:trees)
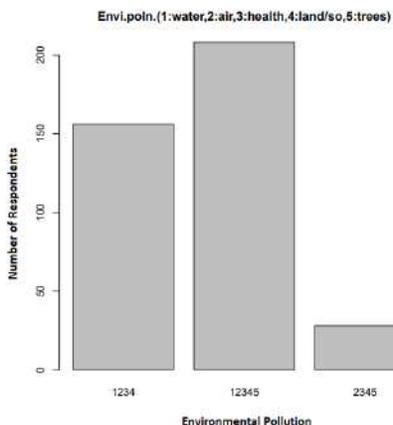
Figure 6.35: Opinion about Environmental pollution problems

(1: Water pollution, 2: Air pollution, 3: Health problem, 4: Land/Soil erosion, 5: Loss of trees)

Table 6.61: Opinion about your local environment

(1: Very ugly, 2: Ugly, 3: Moderate, 4: Clean, 5: Healthy)

Sl No.	Opinion	Number	Percent
1	1	5.00	1.29
2	2	15.00	3.88
3	3	268.00	69.25
4	4	6.00	1.55
5	4,5	3.00	0.78
6	5	83.00	21.45
7	NA	7.00	1.81

Local environment Condition
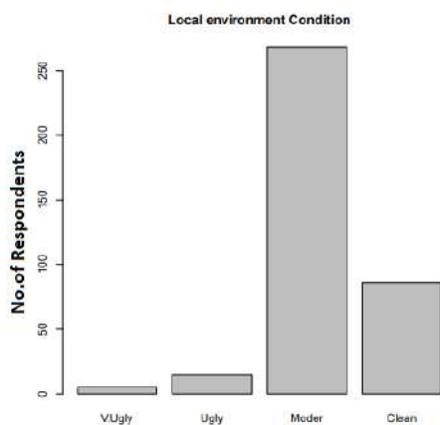
Figure 6.36: Opinion about your local environment

(1: Very ugly, 2: Ugly, 3: Moderate, 4: Clean, 5: Healthy)

Table 6.62: Opinion about availability of health facilities

Sl No.	Opinion	Number	Percent
1	Yes	90	23.25
2	No	257	66.41
3	NA	40	10.33
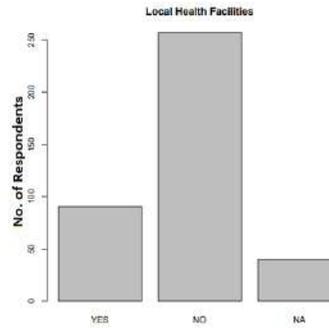
Figure 6.37: Opinion about availability of health facilities

Table 6.63: Opinion about change in the landscape of your district

Sl No.	Opinion	Number	Percent
1	Change	367	94.82
2	No change	6	1.55
3	NA	14	3.62
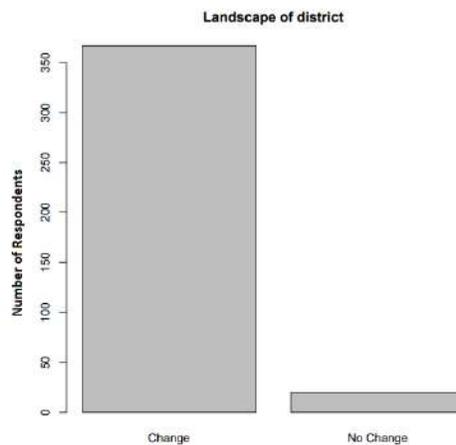
Figure 6.38: Opinion about change in the landscape of your district

e) Opinion on expansion of UPCL and setting up new industry

The opinion about expansion of UPCL was against (97.4%). For new industry 93.4% expressed against setting up of any new industry in the region (Tables 6.65 & 6.66 and Figures 6.39 & 6.40).

Table 6.64: Health Effects

Anyone in the family suffering from ill health

Sl No	Opinion	Number	Percent
1	Yes	62	16.20
2	No	36	9.30
3	NA	289	74.67

Table 6.65: Opinion about the Expansion of UPCL plant

Sl No	Opinion	Number	Percent
1	Yes	9	2.32
2	No	377	97.41
3	NA	1	0.26
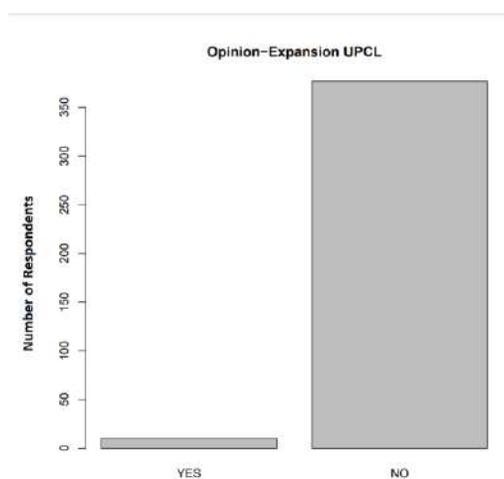
Figure 6.39: Opinion about the expansion of UPCL

Table 6.66: Opinion about starting new industries in the area

Sl No.	Opinion	Number.	Percent
1	Yes	23	5.94
2	No	361	93.28
3	NA	3	0.77
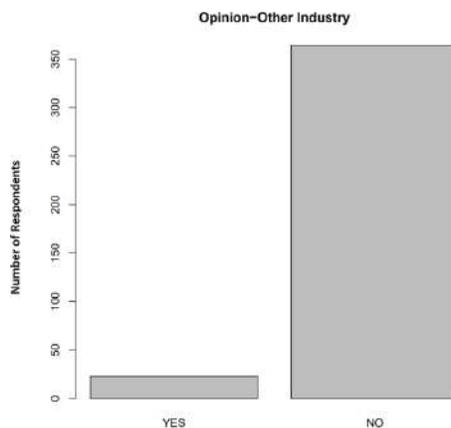
Figure 6.40: Opinion about starting new industries in the area

6.23: Human-Animal Conflict

Udupi district is an ecologically sensitive area in which Areas like Edu, Nooralbettu, Mala, Kervashe, Shirlalu, Matlapadi, Andaru, Mudradi, Charaand, Nadpalu are known for their rich bio- diversity. The district is located in between two major ecologically sensitive areas with western - Ghats on eastern side, and Arabian sea on the western side, which makes the district a unique and rare mixture of two ecological flavors. The district is the hub of tradition and culture. These ecologically sensitive areas are also noted for endemic flora and fauna. The human-animal conflict is a major issue which exists over the years on account of increased urbanization and industrialization in the region. The human-animal conflicts comprise of straying of Leopard, Wild boar, Gaur and Deer in to human habitation leading to cattle kills, human injury, crop depredation and damage to property. The details of Man-animal conflict at Udupi range have been given in the tabular form as below Table 6.67, cases of relocation of rescued animals are shown in Table 6.68 and compensation provided to villagers are in Table 6.69.

Table 6.67: Recent year wise list of crop damage, cattle kills and attack on humans

Sl. No.	Year	Frequency Cases of animal translocation	Frequency Cases of crop damage	Frequency Cases of cattle kills	Frequency Cases of human attack
1	2018-19	1	1	3	0
2	2019-20	3	0	3	0
3	2020-21	5	0	0	1
4	2021-22	1	0	0	0

Table 6.68: The list of cases of animal relocation

Sl. No.	Range	Year	Wild animals	Rescued and relocated wild animals
1	Udupi	2018-19	Leopard	-
			Gaur	1
			Spotted deer	-
			Sambar deer	-
			Monkey	-
			Others	-
2	Udupi	2019-20	Leopard	3
			Gaur	-
			Spotted deer	-
			Sambar deer	-
			Others	-
3	Udupi	2020-21	Leopard	3
			Indian rock python	2
4	Udupi	2021-22	Leopard	1

(Source: KFD 2021)

Figure 6.41: Recent 3-year information regarding the compensation

(Source: KFD 2021)

Table 6.69: Compensation provided at Udupi district for wild animal attack

Sl. No.	Year	Attacked place	Attacked by animal	Impairment details	Relief fund utilized by	Provided relief fund in Rs
1	2018-19	In Kapu taluk, Santhoor village ranganakeregadduge house	Leopard	Killed a domestic cow	Mr. Mohan poojari, Santhoor village	6,000/
		In Udupi taluk, heggunje village hebbadihosamane	Leopard	Killed a domestic cow	Mrs. Bhageerathi Shedthi, Heggunje village	10,000/
		In Kaaduru village baayarabettu	Leopard	Killed a domestic cow	Mr. Bhaskar achari, kaaduru village	7,000/
		In Udupi taluk bommarabettu Village guddeyangadi.	Gaur	Destructed Crops	Mr. Prakash S, Devadiga, Bommarabettu village	4,000/

		In Brahmavara taluk, Heggunje village, Neerjeddu	Leopard	Killed a domestic cow	Mrs. Rukmini, Heggunje village,	10,000/
2	2019-20	In Brahmavara taluk, Giliyaru village badamane	Leopard	Killed a domestic cow	Mrs. Gulabhi Shedthi, Giliyaru village	10,000/
		In Kaaputaluk, Shirva village, panjimar	Leopard	Killed a domestic cow	Mr. Loku Shetty, Shirva village	10,000/
3	2020-21	In Brahmavara taluk, Giliyaru village	Wild boar	Human attack	Mr. Satheesh Shetty, Giliyaru village	13,626/

(Source: KFD 2021)

The animals which stray into the human habitation are captured and trans-located back to the wild. Crop compensation, compensation for cattle kills and human injury, etc. are given by the government to the affected people. This information shows that the study area is highly sensitive from the point of various ecological balance of the region. The habitat of wild animals has been severely affected due to rapid industrialization and other anthropogenic activities.

6.24 Significant findings of the study

Presently UPCL is using Seawater in cooling tower and it passes through effluent discharge pipeline. The blowdown from cooling tower is collecting into the intermediate storage sump to reduce the temperature and then discharged back into the sea at a distance of 650 m in deep sea for better diffusion. But the UPCL discharge pipe was broken long time back and presently the blowdown water is being discharging at the bay itself. UPCL has not yet installed online temperature sensor at the collection pond or at discharge point.

It is seen that UPCL is not maintaining proper discharges at proper distance in the sea and temperature of the cooling tower blow down water. This will likely affect the marine environment nearer to the discharge point area. In case of further additional plants it will give more Environmental load to sea if it is not treated and discharged is not advisable under the given circumstances.

UPCL doesn't have the proper fly ash / bottom ash inventorization as the relevant records were not evidenced. The present dyke ponds are not being properly maintained and the depth of dyke ponds are low and no overflow water collection facility during heavy rainy period could be seen. In view of this, there is a possibility of overflow of water from dyke pond into the nearby villages and agricultural farms. The present ash generation per day 673 Tons and per year (considering 235 days' operation) is 1,58,146 Tons.

UPCL dyke ponds are in dry state and there is possibility of fly ash becoming air borne into the nearby environment. Long-term exposure to fly ash in the air can lead to serious pulmonary illnesses like bronchitis, silicosis, fibrosis, pneumonitis, etc. The ash contains toxic heavy metals too that are known carcinogens.

UPCL is not following the CPCB / KSPCB coal handling guidelines and physically it has been observed that the black colour leachate water is being pumped into the cooling tower blow down water collection pond.

In Stack Emission monitoring of the thermal boilers both the stacks are not complying for Sulphur Dioxide emissions with Concentration of 886 mg/Nm^3 & 1192 mg/Nm^3 against the CPCB Emission Limit value of 600 mg/Nm^3. Other parameters were within the emissions limits. Since the study team has analysed the emission from Stack only for one day, continuous Stack Emission monitoring is required across the seasons for the analysing the long term impacts when the Plant Load Factor (PLF) is at designed levels.

Based on the Stack Monitoring Emission results and considering all the modeling parameters like the location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate the Ground Level Concentration (GLC) at 2.0 Km and 5.0 Km was calculated. These stacks typically operate

on a continuous basis with relatively uniform emission rates. The Consolidated GLC observed is given in the Table 6.23.

Although all the parameters meet the NAAQ Standards at 2 Km and 5 KM radius. However, it is observed that SO_2 and NO_2 (for Boiler 2) does not meet the standards at 0.8 Km and 0.76 Km distance. Adverse Environmental impacts are likely at this radius with respect to SO_2 and NO_2 emissions.

Plant load factor is started to be have declined from 31 to 21 percent. Before asking for an additional unit, the company should optimize production, keeping all the environmental parameters under control.

a) Groundwater:

In April 2021, Mudarangadi Village - 8, Mudarangadi Village 8B, R and R Adamar, Ullooru-2, Hejamady, Village, Inna, Nandikoor Village had Iron (Fe), Ammonia NH3-N, pH at 25°C, Nitrate (NO3), Manganese (Mn) pH at 25°C have exceeded the limits as per the Drinking Water Standards IS 10500: 2012 permissible limits in the absence of alternate sources. Further Zinc (Zn), Fluoride (F), Copper (Cu), Nitrite (NO2), Lead (Pb), Phosphate (P) are below detection level.

b) Heavy Metals detection:

During the sampling and analysis in the month of March 2021, the samples from Mudarangadi Village 3A, Mudarangadi Village 3B, R and R Adamar 4, Ullooru-2, Hejamady Village, Inna, Nandikoor Village, Tenka Yermal 8, Tenka Yermal 8B were collected and analysed. It was found that Iron (Fe), Ammonia NH3-N, pH at 25°C, Iron(Fe), Lead (Pb), Nitrate (NO3), Manganese (Mn), Ammonia NH3-N, have exceeded the limits as per the Drinking Water Standards IS 10500 2012 permissible limits in the absence of alternate sources. Further Fluoride (F), Copper (Cu), Zinc (Zn), Manganese (Mn), Total hardness (CaCO3), Calcium (Ca), Magnesium (Mg) were below detection level.

c) Flora & Fauna:

The study area is part of the coastal region which has several highly dynamic ecosystems. The landmass consists of plains, Western Ghats and the wetland regions and support unique ecological niches.

d) Land Use Land Cover:

<p align="center">**Table 6.70: LULC change between 2002 and 2019**</p>

Landuse - Landcover (Level-I and III) changes between 2002 and 2019					
LULC Category		**Area**			**% difference**
		2002(Ha)	**2019(Ha)**	**Difference(Ha)**	
Level-I	Agricultural Land	19123.6	17781.6	-1342	-7.55 Decrease
Level-I	Built up	1567.14	3567.97	2000.83	56.08 Increase
Level-I	Forest	144.87	144.48	-0.39	-0.27 Decrease
Level-I	Waste land	3838.89	3182.37	-656.52	-20.63 Decrease
Level-I	Waterbodies	618.39	616.49	-1.9	-0.31 Decrease
Grand Total		25292.91	25292.91		

Based on this the land managers and conservationists would give due emphasis on understanding how the changes among different land use types are related and act accordingly on devising land use plan, agricultural production and conservation strategies.

e) Peoples' perception:

Based on the analysis of the survey data following conclusions have emerged. This is purely an opinion or perception based socio-economic survey.

1   A large number of respondents who are primarily agriculturists have lost and reduced their agricultural productivity from their agricultural land due to setting up of UPCL plant. People have also lost their houses and land which has affected the cost of living.

2   Majority of the respondents are of the opinion that there are no benefits from the UPCL plant and there is no improvement in their standard of living and infrastructure also.

3   Health conditions of the residents of the area were adversely affected by the UPCL plant. Many people (54.25%) are of the opinion that people are suffering from multiple health problems and 39 percent expressed that people suffered from respiratory problems.

4   By and large people were of the opinion that environmental pollution occurred with respect to Air, Water and Soil. However, 69.25 percent of respondent's local Environmental conditions were moderate.

5   Most of the respondents (97.4%) expressed their opinion against the expansion of UPCL plant and 93.4% expressed their opinion against setting up of any new industry in the region.

Figure 6.42: Study team's visit to the villages affected by the UPCL.

f) General Observations by the people

The following people's perception and observations are of greater concern which calls for in-depth investigation.

- There is a drastic increase in skin, bronchial, cancer and heart related diseases. This complaint also supported by the concerned Primary Health Centres (PHC) data in the region.

- After the commencement of the coal based thermal plant, farmers have observed black dust deposition on the leaves of plants which in turn affected the yields. Ex; Allegedly Jasmine flowers yields have reduced by 60% according to the farmer.

- Allegedly due to the increase in the salinity of the farmland, farmers are growing only one crop, where earlier they used to grow two to three crops per year. This phenomena (salinity) has affected the paddy seed germination.

- The water has a bad smell and not potable for drinking at some locations. Prior to the thermal plant, farmers used to drink from the streams and children used to play in these streams.

- The villagers said that the skin and nails of the legs and arms of the men working in the polluted water of the streams are affected.

- The villagers also complained that the smoke / steam coming out from the UPCL stack/cooling towers causes increase in the atmospheric temperature.

Allegedly discharge of effluents from Thermal power plant and ash pond including hazardous waste to the nearby natural streams during rainy season has become a common phenomenon. It contaminates farmland as well as surface and groundwater bodies. This resulted in reduction in crop productivity of both agriculture and horticulture crops. In turn it enhanced the growth of weeds and saline resistant plants. The farmers said due to this, they have been spending more money on removal of these weeds.

Figure 6.43: *Acrostichum aureum* **L.**

Interestingly, the growth of plant *Acrostichum aureum* L. which is a halophyte, salt tolerant plant that grows in soil or waters of high salinity, is an indicator to show the increase in the soil salinity of nearby villages.

Figure 6.44: *Acrostichum aureum* **L. is profusely growing in the drains of coal yard of UPCL**

g) Fishermen community's observations:

- Earlier they used to get fishes near to the seashore. Now, they have to go deep into the sea for fishing with great difficulties and risking their lives.

- Tenka Yermal fishermen alleged that they cannot catch fish using "Rampani" a type of fishing, at the location where effluents from UPCL are discharged, as UPCL pipelines are broken and lying on the seashore.

- They also complained that UPCL discharges untreated effluents during the night time.

- They alleged that during rainy season whenever the UPCL operates, they release untreated effluents directly to the sea.

- They also observed that hot water released by the UPCL causes deaths of sensitive marine fauna like baby dolphins (Calves) and Cuttle fishes.

- The fishermen community informed that before the commissioning of the coal based thermal power plant, there was evidence of sea turtles laying eggs at Tenka Yermal. Due to effluent discharge in to the sea, the diversity of the turtles and other marine creatures are badly affected and is of concern.

Figure 6.45: The clean and normal seawater in the Tenka – Yermal

(Clean Seashore before discharge of effluent from UPCL)

Figure 6.46: Black colour in seawater at Tenka Yermal Village

(Due to direct discharge of effluents by UPCL at Tenka Yermal Village.)

- Different Newspaper articles highlighting the fishermen's grievances due to broken UPCL effluent discharge pipe on the seashore of Tenka Yermal Village are reported often. (Figure numbers 6.47, 6.48, 6.49 and 6.50)

Figure 6.47: Newspaper article in Vartha Bharathi dated 27/02/2021

Figure 6.48: Newspaper article in Vijaya Vaani dated 27/02/2021

Figure 6.49: Newspaper article in Praja Vaani dated 27/02/2021
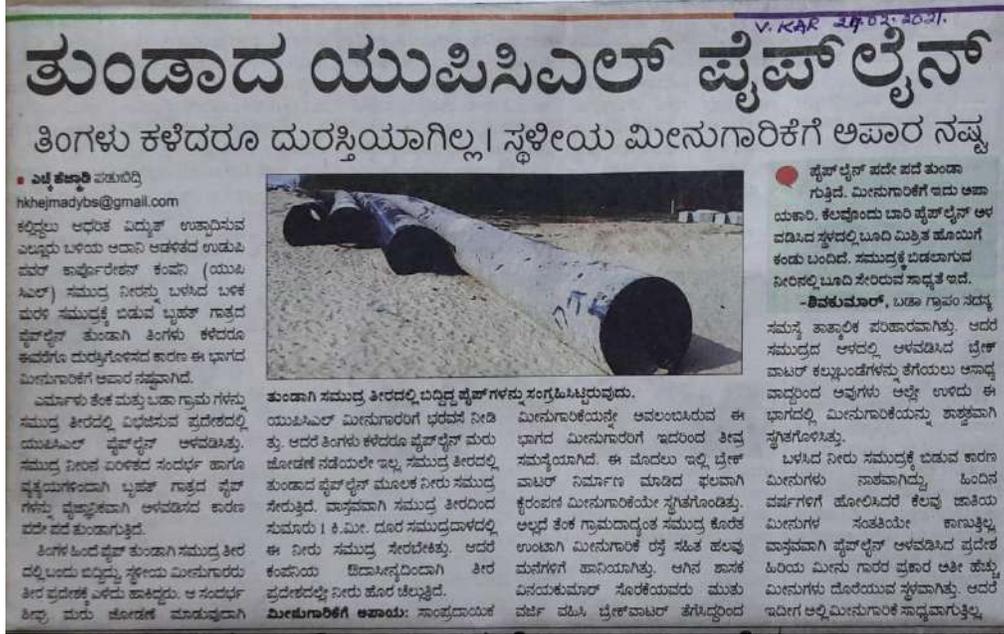
Figure 6.50: Newspaper article in Vijaya Karnataka dated 27/02/2021

- Newspaper article highlighting the farmer's grievances every year during the rainy season due to the UPCL Pipeline passing through farmer's paddy field which is affecting the land and yield in Yelluru village. (Figure number 6.51).

Figure 6.51: Newspaper article regarding agricultural loss due to UPCL Pipeline

- Newspaper article highlighting the UPCL's Fly ash issues rose because of the mismanagement of Fly Ash and Bottom Ash during transporting the Fly ash and Bottom Ash by UPCL (Figure 6.52).

ಹಾರುಬೂದಿ ಸಾಗಾಟ ಬೇಡ

ಸಂ. ಕ. ಸಮಾಚಾರ, ಪಡುಬಿದ್ರಿ

ಆದಾನಿ ಯುಪಿಸಿಎಲ್ ಉಷ್ಣವಿದ್ಯುತ್ ಸ್ಥಾವರದಿಂದ ಸಾಂತೂರಿನಲ್ಲಿರುವ ಹಾರು ಬೂದಿ ಘಟಕಕ್ಕೆ 'ಫ್ಲೈ ಹ್ಯಾಷ್ ಹಾಗೂ ಬೊಟ್ಟಮ್ ಹ್ಯಾಷ್'ನ್ನು ತೆರೆದ ವಾಹನ ವಾಹನದಲ್ಲಿ ಸಾಗಿಸುತ್ತಿದ್ದು ಇದು ಅವೈಜ್ಞಾನಿಕ ಸಾಗಾಟವಾಗಿದ್ದು ಕೂಡಲೇ ನಿಲ್ಲಿಸಿ ಎಂದು ಗ್ರಾಮಸ್ಥರು ದೂರಿದ್ದಾರೆ.

ಇದರಿಂದಾಗಿ ಈ ಗ್ರಾಮದ ಜನತೆಗೆ ತೊಂದರೆ ಉಂಟಾಗಿದ್ದು ಮಾತ್ರವಲ್ಲದೆ, ಆರೋಗ್ಯದ ಮೇಲೂ ದುಷ್ಪರಿಣಾಮ ಬೀರುವುದರಲ್ಲಿ ಸಂದೇಹವಿಲ್ಲ. ಆದೂ ಅಲ್ಲದೆ ಹಾರುಬೂದಿ ಘಟಕದಿಂದ 'ಬಾಟಮ್ ಹ್ಯಾಷ್'ನ್ನು ಬೇರೆ ಕಡೆ ಸಾಗಿಸುವಾಗಲೂ ಯಾವುದೇ ರೀತಿಯ ಮುಂಜಾಗ್ರತಾ ಕ್ರಮಗಳನ್ನು ಅನುಸರಿಸದಿರುವುದು ಜನರ ಆಕ್ರೋಶಕ್ಕೆ ಕಾರಣವಾಗಿರುತ್ತದೆ. ಈ ಬಗ್ಗೆ ಮುದರಂಗಡಿ ಗ್ರಾಮ ಪಂಚಾಯತ್ ಉಪಾಧ್ಯಕ್ಷರು ಹಾಗೂ ಸದಸ್ಯರು ತೆರೆದ ವಾಹನಗಳು ಬೂದಿ ತುಂಬಿ ಸಂಚರಿಸುತ್ತಿದ್ದ ವೇಳೆ ಸ್ಥಳಕ್ಕೆ ಭೇಟಿ ಕೊಟ್ಟು ಕಂಪನಿಯ ಅಧಿಕಾರಿಗಳನ್ನು ಸ್ಥಳಕ್ಕೆ ಕರೆಯಿಸಿ ಎಚ್ಚರಿಕೆ ನೀಡಿದ್ದು, ಮುಂದಿನ ದಿನಗಳಲ್ಲಿ ಯುಪಿಸಿಎಲ್ ಕಡೆಯಿಂದ ಇಂತಹ ಬೇಜವಾಬ್ದಾರಿ ಕ್ರಮಗಳು ಮನರಾವರ್ತಿಸಿದರೆ ಕಂಪನಿಯ ವಿರುದ್ಧ ತಮ್ಮ ನಡೆಯನ್ನು ವ್ಯಕ್ತಪಡಿಸುವುದಾಗಿ ಎಚ್ಚರಿಸಿದರು.

Figure 6.52: Newspaper article highlighting the issue of Fly ash transportation.

- The study team referred to similarity of the reports by Centre for Ecological Sciences (CES). The study team's field observations and people's perceptions in the report entitled as "Environmental profile and people's livelihood aspects in the vicinity of a coal based thermal power plant at Yelluru Panchayat, Udupi district. Centre for Ecological Sciences Technical Report "(C. E. S., T. R. 126.)" were almost overlapping.

- The farmers alleged that saline mist discharged from the UPCL cooling towers are released into the atmosphere and its deposition on the farmland resulted in reduced crop yields. It also affected the growth of the plants and vegetation. (Farmers showed their corroded farm equipment as well as household utensils as shown in the Figure no's 6.61 and 6.62).

- Increased salinity of soil and water affected the ecosystem, especially was evident on farmer's friend, the living organisms particularly frogs and snakes.

- They also complained about the decrease in the population of useful frogs and snakes. In turn, farmers are forced to spend more money on insecticides and pesticides.

- Grazing on the grasses and vegetation which contains a layer of discharged fly ash and other pollutants of UPCL, has harmed the health of live stocks according to the local farmers.

- Farmer's observation is that the livestock from Ullooru and other villages whose proximity is closer to UPCL, the infertility rate is high. Due to this reason farmers are not buying and bringing livestock from those villages. (It has affected the fertilization in livestock).

- In univocal voice, the farmers expressed with the existing two UPCL units, they have suffered extremely and so are not in favour of its expansion.

h) Rehabilitation and Resettlement (R&R) people's observation report on UPCL:

The Study team met the Rehabilitated and Resettled people at Adamar along with the UPCL personnel (DGM environment and others) on 24th December 2020. R & R people complained that the National Rehabilitation and Resettlement policy 2007 has not been followed by UPCL. Many complained that they were forcibly evicted and also that some were evicted at midnight. They have been offered many incentives such as "one job for one rehabilitated" family but many are yet to get the jobs as promised by the company. However, few of them are given lower-order jobs and are working on a contract basis. Sadly, after a few years of service, couple of them were removed from the job citing silly reasons. Many incentives remained just on papers, they never materialized. R&R people are frustrated and furious towards the UPCL. Further they added that, when they were farmers they led a dignified life but now at R&R colony they feel that their present

condition is miserable. Even the basic amenities like drinking water, electricity, proper roads, and health services are not adequately provided and maintained. They also complained that sometimes they don't have water for a week; they have to walk for more than a kilometer to get drinking water. They even complained about the corrosion of their solar panels, TV antenna, utensils, etc. They were also unhappy about the services of mobile health service center as the medical staff doesn't give proper attention and simply refer the patients to the PHC at Padubidri. Whatever money was received as compensation was spent to build their new house. They are not allowed to have own bore wells. While constructing a well they have to spend lakhs of rupees on digging the well and there is no guarantee of getting potable water. They are not allowed to grow trees and do farming activities. The UPCL representative who approached the people at the beginning of the rehabilitation and resettlement with lucrative incentives never turned up later on. Their anger towards the UPCL is immeasurable. R & R people are not provided with R.T.C. and the area is not handed over to the panchayat yet.

R&R people summarized their opinion that UPCL are not interested in the well-being of the local people. But more interested in their business and increasing their land unit.

Figure 6.53: Visit to R & R Colony by Study Team and UPCL - Adani Staff 24/12/2020

- The black colour water shown in the figure below, has been let out and joins the rain water (brown in colour) in the stream of Ullooru Village, close to UPCL Coal Yard. (Figure 6.54)

Figure 6.54: During the rainy season, the effluent from UPCL

- The field visit by Study Team, KSPCB Udupi Officials and UPCL - Adani Staff on 23-02- 2021. At the backdrop, broken UPCL Effluent discharge pipe is seen. (Figure 6.55)

Figure 6.55: Tenka Yermal Seashore

Figure 6.56: UPCL AAQMS Stations are blocked/surrounded by vegetation

(supposed to be away from vegetation's, plants and trees according to CPCB norms)

Figure 6.57: UPCL AAQMS Devices are not in proper functional conditions

Figure 6.58: Coal Dust from UPCL Thermal Power Plant on Banana Leaves

(Affecting the yield of farmer at Nandikoor Village)

Figure 6.59: Black ash emitted by the UPCL

(Deposits on coconut leaves in a farm and affecting the farmland and yield.)

Figure 6.60: Stinking well water and not potable for drinking.

(Close to UPCL Discharge Pipe at Tenka Yermal Village)

Figure 6.61: Stinking water with high iron contents and not potable for drinking.

(At Ullooru Village, Close to UPCL Coal Yard)

Figure 6.62: Ullooru Village Bore Well Water without Dissolved Oxygen.

(Which is dirty and has bad smell, making it not potable for drinking)

Figure 6.63: Jet black water coming out of the pipe and filling the sedimentation tanks.

(At UPCL Pump house, Tenka Yermal)

Figure 6.64: Broken pieces of effluent discharge pipeline of UPCL

(Violating CRZ Norms)

Figure 6.65: Broken Effluent Discharge Pipeline of UPCL as on 23/02/2021

(Violating CRZ Norms)

Figure 6.66: "Rampani"- fishermen community's traditional way of catching fish

In which the hundreds of fishermen families are involved. (This is affected in the Tenka-Yermal Village after setting of UPCL Effluent Discharge Pipeline)

Figure 6.67: UPCL Ash Pond, Santhoor Village

Figure 6.68: Hazardous smoke emitted from UPCL

Figure 6.69: Hazardous smoke emitted from UPCL affecting the fragile ecosystems

Figure 6.70: Rust in the Metal Lamp Guard at Nandikooru farmer's house

(According to villagers, this is due to the saline water vapours emitted from UPCL Power Plant)

Figure 6.71: Broken asbestos sheet of a farmer's house in Ullooru village

(According to villagers, this is due to atmospheric pollutants emitted from UPCL Power Plant)

Figure 6.72: Coal found on the railway track in Ullooru village

(Spillages from the railway rakes transporting coal for UPCL)

Figure 6.73: Many houses are abandoned by the people at Yelluru and Nandikoor villages

This is due to the environmental pollution caused by the UPCL, mainly resulting in lack of potable water and health issues.

Report of the Reconstituted Expert committee (2021):

The Reconstituted Expert committee estimated the Environmental compensation of 74.93 crores (which includes the 4.89crores estimated by the earlier committee for the non-compliance) to be paid by UPCL. This is based on the health status of the people with reference to the air borne diseases in the surrounding villages located within 10 kms from UPCL this was supported by the health records of the Government owned Public Health Centres in the 33 villages around the UPCL plant.

Chapter 7

CONCLUSIONS

The following are the major conclusions of the present assessment study.

a) Results show that the carrying capacity of ambient atmosphere of SO_2 [359 µg/m^3] is exceeding the National Ambient Air Quality standards [80 µg/m^3]. Additionally, mass emission load of SO_2 emissions [70184 kg/day (70.184 Tons/day)] is too high; similarly, concentration of NO_X [149.9 µg/m^3] exceeds the National Ambient Air Quality standards [80 µg/m^3] and mass emission load of NOx emissions [27598 kg/day (27.598 Tons/Day)] is also high. This is likely to have an adverse effect on human health and agricultural output.

b) Dust load of atmosphere from the plant boilers per day is 2686 kg/day (2.69 Tons/day) and the same will impact the nearby villages farming and social life.

c) It has also been observed that there is fly ash deposition on the plants and agricultural farmland. There are number of public complaints on the fly ash deposition on their houses and that crop yield is declining with each passing year. Fly ash dust can get deposited on topsoil increasing the pH, which can affect the plants and animals. It is likely that improper management of fly ash from the power plant has led to groundwater contamination. Expansion of power plant may further aggravate groundwater and soil contamination with heavy metals.

d) Regarding carrying capacity of water resources; as against the total water availability of 16.38 BCM, only 0.32 BCM is currently used for various purposes in the Udupi district. It works out to 2 percent of the total water availability in the district. Even with the projected demand for water at 0.74 BCM, the district still has a water balance of 15.95 BCM. The carrying capacity for water resources is assessed as more than 3, which is not a concern at this point.

e) Average ground level concentration of all the monitored parameters such as the particulate matter, carbon monoxide, nitrogen oxides and Sulphur dioxide were high at a distance of 0.8 Km. Ground level concentration levels of all these parameters are within tolerable limits at 2 Km and 5 Km distance. However, this requires to be studied across seasons.

f) Groundwater sampling was carried out at 10 locations and analysed as per the drinking water standards (IS 10500: 2012 permissible limits in the absence of alternate sources). Aluminium (Al) was found to exceed the limits in the Pump House GW location and Manganese (Mn) in the UPCL ash pond area and the Ullooru GW sample. Lead (Pb) was found to exceed the limit in the UPCL ash pond area groundwater sample. Samples from

Nandikoor (Well Water), Ullooru-2- Yelluru (Well Water) Ullooru-1 (Groundwater) exceeded the limits as per the drinking water standards IS 10500 2012 permissible limits. Levels of heavy metals in the soil were highest for Fe and Mn followed by Zn, Cr and Cu.

g) Expansion of UPCL or any other Industrial activity, which can potentially create pollution need careful consideration and additional studies. The study area is a part of the coastal region, and a highly dynamic ecosystem. The landmass consist of Western Ghats and the wetland regions supporting unique ecological niches. People living in the narrow strip between Western Ghats and the coast depend on these ecosystems for their livelihood.

h) A rapid assessment of flora and fauna in the study area was carried out despite prevailing pandemic situation. The effects of effluents discharged by UPCL and other industries into the rivers, lakes, ponds, streams and Arabian Sea on amphibians, reptiles, fishes and other aquatic, marine, terrestrial fauna as well as flora need a study covering all four seasons in annual cycle. Further, the impact on birds, because of the coal dust, smoke and steam has to be monitored, evaluated and analysed. Amphibians are considered as the best bio-indicators amongst vertebrate animals. The local environmental changes on the amphibians have to be studied in detail. Deposition of coal dust on leaves of various plants requires further investigation for quantum of effect on photosynthetic activity of the plant. Surrounding villagers complained about the reduction in the yield of milk in their cattle, reduction in horticultural and agricultural yields. Issues pertaining to cattle reproductory problems, fishermen community grievances, the health issues of the people living in the vicinity of the UPCL thermal power plant need attention. Accordingly, long term monitoring and detailed study of the area is essential.

i) Study on biodiversity needs to be undertaken across the seasons, as many species of animals tend to shift with seasons as well as according to the changes in the surrounding temperature, relative humidity and other environmental conditions that may shift due to setting up of large industries such as UPCL. Proliferation of industries with large environmental impact in the coastal areas can potentially result in the deterioration of the coastal lands, wetlands and agricultural fields, depleting the biodiversity causing ecological imbalance in the area.

j) LULC study for the study area (25294.94 ha) showed that the agricultural land has decreased by 7.55%, which is 1342.02 hectares from 2002 to 2019. It's been used mostly for built up purposes. The observed change in the built up area is 2000.83 hectares, which is a 56.08% increase. Out of this built up area, rural built-up area increased by 58.6%, urban built-up area increased by 43.27%, hamlets and dispersed household increased by 55.1%, mining/industrial increased by 96.5%, and mixed settlements increased by 72.75% from 2002 to 2019. Forest land decreased by 0.27% (0.39 hectares); it is converted to hamlets and dispersed household from 2002 to 2019.

k) The villagers have raised concerns about their health, agricultural and horticultural crops, fishing and dairy farming activities, which they perceive have reduced drastically after setting up of the thermal Power plant. They allege reduction in yield to the effect of coal dust and fly ash accumulated on the leaves of banana, jasmine, coconut trees, areca palms, etc. and other major food crops. There is dissatisfaction regarding improper standard operating procedures, environmental damages, and CSR and community development activities. Crop compensation, compensation for cattle kills and human injury from the straying wild animals is provided by the government to the affected people.

7.1 Limitations of the study

1. The present assessment being a limited- period, study has not been able to capture the seasonal variations, and this is a major limitation.

2. Current analysis was carried out when the UPCL plant was operating at below normal capacity and hence the results obtained during the study should be considered accordingly. This prompts to carry out the study with the plant operating at designed capacity.

3. Lack of data from UPCL regarding discharge of effluents into the Arabian Sea constraints the study in that regard.

4. Assessing and analyzing the carrying capacity and impacts on the biodiversity requires long-term studies, and the same could not be attempted.

5. Due to the Pandemic situation of Covid-19, the Study team faced major difficulties in visiting the study area to collect more data that could had further enriched the study.

7.2 Recommendations

The following recommendations are presented.

a) This is a short-term study; long-term studies should be undertaken to comprehensively determine the impacts of the power plant and remaining carrying capacity to accommodate the additional quantum of impact across seasons.

b) Prior to expansion UPCL should ensure strict adherence to all environmental norms.

c) Third party ambient air quality monitoring on regular basis may ensure adherence to environmental norms.

d) Monitoring of groundwater quality in open wells in the surrounding area of UPCL is necessary.

e) Desirably the information on the agriculture, horticulture, fishing and farming crops should be periodically collected and reasons for adverse impacts identified and mitigated in the study area and even beyond.

f) Human health monitoring in the surrounding villagers as well as by the other villages beyond 10 Km from the plant is desirable.

g) Airborne particles may be monitored in routine and data collected.

h) A detailed study on the ramifications of the UPCL seawater discharges into Arabian Sea and on coastal zone, and the present status of the marine biology should be undertaken. A clear demarcation of HTL and LTL should be made and adherence to notifications under the CRZ Rules 2019 needs to be ensured.

i) Comprehensive Social Audit of industrial activity would help in identification and prioritization of the concerns of local communities.

j) There are several critical ecosystems in the study area like Myristica swamps, island ecosystems, and other pristine wildlife habitats (Figure 7.1). These critical ecosystems are influenced by monsoonal climate. Therefore, long-term monitoring and detailed study of the area is very essential with reference to the implications of UPCL and its capacity expansion for terrestrial, freshwater and marine biodiversity and ecosystems.

Figure 7.1: Monsoon clouds over the Western Ghats in the study area landscape

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Annexures

1. Glens Report "Environmental Monitoring and Analysis and Source Dispersion Modeling Study" at UPCL, Udupi.

2. Methodology given by CPCB

3. Interim Report of EMPRI submitted to the Hon'ble NGT

4. Assessment of Land Carrying Capacity of Udupi

Report On

Environmental Monitoring and Analysis and Source Dispersion Modelling Study at UPCL

To

Environmental Management &
Policy Research Institute

Environment Management and Policy Research Institute - Bangalore

Conducted By

G Lens Innovation Labs Pvt Ltd.
for a greener tomorrow

GLens Innovation Labs Pvt Ltd
Chennai

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CONTENTS

1. METHODOLOGY FOR THE MEASUREMENT OF AMBIENT AIR SAMPLING AND ANALYSIS

1.1 Sitting Requirements

Samplers have sited to meet the goals of the specific monitoring project. For this study sampling to determine compliance with the National Ambient Air Quality Standards (NAAQS), sampler sitting is described in CPCB guidelines. The monitoring has been done at outside the zone of influence of sources located within the designated zone of representation for the monitoring site.

Height of the inlet kept to be 3 – 10 m above the ground level also at a suitable distance from any direct pollution source including traffic.

Large nearby buildings and trees extending above the height of the monitor may present barriers or deposition surfaces for PM. Distance of the sampler to any air flow obstacle i.e. buildings, has been considered to be more than two times the height of the obstacle above the sampler. Certain trees may also be sources of PM in the form of detritus, pollen, or insect parts to avoid this have been located the sampler > 20 m from nearby trees. Also care has been taken between PM10 & PM2.5 the minimum distance between two Samplers maintained more than 2 m.

2.0 Methodology for sampling and analysis of Particulate Matter (PM10) in ambient air (Gravimetric Method) Standard

The national ambient air quality standards for Particulate Matter PM10 is presented in the table

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)
Particulate Matter, PM10, μg/m^3	Annual * 24 Hours **	60 100	60 100
* Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals. ** 24 hourly or 8 hourly or 1 hourly monitored value, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.			

Principle of the method

Air is drawn through a size-selective inlet and through a 20.3 X 25.4 cm (8 X 10 in) filter at a flow rate, which is typically 1132 L/min. Particles with aerodynamic diameter less than the cut-point of the inlet are collected, by the filter. The mass of these particles is determined by the difference in filter weights prior to and after sampling. The concentration of PM10 in the designated size range is calculated by dividing the weight gain of the filter by the volume of air sampled.

Instrument/Equipment
The following items are used to perform the monitoring and analysis of Particulate Matter PM10 in ambient air:

Analytical balance: 5 digit with valid calibrations

Sampler : High Volume Sampler with size selective inlet for PM10

Calibrated flow-measuring device to control the airflow at 1100 to 1300 l/min.

Reagents / Chemicals
Filter Media – A MCE filter of 20.3 X 25.4 cm (8 X 10 in) size (Whatmann)

Sampling
Field Sampling - Tilt back the inlet and secure it according to manufacturer's instructions. Loosen the faceplate wing nuts and remove the faceplate. Remove the filter from its jacket and centre it on the support screen with the rough side of the filter facing upwards. Replace the faceplate and tighten the wing nuts to secure the rubber gasket against the filter edge. Gently lower the inlet. Recorded the designated flow rate and elapsed time meter on the data sheet. The length of sampling is fixed for 24 hours. During this period, several reading (hourly) of flow rate has been taken and recorded in the field data sheet.

After the required time of sampling, recorded the flow meter reading, taken out the filter media from the sampler, and kept in a envelope marked sample ID.

Analysis
Applied the code to the filter and conditioned the filter in conditioning room maintained within 20-30□ C and 40-50% relative humidity or in an airtight desiccator for 24 hours. Taken the initial weight of the filter paper (Wi) before sampling. Condition the filter after sampling in conditioning room maintained within 20-30□ C and 40-50% relative

humidity or in an airtight desiccator for 24 hours. Taken the final weight of filter paper (Wf).

SECTION 1 AIR INLET

FILTER COVER

GASKET

FILTER

CYCLONE ASSEMBLY

SAMPLE BOTTLE

TO SUCTION DEVICE

SECTION 2 CYCLONE
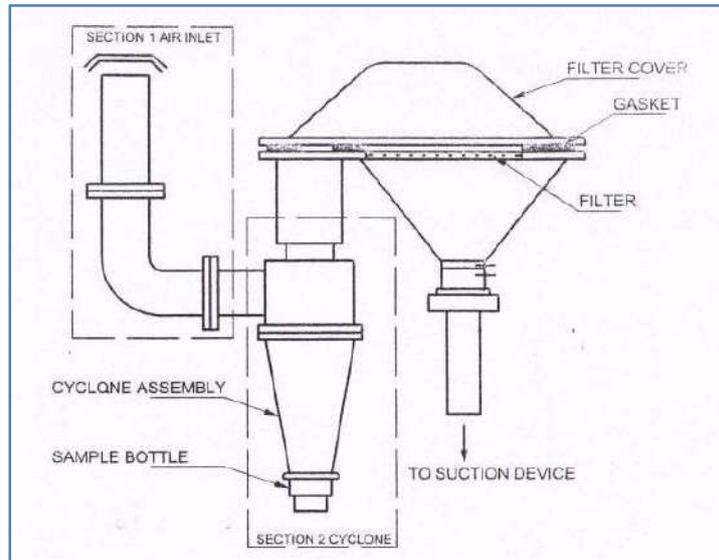
PM10 Sampler (Cyclonic Inlet)

Calculation

C_{PM10} µg/m3   = $(Wf - Wi) \times 10^6 / V$

Where,

C_{PM10}	=	Concentration of Particulate Matter, µg/m^3
Wf	=	Final weight of filter in g
Wi	=	Initial weight of filter in g
10^6	=	Conversion of g to µg
V	=	Volume of air sampled, m^3

Quality Control

Quality Control (QC) is the techniques which AC TECH is used to fulfill requirements for quality. The QC procedures for the air sampling and monitoring includes the preventative maintenance of equipment, calibration of equipment, analysis of field blanks and lab blanks.

FLOW CHART FOR MEASUREMENT OF PM10

Check the filter for any physical damages

⬇

Mark identification number on the filter

⬇

Condition the filter in conditioning room / desiccator for 24 hours

⬇

Record initial weight

⬇

Place the filter on the sampler

⬇

Run the sampler for eight hours

⬇

Record the flow rate on hourly basis

⬇

Remove the filter from the sampler

⬇

Keep the exposed filter in a proper container

⬇

Record the total time of sampling & average flowrate

⬇

Again condition the filter in conditioning room / desiccator for 24 hours

⬇

Record final weight

⬇

Calculate the concentration of PM10 in µg/m3

Reference:

IS 5182 Part 23 Method of Measurement of Air Pollution: Respirable suspended Particulate Matter (PM10) cyclonic flow technique.

3.0 Methodology for determination of PM$_{2.5}$ in ambient air (Gravimetric Method)

1. Standard

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)
Particulate Matter, PM2.5, µg/m^3	Annual *	40	40
	24 Hours **	60	60

* Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 8 hourly or 1 hourly monitored value, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

2.0 Principle

An electrically powered air sampler draws ambient air at a constant volumetric flow rate (16.7 lpm) maintained by a volumetric flow controller into specially designed inertial particle-size separator (impactors) where the suspended particulate matter in the PM2.5 size ranges is separated for collection on a 47 mm polytetrafluoroethylene (PTFE) filter over a 24 hours sampling period. Each filter is weighed before and after sample collection to determine the net gain due to the particulate matter. The mass concentration in the ambient air is computed as the total mass of collected particles in the PM2.5 size ranges divided by the actual volume of air sampled, and is expressed in µg/m3.

Moisture content can affect filter weight. Filters are equilibrated for a minimum of 24 hours in a controlled environment prior to pre- and post- weighing. The Humidity chamber relative humidity were maintained at a mean value range of 45 ± 5 % and its air temperature were maintained at a mean value range of 25.0 ± ºC.

Apparatus and Materials

Sampling equipment designated as FEM (Federal Equivalent Method)

Electronic microbalance with a minimum resolution of 0.001 mg and a precision of ± 0.001 mg, supplied with a balance pan. The microbalance is positioned on a vibration-damping balance support table.

Calibration weights, utilized as Mass Reference Standards, should be non-corroding, range in weight from 100 mg to 200 mg, and be certified as traceable to NIST mass standards. The weights should be ASTM Class1 category with a tolerance of 0.025 mg.

- Non-serrated forceps for handling filters.

- Non-metallic, non-serrated forceps for handling weights.

- 47 mm Filter: Teflon membrane, 46.2 mm effective diameter with a polypropylene
  support ring

- Filter support cassettes and covers.

- Relative Humidity / Temperature recorder.

- Zip-lock plastic bags, 6"x 9".

- Disposable laboratory wipes.

- Impactor oil/grease

Filter Conditioning

Gravimetric measurement is the net mass on a filter by weighing the filter before and after sampling with a balance in a temperature and relative humidity controlled environment as described in SOPs. To minimize particle volatilization and aerosol liquid water bias, as per PM2.5 reference methods the filters are equilibrated for 24 hours at a constant (within ±5%) relative humidity 45 % and at a constant (within ±2ºC) temperature between 25ºC. These filter equilibrium conditions are intended to minimize the liquid water associated with soluble compounds and to minimize the loss of volatile species.

Weighing of Filters

Handled the pre-conditioned filters by forceps one by one and weighed properly. Recorded the mass in data sheet and log books against respective filter code.

- Always used gloved hands and blunt tweezers to handle filters.

- Replaced and closed the filter container (Petri dishes). Previous Weighed one Control Filters (Archived one) with each batch of ten weighing. Kept separate controls for Pre (Blank filter) and Post (Exposed) sampling filters.

- Put the sample code on from Plastic petri-slide filter containers (Filter Cassette).

- Take out conditioned filter from Plastic petri-slide filter containers (Filter Cassette).

- Weighed the preconditioned filter.

- Recorded and stored it in laboratory coded filter cassette.

Field sampling

On the Field Data sheet, filled in the top portion of the form including: the date/time of visit, the site identification, sampler identification, site name, filter ID number, sample start and stop dates and times, and field operator initials.

- Performed all necessary pre-sampling procedures as described above.

- Performed QA/QC checks or maintenance

- Removed the filter is to be installed from its protective filter cassette carrier.

- Fixed the filter following manufacturer's instructions into place against the bottom of the WINS impactor.

Calculation and Reporting of Mass Concentrations

The equation to calculate the mass of fine particulate matter collected on a Teflon filter is as below:

$$M_{2.5} = (M_f - M_i) \text{ mg} \times 10^3 \text{ µg}$$

Where,

$M_{2.5}$ = total mass of fine particulate collected during sampling period (µg)

M_f = final mass of the conditioned filter after sample collection (mg)

M_i = initial mass of the conditioned filter before sample collection (mg)

10^3 = unit conversion factor for milligrams (mg) to micrograms (µg)

Field records of PM2.5 samplers will provide measurements of the total volume of ambient air passing through the sampler (V) in cubic meters at the actual temperatures and pressures measured during sampling. Use the following formula if V is not available directly from the sampler:

$V = Q_{avg} \times t \times 10^{-3} \ m^3$ Where,

V = total sample value (m^3)

Q_{avg} = average flow rate over the entire duration of the sampling period (L/min)

T = duration of sampling period (min)

10^3 = unit conversion factor for liters (L) into cubic meters (m^3)

The equation given below can be used to determine PM2.5 mass concentration:

$PM_{2.5} = M_{2.5} / V$

Where,

PM2.5 = mass concentration of PM2.5 particulates ($\mu g/m^3$)

PM2.5 = total mass of fine particulate collected during sampling period (μg)

V = total volume of air sampled (m^3).

FLOW CHART FOR MEASUREMENT OF PM2.5

Check the filter for any physical damages

⬇

Mark identification number on the filter

⬇

Condition the filter in conditioning room / desiccator for 24 hours

⬇

Record initial weight

⬇

Place the filter on the sampler

⬇

Run the sampler for eight hours

⬇

Record the flow rate on hourly basis

⬇

Remove the filter from the sampler

⬇

Keep the exposed filter in a proper container

⬇

Record the total time of sampling & average flow rate

⬇

Again condition the filter in conditioning room / desiccator for 24 hours

⬇

Record final weight

⬇

Calculate the concentration of PM2.5 in µg/m3

8.0   References

40 CFR Parts 53 and 58 Revised Requirements for Designation of Reference and Equivalent Methods for PM2.5 and Ambient Air Quality Surveillance for Particulate Matter; Final Rule

2.0   PM2.5 Gravimetric Analysis - Revision 7, August 14, 2003, Page 2 of 24 RTI (Research Triangle Institute, US)

4.0 METHODOLOGY FOR SAMPLING AND ANALYSIS OF SULPHUR DIOXIDE IN AMBIENT AIR (IMPROVED WEST AND GEAKE METHOD)

Standard

The National Ambient Air Quality standards for Sulphur Dioxide is presented in the table

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)
Sulphur Dioxide (SO2), μg/m^3	Annual *	50	20
	24 Hours **	80	80
* Annual Arithmetic mean of minimum 104 measurements in a year, at a particular site, taken twice a week 24 hourly at uniform intervals.			
** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.			

Principle of the Method

Modified West & Gaeke Method (IS 5182 Part 2 Method of Measurement of Air Pollution: Sulphur dioxide): Sulphur dioxide from air is absorbed in a solution of potassium tetrachloro- mercurate (TCM). A dichlorosulphitomercurate complex, which resists oxidation by the oxygen in the air, is formed. Once formed, this complex is stable to strong oxidants such as ozone and oxides of nitrogen and therefore, the absorber solution may be stored for some time prior to analysis. The complex is made to react with para-rosaniline and formaldehyde to form the intensely colored pararosaniline methylsulphonic acid. The absorbance of the solution is measured by means of a suitable spectrophotometer

Instrument/Equipment

The following items are used to perform the monitoring and analysis of nitrogen dioxide in ambient air:

- Analytical balance:

- Vacuum pump: Capable of maintaining an air pressure differential greater than

0.7 atmosphere at the desired flow rate

- Calibrated flow-measuring device to control the airflow from 0.2 to 1 l/min.

- Absorber: all glass midget impinger

- Spectrophotometer: Capable of measuring absorbance at 560 nm equipped with 1 cm path length cells.

- Glass wares: low actinic glassware must be used for analysis.

Reagents / Chemicals

All the chemicals used are Analytical Reagent grade

- Distilled water

- Mercuric chloride

- Potassium chloride / Sodium chloride

- EDTA di sodium salt

Absorbing Reagent, 0.04 M Potassium Tetrachloro mercurate (TCM) - Dissolved 10.86 g, mercuric chloride, 0.066 g EDTA, and 6.0 g potassium chloride or sodium chloride 4.68 gm in water and make up into 1 liter. The pH of this reagent fixed to be approximately 4.0 but, it has been shown that there is no appreciable difference in collection efficiency over the range of pH 5 to pH 3. The absorbing reagent is normally stable for six months. If, any precipitate forms, then we can discard the reagent after recovering the mercury.

Sulphamic Acid (0.6%) - Dissolved 0.6 g sulphamic acid in 100 ml distilled water and prepared freshly.

Formaldehyde (0.2%) - Diluted 5 ml formaldehyde solution (36-38%) to 1 litre with distilled water and prepared freshly.

Purified Pararosaniline Stock Solution (0.2% Nominal): Dissolved 0.5 gm of specially purified pararosaniline (PRA) in 100 ml of distilled water and keep for 2 days (48 hours) before using.

Pararosaniline Working Solution - 10 ml of stock PRA is taken in a 250 ml volumetric flask. Add 15 ml conc. HCL and make up to volume with distilled water.

Stock Iodine Solution (0.1 N) - Placed 12.7 g iodine in a 250 ml beaker, add 40 g potassium iodide and 25 ml water and checked until all is dissolved, then diluted to 1 litre with distilled water.

Iodine Solution (0.01 N) - Prepared approximately 0.01 N iodine solution by diluting 50 ml of stock solution to 500 ml with distilled water.

Starch Indicator Solution - Triturate 0.4 gm soluble starch and 0.002 g mercuric iodide preservative with a little water and added the paste slowly to 200 ml boiling water. Continue boiling until the solution is clear, cool, and transfer to a glass-stoppered bottle.

Stock Sodium Thiosulfate Solution (0.1 N) - Prepared a stock solution by placing 25 g sodium thiosulfate pentahydrate in a beaker, add 0.1 g sodium carbonate and dissolved using boiled, cooled distilled water making the solution up to a final volume of 1 litre. Allowed the solution to stand one day before standardizing.

Sodium Thiosulphate Titrant (0.01 N) - Diluted 100 ml of the stock thiosulfate solution to 1 litre with freshly boiled and cooled distilled water.

Standardized Sulphite Solution for Preparation of Working Sulphite- TCM Solution - Dissolve 0.30 g sodium metabisulphite ($Na_2S_2O_5$) or 0.40   g sodium sulphite (Na_2SO_3) in 500 ml of recently boiled, cooled, distilled water. Sulphite solution is unstable; it is, therefore, important to use water of the highest purity to minimize this instability. This solution contains the equivalent of 320-400 µg/ml of SO_2.

Working Sulphite-TCM Solution - Measured 2 ml of the standard solution into a 100 ml volumetric flask by pipette and brought to mark with 0.04 M TCM. Calculated the concentration of sulphur dioxide in the working solution in micrograms of sulphur dioxide per millilitre. This solution is stable for 30 days by keeping in the refrigerator at 5ºC.

Standard Impinger
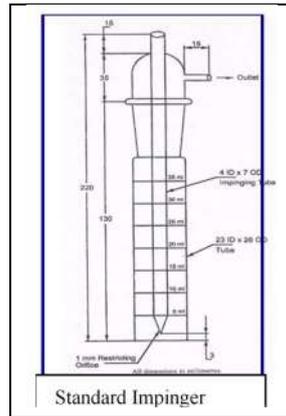
Sampling

Placed 35 ml of absorbing solution in an impinger and sampled for eight hours at the flow rate of 0.5 L/min. After sampling measured the volume of sample and transferred in to a sample storage bottle.

Analysis

Replaced the water lost by evaporation during sampling by adding distilled water up to the calibration mark on the absorber. Mixed thoroughly, pipette out 10 ml of the collected sample into a 25 ml volumetric flask. Added 1 ml 0.6% sulphamic acid and allow reacting for 10 minutes to destroy the nitrite resulting from oxides of nitrogen. Added 2 ml of 0.2% formaldehyde solution and 2 ml pararosaniline solution and made up to 25 ml with distilled water. Prepared a blank in the same manner using 10 ml of unexposed absorbing reagent. After a 30 min color development interval, measured and recorded the absorbance of samples and reagent blank at 560 nm.

Preparation of Standards

Measured 0.5 ml, 1.0 ml, 1.5 ml, 2.0 ml, 2.5 ml, 3.0 ml, 3.5 ml and 4.0 ml of working sulphite TCM solution in 25 ml volumetric flask. Added sufficient TCM solution to each flask to bring the volume to approximately 10 ml. Then added the remaining reagents as described in the procedure for analysis. A reagent blank with 10 ml absorbing solution is also prepared. Recorded the absorbance of each standard and reagent blank and draw the linear graph.

Standard Curve

Plot a curve absorbance (Y axis) versus concentration (X axis). Draw a line of best fit and determine the slope. The reciprocal of slope gives the calibration factor (CF).

Calculation

Concentration of sulphite solution:

Where,

$$C = \frac{(V1-V2) \times N \times K}{V}$$

C   = SO_2 concentration in µg/ml

V1   =   Volume of thiosulfate for blank, ml

V2   =   Volume of thiosulfate for sample, ml

N   =   Normality of thiosulfate

K   =   32000 (Milliequivalent weight SO_2/µg)

V   =   Volume of standard sulphite solution, ml

$$C\ (SO_2\ µg/m^3) = (A_s - A_b) \times CF \times V_s/V_a \times V_t$$

Where,

C SO_2 =   Concentration of Nitrogen dioxide, µg/m^3

A_s =   Absorbance of sample

A_b =   Absorbance of reagent blank

CF   =   Calibration factor

V_a =   Volume of air sampled, m^3

V_s =   Volume of sample, ml

V_t =   Volume of aliquot taken for analysis, ml

Quality Control

Quality Control (QC) is the techniques that are used to fulfill requirements for quality. The QC procedures for the air sampling and monitoring sections of this protocol include preventative maintenance of equipment, calibration of equipment, analysis of field blanks and lab blanks.

Reference

IS 5182 Part 2 Method of Measurement of Air Pollution: Sulphur Dioxide

FLOW CHART FOR MEASUREMENT OF SULPHUR DIOXIDE

Place 30 ml of absorbing media in an impinger

⬇

Connect it to the gas-sampling manifold of gas sampling device (RDS/HVS).

⬇

Draw air at a sampling rate of 0.5 lpm for eight hours

⬇

Check the volume of sample at the end of sampling and record   it

⬇

Transfer the exposed samples in storage bottle and preserve

⬇

Prepare calibration graph as recommended in method

⬇

Take 10/20 ml. aliquot of sample in 25 ml. Vol. Flask

⬇

Take 10/20 ml. of unexposed sample in 25 ml. Vol. Flask (blank)

⬇

Add 1 ml Sulphamic acid.   Keep it 10 minutes

⬇

Add 2 ml formaldehyde

⬇

Add 2 ml working PRA

⬇

Make up to mark (25 ml.) with distilled water.

⬇

Keep it 30 minutes for reaction

⬇

Set Zero of spectrophotometer with Distilled water

⬇

Measure absorbance at 560 nm

⬇

Calculate concentration using calibration graph

⬇

Calculate concentration of Sulphur Dioxide in $\mu g/m^3$

5.0 METHODOLOGY FOR SAMPLING AND ANALYSIS OF NITROGEN DIOXIDE IN AMBIENT AIR (MODIFIED JACOB AND HOCHHEISER METHOD)

Standard

The National Ambient Air Quality Standard for Nitrogen Dioxide is presented in the table:

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)
Nitrogen Dioxide (NO2), $\mu g/m^3$	Annual *	40	30
	24 Hours **	80	80

* Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive

Principle of the method

Modified Jacobs & Hochheiser Method (IS 5182 Part 6 Methods for Measurement of Air Pollution: Oxides of nitrogen).

Ambient nitrogen dioxide (NO$_2$) is collected by bubbling air through a solution of sodium hydroxide and sodium arsenite. The concentration of nitrite ion (NO$^-_2$) produced during sampling is determined calorimetrically by reacting the nitrite ion with phosphoric acid, sulfanilamide, and N-(1-naphthyl)- ethylenediamine di-hydrochloride (NEDA) and measuring the absorbance of the highly coloured azo-dye at 540 nm.

Instrument/Equipment

The following items are used to perform the monitoring and analysis of nitrogen dioxide in ambient air:

Analytical balance:

Vacuum pump: Vacuum pump used of having 0.6 atmospheres across the flow control device. Flow control device capable of maintaining a constant flow of 200-1000 ml per minute through the sampling solution

Calibrated flow measuring device: To control the airflow from 0.2 to 1 l/min.

Absorber: a midget impinger

Spectrophotometer: Capable of measuring absorbance at 540 nm equipped with 1 cm path length cells.

Glass wares: low actinic glasswares are used for analysis

Reagents / Chemicals
All the chemicals used are Analytical Reagent grade

Distilled water

Sodium hydroxide

Sodium Arsenite

Absorbing solution (Dissolved 4.0 g of sodium hydroxide in distilled water, add 1.0 g of sodium Arsenite, and diluted to 1,000 ml with distilled water)

Sulphanilamide - Melting point 165 to 167$^\text{o}$C

N-(1-Naphthyl)-ethylenediamine Di-hydrochloride (NEDA) - A 1% aqueous solution should have only one absorption peak at 320 nm over the range of 260-400 nm. NEDA showing more than one absorption peak over this range is impure and should not be used

Hydrogen Peroxide - 30%

Phosphoric Acid - 85%

Sulphanilamide Solution - Dissolved 20 g of sulphanilamide in 700 ml of distilled water. Add, with mixing, 50 ml of 85% phosphoric acid and diluted to 1,000 ml. This solution is stable for one month and it will be stored at refrigerated

NEDA Solution - Dissolved 0.5 g of NEDA in 500 ml of distilled water. This solution is stable for one month, This solution kept at refrigerated and protected from light.

Hydrogen Peroxide Solution - Diluted 0.2 ml of 30% hydrogen peroxide to 250 ml with distilled water. This solution has been used for one month and the prepared solution is kept in refrigerated and protected from light

Sodium nitrite - Assay of 97% NaNO$_2$ or greater

Sodium Nitrite stock solution (1000 µg NO_2/ml)

Sodium Nitrite solution (10 µg NO_2/ml.)

Sodium Nitrite working solution (1   µg NO_2/ml) (Diluted with absorbing reagent, prepare fresh daily)

Sampling

Placed 35 ml of absorbing solution in an impinger and sample for eight hour at the flow rate of 0.5 L/min. After sampling measured the volume of sample and transfered to a sample storage bottle.

Analysis

Replaced the water lost by evaporation during sampling by adding distilled water up to the calibration mark on the absorber, mix thoroughly.

Pipetted out 10 ml of the collected sample into a 50 ml volumetric flask. Pipette in 1 ml of hydrogen peroxide solution, 10 ml of sulphanilamide solution, and 1.4 ml of NEDA solution, with thorough mixing after the addition of each reagent and make up to 50 ml with distilled water.

Prepared a blank in the same manner using 10 ml of unexposed absorbing reagent.

After a 10 min colour development interval, measured and recorded the absorbance of samples and reagent blank at 540 nm.

Used distilled water; not the reagent blank, as the optical reference

Samples with an absorbance greater than 1.0 must be re-analyzed after diluting an aliquot of the collected samples with an equal quantity of unexposed absorbing reagent.

A randomly selected 5-10% of the samples are being re-analyzed as apart of an internal quality assurance program.

Calibration

Preparation of Standards

Pipette 5, 10, 15, 20 and 25 ml of working standard solution in to 50 ml volumetric flask. Fill to 20 ml mark with absorbing solution. A reagent blank with 10 ml absorbing solution is also prepared. Add reagents to each volumetric flask as in the procedure for

analysis. Recorded the absorbance of each standard and reagent blank against distilled water reference.

Standard Curve:

Plot a curve absorbance (Y axis) versus concentration (X axis). Draw a line of best fit and determine the slope. The reciprocal of slope gives the calibration factor (CF).

Calculation

$C\ (NO_2\ \mu g/m^3) = (A_s - A_b) \times CF \times V_s/\ V_a \times V_t \times 0.82$

Where,

C NO2	=	Concentration of Nitrogen dioxide, $\mu g/m^3$
A_s	=	Absorbance of sample
A_b	=	Absorbance of reagent blank
CF	=	Calibration factor
V_a	=	Volume of air sampled, m^3
V_s	=	Volume of sample, ml
V_t	=	Volume of aliquot taken for analysis, ml
0.82	=	Sampling efficiency

Reference

IS 5182 Part 6 Methods for Measurement of Air Pollution: Oxides of Nitrogen

FLOW CHART FOR MEASUREMENT OF NITROGEN DIOXIDE
Place 30 ml of absorbing media in an impinger
Connect it to the gas sampling manifold of gas sampling device (RDS/HVS)
Draw air at a sampling rate of 0.5 lpm for 8 hours
Check the volume of sample at the end of sampling and record   it
Transfer the exposed samples in storage bottle and preserve
Prepare calibration graph as recommended in method
Take 10 ml. aliquot of sample in 50 ml. Vol. Flask
Take 10 ml. of unexposed sample in 50 ml. Vol. Flask (blank)
Add 1ml hydrogen peroxide,
Add 10ml Sulphanilamide
Add 1.4 ml NEDA
Make up to mark (50 ml.) with distilled water.
Keep it 10 minutes for reaction
Set Zero of spectrophotometer with Distilled water
Measure absorbance at 540 nm
Calculate concentration using calibration graph
Calculate concentration of Nitrogen Dioxide in $\mu g/m^3$

Google Earth Map – Ambient Air Quality Monitoring Locations

From UPCL Plant to AAQ1 Station   =   6.57km

From UPCL Plant to AAQ2 Station   =   6.90km

From UPCL Plant to AAQ3 Station   =   2.86km

From UPCL Plant to AAQ4 Station   =   0.54km

From UPCL Plant to AAQ5 Station   =   Within the plant and from stack it is 0.37km

From UPCL Plant to AAQ6 Station   =   4.29km

From UPCL Plant to AAQ7 Station   =   1.34km

From Cooling Tower Reservoir to See =   4.4km

S1 = PUMP HOUSE SEA WATER SEDIMENTATION TANK -1

S2 = PUMP HOUSE SEA WATER SEDIMENTATION TANK -II

S3 = PUMP HOUSE

S4 = HEJAMADY VILLAGE

S5 = INNA VILLAGE

S6 = JM NANDIKOOR VILLAGE

S7 = NEAR FIRE STATION

S8 = MADRANGDI VILLAGE

S9 = R & R ADAMAR VILLAGE
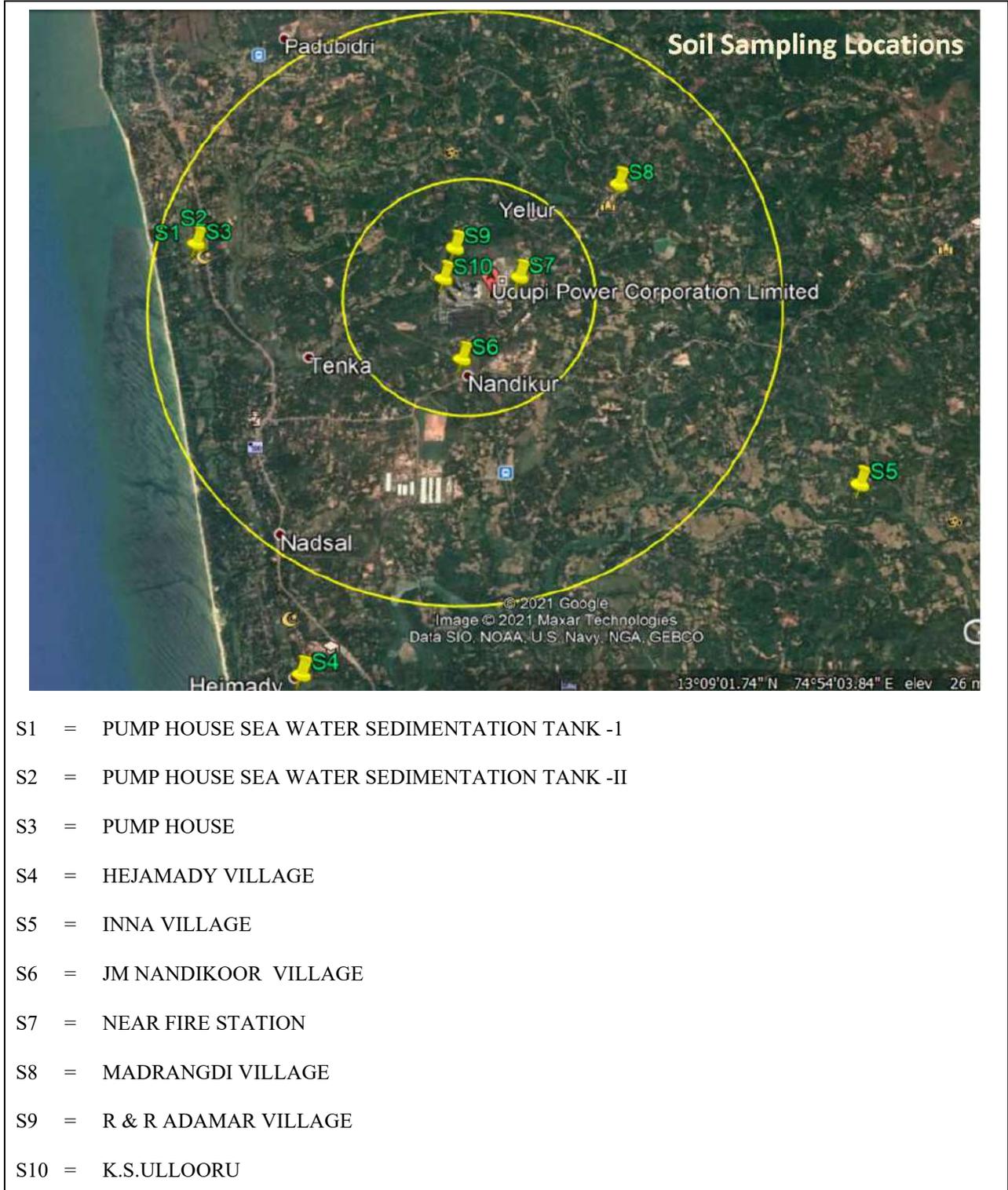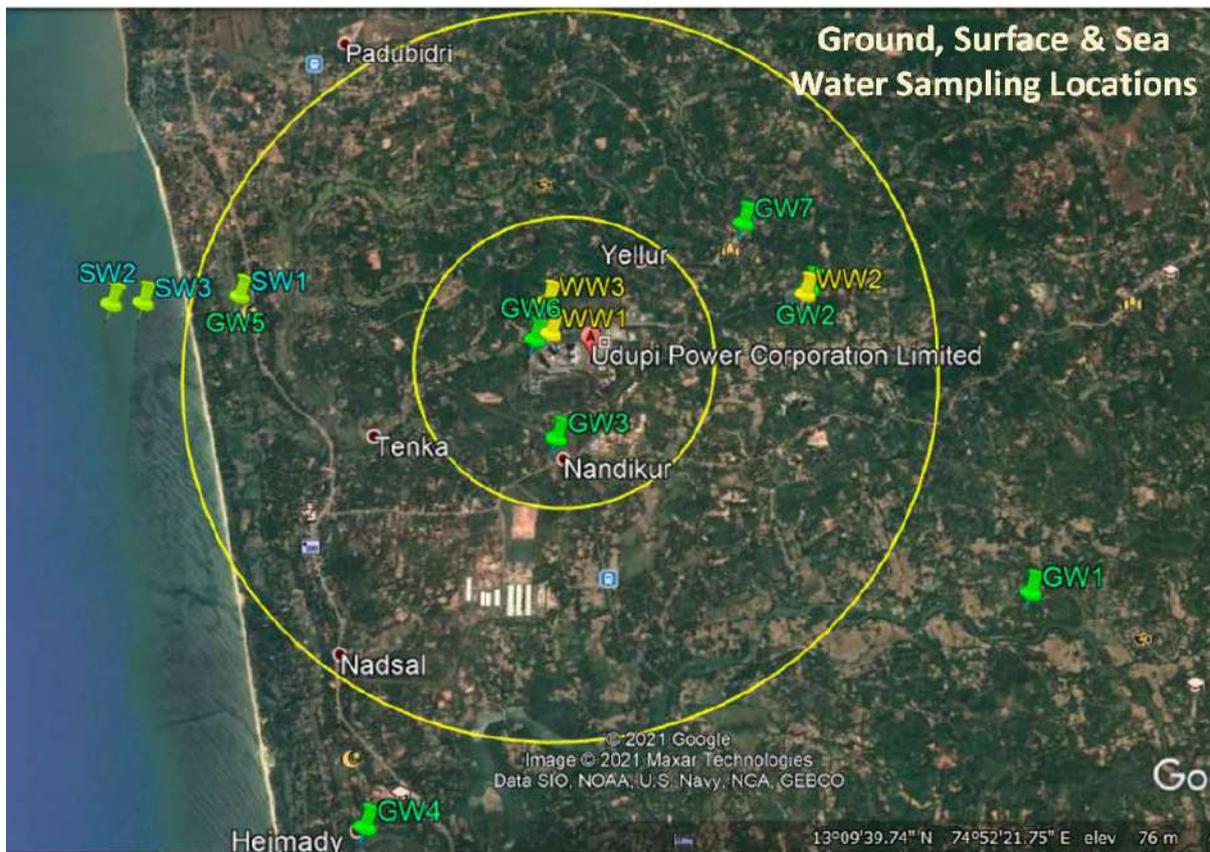
S10 = K.S.ULLOORU

GW1	=	INNA VILLAGE
GW2	=	UPCL ASH POND
GW3	=	JM NANDIKOOR VILLAGE
GW4	=	HEJAMADY VILLAGE
GW5	=	PUMP HOUSE
GW6	=	K.S.ULLOORU
GW7	=	MUDRANGADI VILLAGE
GW8	=	R & R ADAMAR VILLAGE
SW1	=	PUMP HOUSE – SEDIMENTATION TANK
SW2	=	INTAKE SEA WATER
SW3	=	OUT TAKE SEA WATER
WW1	=	UPCL COOLING TOWER DISPOSAL WATER
WW2	=	UPCL GUARD POND
WW3	=	R & R ADAMAR VILLAGE

7.0 DETAILS OF RESULTS AND DISCUSSIONS AMBIENT AIR QUALITY MONITORING

Day- 1: *The AAQM Station-1:* The study at Udupi (Covering Udupi Power Corporation) in which the sampling location selected at Top of the fire Station which is inside of Udupi Power Corporation. The predominant wind direction during sampling period was WNW and the ambient temperature in the range between 25 – 33.3ºC and Relative humidity in the range 49 – 85 %. The height of the sampling location is around 5m from the ground level.

LOCATION - TOP OF THE FIRE STATION
SAMPLING DATE & TIME 02.04.2021 [12:05 Hrs] - 03.04.2021 [12:05 Hrs]
S.NO	POLLUTANT	UNIT	RESULT
1	Sulphur Dioxide as SO_2	$\mu g/m^3$	12.4
2	Nitrogen Dioxide as NO_2	$\mu g/m^3$	15.5
3	Particulate Matter ($PM_{10)}$	$\mu g/m^3$	54.5
4	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	23.4

Day- 1: *The AAQM Station-2*: The study at Udupi (Covering Udupi Power Corporation) in which the sampling location selected at Mudurangadi Village. Predominant wind direction during the sampling period was WNW and the ambient temperature in the range between 25 – 33.3ºC and Relative humidity in the range 49 – 85 %. The height of the sampling location is around 5m from the ground level.

LOCATION - MUDURANGADI VILLAGE
SAMPLING DATE & TIME 02.04.2021 [12:40 Hrs] - 03.04.2021 [12:40 Hrs]
S.NO	POLLUTANT	UNIT	RESULT
1	Sulphur Dioxide as SO_2	$\mu g/m^3$	6.7
2	Nitrogen Dioxide as NO_2	$\mu g/m^3$	11.7
3	Particulate Matter ($PM_{10)}$	$\mu g/m^3$	52.7
4	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	22.1

Day- 1: *The AAQM Station-3:* The study at Udupi (Covering Udupi Power Corporation) in which the sampling location selected at R&R Colony, Adamar Village. The predominant

wind direction during sampling period was WNW and the ambient temperature in the range between 25 – 33.3°C and Relative humidity in the range between 49 – 85 %. The height of the sampling location is around 5m from the ground level.

LOCATION - R & R COLONY, ADAMAR VILLAGE			
SAMPLING DATE & TIME 02.04.2021 [13:10 Hrs] - 03.04.2021 [13:10 Hrs]			
S.NO	POLLUTANT	UNIT	RESULT
1	Sulphur Dioxide as SO_2	$\mu g/m^3$	9.2
2	Nitrogen Dioxide as NO_2	$\mu g/m^3$	13.3
3	Particulate Matter (PM_{10})	$\mu g/m^3$	45.5
4	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	16.4

Day- 1: *The AAQM Station-4:* The study at Udupi (Covering Udupi Power Corporation) in which the sampling location selected at UPCL sea water pump house (Thenka – Yermal Village). The predominant wind direction during sampling period was WNW and the ambient temperature in the range between 25 – 33.3°C and Relative humidity in the range 49 – 85 %. The height of the sampling location is around 5m from the ground level.

LOCATION - UPCL SEA WATER PUMP HOUSE (THENKA-YERMAL VILLAGE)			
SAMPLING DATE & TIME 02.04.2021 [15:00 Hrs] - 03.04.2021 [15:00 Hrs]			
S.NO	POLLUTANT	UNIT	RESULT
1	Sulphur Dioxide as SO_2	$\mu g/m^3$	12.1
2	Nitrogen Dioxide as NO_2	$\mu g/m^3$	14.6
3	Particulate Matter (PM_{10})	$\mu g/m^3$	47
4	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	17.7

Day- 1: *The AAQM Station-5:* The study at Udupi (Covering Udupi Power Corporation) in which the sampling location selected at Hejamady village. The predominant wind direction during the sampling period was WNW and the ambient temperature in the range between 25 – 33.3ºC and Relative humidity in the range between 49 – 85 %. The height of the sampling location is around 5m from the ground level.

LOCATION - HEJAMADY VILLAGE			
SAMPLING DATE & TIME 02.04.2021 [15:55 Hrs] – 03.04.2021 [15:55 Hrs]			
S.NO	POLLUTANT	UNIT	RESULT
1	Sulphur Dioxide as SO_2	$\mu g/m^3$	9.7
2	Nitrogen Dioxide as NO_2	$\mu g/m^3$	12.4
3	Particulate Matter (PM_{10})	$\mu g/m^3$	50.3
4	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	18.8

Day- 1: *The AAQM Station-6*: The study at Udupi (Covering Udupi Power Corporation) in which the sampling location selected at Inna Village. The predominant wind direction during the sampling period was WNW and the ambient temperature in the range between 25 – 33.3ºC and Relative humidity in the range between 49 – 85 %. The height of the sampling location is around 5m from the ground level.

LOCATION - INNA- VILLAGE			
SAMPLING DATE & TIME 02.04.2021 [16:50 Hrs] - 03.04.2021 [16:50 Hrs]			
S.NO	POLLUTANT	UNIT	RESULT
1	Sulphur Dioxide as SO_2	$\mu g/m^3$	10
2	Nitrogen Dioxide as NO_2	$\mu g/m^3$	14
3	Particulate Matter (PM_{10})	$\mu g/m^3$	50.2
4	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	24.5

Day- 1: *The AAQM Station-7*: The study at Udupi (Covering Udupi Power Corporation) in which the sampling location selected at Nadikoor Village. The predominant wind direction during the sampling period was WNW and the ambient temperature in the range between 25 – 33.3ºC and Relative humidity in the range between 49 – 85 %. The height of the sampling location is around 5m from the ground level.

LOCATION - NANDIKOOR VILLAGE			
SAMPLING DATE & TIME 02.04.2021 [17:00 Hrs] – 03.04.2021 [17:00 Hrs]			
S.NO	POLLUTANT	UNIT	RESULT
1	Sulphur Dioxide as SO_2	$\mu g/m^3$	11.7
2	Nitrogen Dioxide as NO_2	$\mu g/m^3$	12.2
3	Particulate Matter (PM_{10})	$\mu g/m^3$	56.6
4	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	24.2

Day:1 AAQM Consolidated Monitoring Results [02.04.2021 to 03.04.2021]				
Sampling Location	SO2	NO2	PM10	PM2.5
Top of the Fire Station	12.4	15.5	54.5	23.5
Mudurangadi Village	6.7	11.7	52.7	22.1
R&R Colony, Adamar Village	9.2	13.3	45.5	16.4
UPCL Sea Water Pump House	12.1	14.6	47	17.7
Hejamady Village	9.7	12.4	50.3	18.8
Inna Village	10	12	51.1	20
Nadikoor Village	11	12.8	49.4	18.9

Day:1 AAQM Consolidated Monitoring Results

DAY:1 AAQM CONSOLIDATED MONITORING RESULTS

CONCLUSION:

In Ambient Air Quality monitoring seven sampling locations were identified to assess the GLC of point source emission of Gaseous and Particulate matter. The sampling locations are Top of the fire station, Mudurangadi village, UPCL Sea Water Pump House (Thenka-Yermal Village), Hejamady Village, Inna- Village and Nandikoor Village.

- *Sulphur Dioxide as SO₂:* Ambient Air Quality measurement values of SO_2 are ranging from 6.7 to 12.4μg/m^3. Highest value of 12.4μg/m^3 is obtained and however the values are within the NAAQM standards.

- *Nitrogen Dioxide as NO₂:* Ambient Air Quality values of NO_2 are ranging from 11.7 to 15.5μg/m^3. Highest value of 15.5μg/m^3 is obtained and however the values are within the NAAQM standards.

- *Particulate Matter (PM₁₀):* Ambient Air Quality values of PM_{10} are ranging from 45.5 to 56.6μg/m^3. Highest value of 56.6μg/m^3 is obtained and however the values are within the NAAQM standards.

- *Particulate Matter (PM₂.₅):* Ambient Air Quality values of $PM_{2.5}$ are ranging from 16.4 to 24.2μg/m^3. Highest value of 26.4μg/m^3 is obtained and however the values are within the NAAQM standards.

7.1 DAY-2 AMBIENT AIR QUALITY MONITORING RESULTS:

Day- 2: *The AAQM Station-1:* The study at Udupi (Covering Udupi Power Corporation) in which the sampling location selected at Top of the fire Station which is inside of Udupi Power Corporation. Predominant wind direction during the sampling period was WNW and the ambient temperature in the range between 25 – 32.8ºC and Relative humidity in the range between 49 – 82 %. The height of the sampling location is around 5m from the ground level.

LOCATION - TOP OF THE FIRE STATION			
SAMPLING DATE & TIME 02.04.2021 [12:10 Hrs] - 03.04.2021 [12:10 Hrs]			
S.NO	POLLUTANT	UNIT	RESULT
1	Sulphur Dioxide as SO_2	$\mu g/m^3$	13.2
2	Nitrogen Dioxide as NO_2	$\mu g/m^3$	13.8
3	Particulate Matter (PM_{10})	$\mu g/m^3$	58.8
4	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	26.4

Day-2: *The AAQM Station-2*: The study at Udupi (Covering Udupi Power Corporation) in which the sampling location selected at Mudurangadi Village. Predominant wind direction during the sampling period was WNW and the ambient temperature in the range between 25 – 32.8ºC and Relative humidity in the range between 49 – 82 %. The height of the sampling location is around 5m from the ground level.

LOCATION - MUDURANGADI VILLAGE			
SAMPLING DATE & TIME 02.04.2021 [12:45 Hrs] - 03.04.2021 [12:45 Hrs]			
S.NO	POLLUTANT	UNIT	RESULT
1	Sulphur Dioxide as SO_2	$\mu g/m^3$	7.3
2	Nitrogen Dioxide as NO_2	$\mu g/m^3$	11.1
3	Particulate Matter (PM_{10})	$\mu g/m^3$	50.9
4	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	26.6

Day- 2: *The AAQM Station-3:* The study at Udupi (Covering Udupi Power Corporation) in which the sampling location selected at R&R Colony, Adamar Village. Predominant wind direction during the sampling period was WNW and the ambient temperature in the range between 25 – 32.8ºC and Relative humidity in the range between 49 – 82 %. The height of the sampling location is around 5m from the ground level.

LOCATION - R & R COLONY, ADAMAR VILLAGE			
SAMPLING DATE & TIME 02.04.2021 [13:15 Hrs] - 03.04.2021 [13:15 Hrs]			
S.NO	POLLUTANT	UNIT	RESULT
1	Sulphur Dioxide as SO_2	$\mu g/m^3$	8.0
2	Nitrogen Dioxide as NO_2	$\mu g/m^3$	9.5
3	Particulate Matter (PM_{10})	$\mu g/m^3$	52.5
4	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	20.7

Day- 2: *The AAQM Station-4:* The study at Udupi (Covering Udupi Power Corporation) in which the sampling location selected at UPCL sea water pump house (Thenka – Yermal Village). The predominant wind direction during sampling period was WNW and the ambient temperature in the range between 25 – 32.8ºC and Relative humidity in the range between 49 – 82%. The height of the sampling location is around 5m from the ground level.

LOCATION - UPCL SEA WATER PUMP HOUSE (THENKA-YERMAL VILLAGE)			
SAMPLING DATE & TIME 02.04.2021 [15:05 Hrs] - 03.04.2021 [15:05 Hrs]			
S.NO	POLLUTANT	UNIT	RESULT
1	Sulphur Dioxide as SO_2	$\mu g/m^3$	9.7
2	Nitrogen Dioxide as NO_2	$\mu g/m^3$	11
3	Particulate Matter (PM_{10})	$\mu g/m^3$	51.4
4	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	19.4

Day- 2: *The AAQM Station-5:* The study at Udupi (Covering Udupi Power Corporation) in which the sampling location selected at Hejamady village. The predominant wind direction during the sampling period was WNW and the ambient temperature in the range between 25 – 32.8ºC and Relative humidity in the range between 49 – 82 %. The height of the sampling location is around 5m from the ground level.

LOCATION - HEJAMADY VILLAGE			
SAMPLING DATE & TIME 02.04.2021 [16:00 Hrs] - 03.04.2021 [16:00 Hrs]			
S.NO	POLLUTANT	UNIT	RESULT
1	Sulphur Dioxide as SO_2	$\mu g/m^3$	10.4
2	Nitrogen Dioxide as NO_2	$\mu g/m^3$	14.2
3	Particulate Matter (PM_{10})	$\mu g/m^3$	53.0
4	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	21.1

Day- 2: *The AAQM Station-6*: The study at Udupi (Covering Udupi Power Corporation) in which the sampling location selected at Inna Village. The predominant wind direction during the sampling period was WNW and the ambient temperature in the range between 25 – 32.8ºC and Relative humidity in the range between 49 – 82 %. The height of the sampling location is around 5m from the ground level.

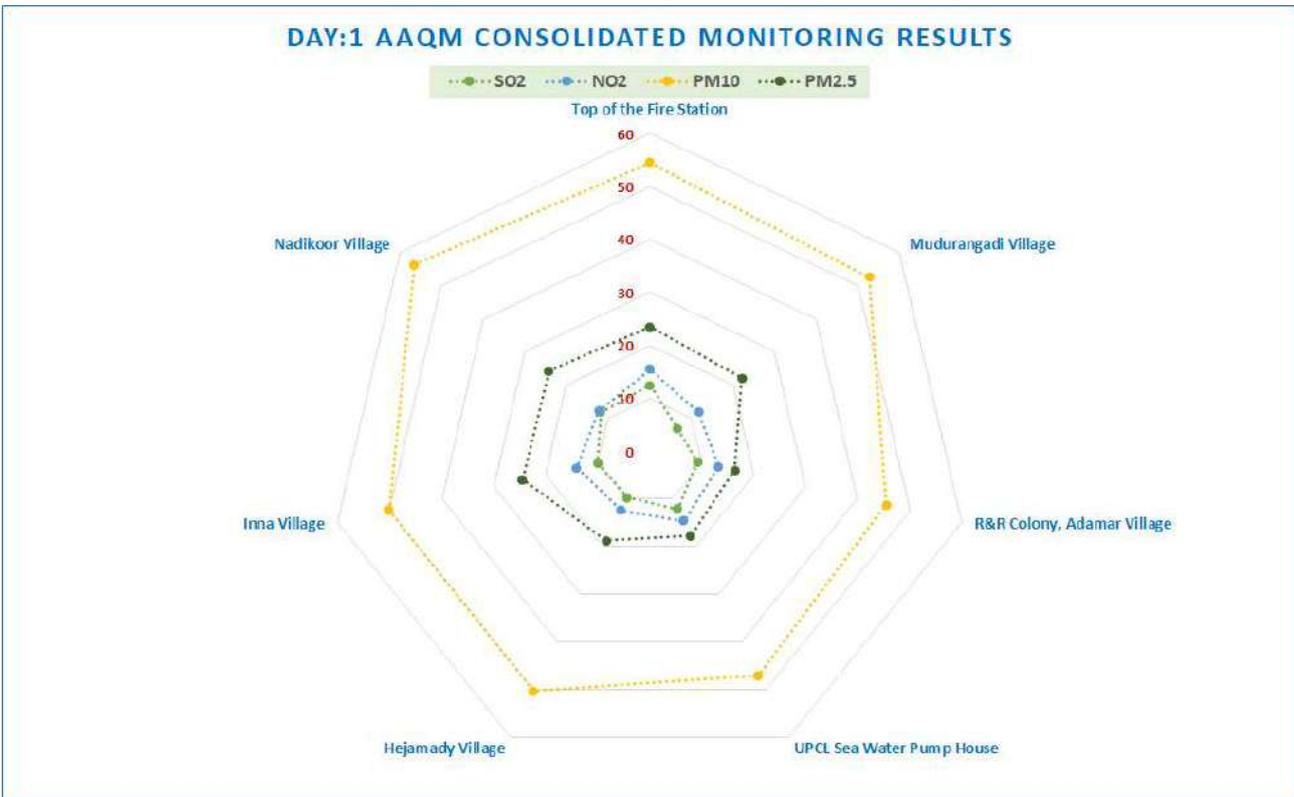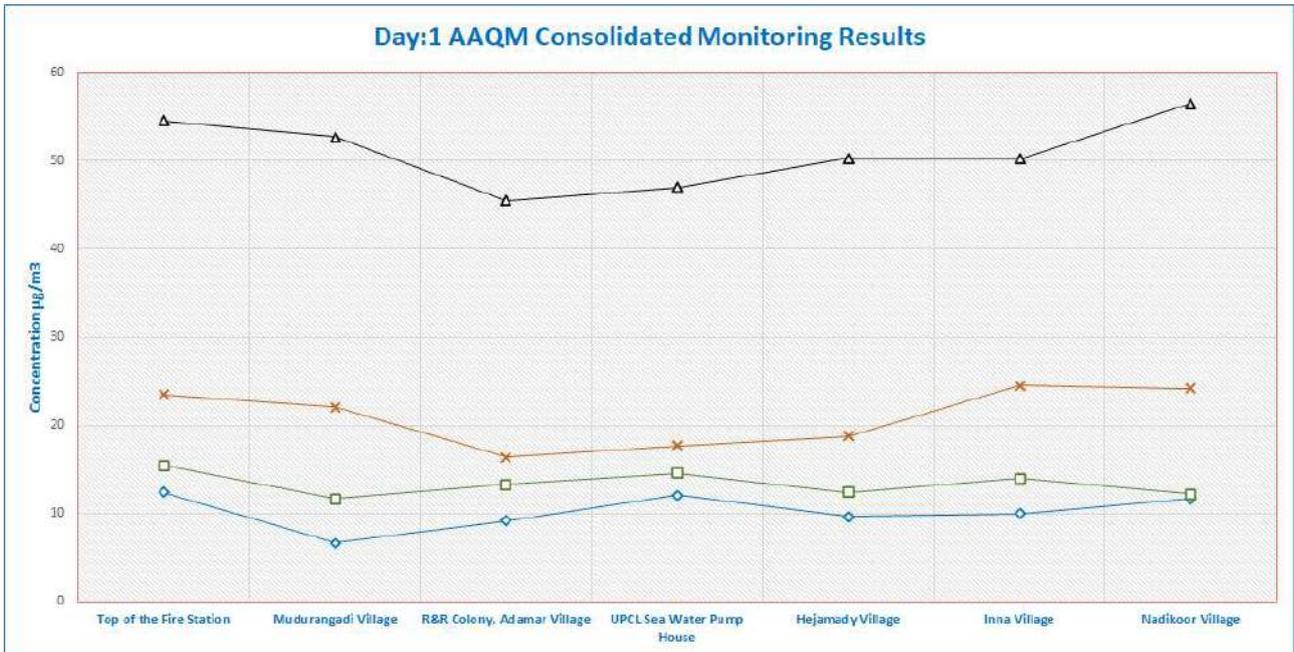| LOCATION - INNA- VILLAGE			
SAMPLING DATE & TIME 02.04.2021 [16:55 Hrs] - 03.04.2021 [16:55 Hrs]			
S.NO	POLLUTANT	UNIT	RESULT
1	Sulphur Dioxide as SO_2	$\mu g/m^3$	10
2	Nitrogen Dioxide as NO_2	$\mu g/m^3$	12
3	Particulate Matter (PM_{10})	$\mu g/m^3$	51.1
4	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	20

Day- 2: *The AAQM Station-7*: The study at Udupi (Covering Udupi Power Corporation) in which the sampling location selected at Nadikoor Village. The predominant wind direction during the sampling period was WNW and the ambient temperature in the range between 25 – 32.8°C and Relative humidity in the range between 49 – 82 %. The height of the sampling location is around 5m from the ground level.

LOCATION - NANDIKOOR VILLAGE			
SAMPLING DATE & TIME 02.04.2021 [17:10 Hrs] - 03.04.2021 [17:10 Hrs]			
S.NO	POLLUTANT	UNIT	RESULT
1	Sulphur Dioxide as SO_2	$\mu g/m^3$	11
2	Nitrogen Dioxide as NO_2	$\mu g/m^3$	12.8
3	Particulate Matter (PM_{10})	$\mu g/m^3$	49.4
4	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	18.9

Day:2 AAQM Consolidated Monitoring Results				
Sampling Location	SO2	NO2	PM10	PM2.5
Top of the Fire Station	13.2	13.8	58.8	26.4
Mudurangadi Village	7.3	11.1	50.9	26.6
R&R Colony, Adamar Village	8	9.5	52.5	20.7
UPCL Sea Water Pump House	9.7	11	51.4	19.4
Hejamady Village	10.4	14.2	53	21.1
Inna Village	10	12	51.1	20
Nadikoor Village	11	12.8	49.4	18.9

CONCLUSION:

In Ambient Air Quality monitoring seven sampling locations were identified to assess the GLC of point source emission of Gaseous and Particulate matter. The sampling locations are Top of the fire station, Mudurangadi village, UPCL Sea Water Pump House (Thenka-Yermal Village), Hejamady Village, Inna- Village and Nandikoor Village.

- *Sulphur Dioxide as SO2:* Ambient Air Quality measurement values of SO_2 are ranging from 7.3 to 13.2µg/m^3. Highest value of 13.2µg/m^3 is obtained and however the values are within the NAAQM standards.

- *Nitrogen Dioxide as NO2:* Ambient Air Quality values of NO_2 are ranging from 9.5 to 14.2µg/m^3. Highest value of 14.2µg/m^3 is obtained and however the values are within the NAAQM standards.

- *Particulate Matter (PM10):* Ambient Air Quality values of PM_{10} are ranging from 49.4 to 58.8µg/m^3. Highest value of 58.8µg/m^3 is obtained and however the values are within the NAAQM standards.

- *Particulate Matter (PM2.5):* Ambient Air Quality values of $PM_{2.5}$ are ranging from 18.9 to 26.4µg/m^3. Highest value of 26.4µg/m^3 is obtained and however the values are within the NAAQM standards.

8.0   STACK EMISSION MONITORING AND ANALYSIS:

 PROCEDURES FOR THE STACK EMISSION MONITORING AND ANALYSIS:

The assessment is exercised the technical and quality aspects to meet the requirements of standard test method. The diagram below illustrates the evaluation following the applied steps:
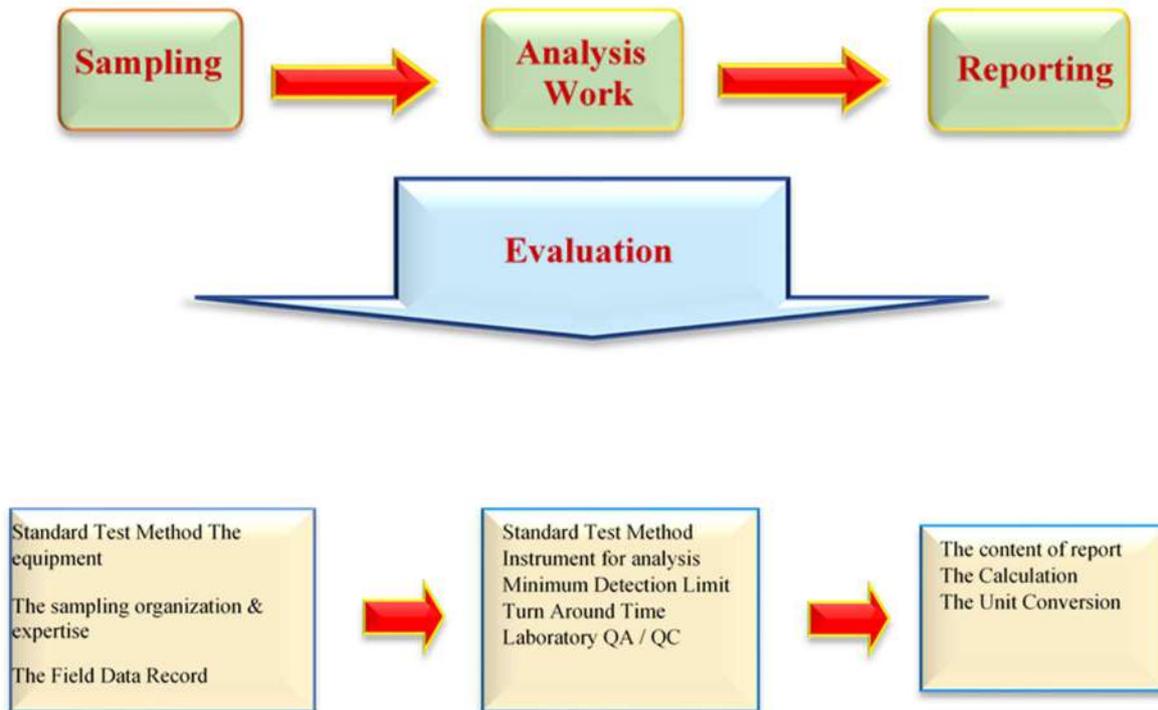
The evaluation is based on the activities of stack measurement. The activity is consisting of 3 steps of work: Sampling Work, Analysis Work and Reporting. Each step is contributing to the accuracy of the results.

1.1 Exhaust Gas Volume Stream

1.1.1 Velocity

The velocity profile was measured using the discontinuous network measurement according to EPA Method -1. The measurement was carried out with a Prandtl tube (Pitot Tube) in connection with micro manometers.
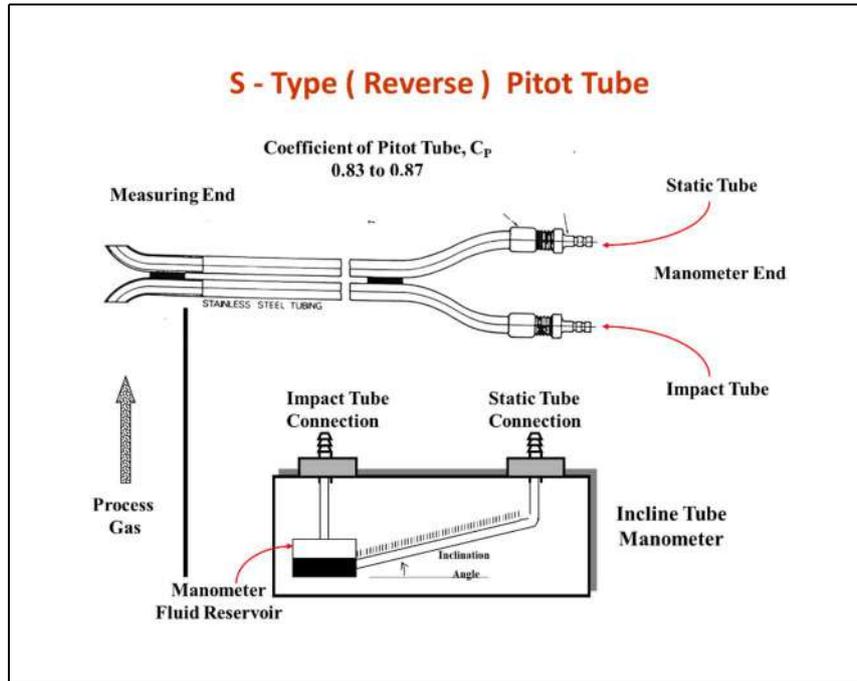
Pitot tube is used to measure the instantaneous velocity without disturbing the plant operations. Measure the point velocities at each traverse point and find out the average velocity. By the use of pitot tube measure difference in impact and the static pressured by means of manometer in terms of velocity head and actual velocity of the gas is calculated using the following equation.

$$V_{m/sec} = 34.96 \times C_p \left[\frac{\Delta P \times T_s}{P_s \times M_w} \right]^{0.5}$$

Where,

Cp = Pitot Tube Coefficient

ΔP = Velocity Pressure, mmWc

Ts = Flue Gas Temperature, °K

Ps = Absolute Stack Pressure, mmHg

Mw = Molecular Weight of Flue Gas, Kg/Kg mole

• *Prandl tube (Pitot tube)*

o EPA design

• *Dynamic pressure & Static Pressure*

o Micro manometer

o Ranges: 0 -1000 [mmWc]

o Accuracy: ± 1 [%] of measuring range

- *Exhaust gas temperature*

During the whole measuring period the temperature of the exhaust gas was measured in one point of the cross-section area of the stack with a calibrated Fe-Cu-Ni thermocouple in connection with a display unit.

• Temperature range: 0 - 1200 [°C]

• Accuracy: ± 2 [°C]

PARTICULATE MATTER: *Field Sampling Procedure:*

Duct Cross section and Number of Traverse Points :

The sampling ports and the duct walls from the probable dust deposits are checked. The cross section of the duct is measured and decided the number of traverse points from which the measurements and samples is taken. The length of the sampling port from the inner side of the duct is measured and added the port length to the traverse points and marked the distances of traverse points on the pitot tube.

The following measurements are taken to calculate the velocity, flowrate and optimum Nozzle diameter.

1. Velocity Head Measurement

2. Absolute Static Pressure of the stack

3. Absolute Stack Temperature

4. Molecular weight of the gas

5. Moisture content of the gas

Velocity of the gas: Calculated the velocity of the gases at each traverse point using the velocity equation with the data collected from the velocity head measurement, absolute stack

pressure, absolute stack temperature and molecular weight of the gas and estimated the arithmetic average velocity across the cross section.

Normal Flow Rate of the Gases: With the average gas velocity and the cross sectional area of the duct the total flow rate of the gases at the stack conditions is calculated as given in the flow rate of gases at normal conditions.

Flow Rate at Stack Condition$_{m3/Hr}$

Qs = Avg Velocity, M/Sec x Area of Flow Cross Section, M²

Normalized Flow Rate, Nm3$_{Dry}$/Hr

$$Qn = Qs \times \frac{Ps \times Tn}{Pn \times Ts} \times (1 - Bw)$$

Selection of Optimum Nozzle dia: For the calculation of the optimum iso-kinetic flow rate range it is required to estimate the suitable nozzle diameter using the super iso-kinetic sampling method. The nearest diameter nozzle available in the kit is selected, as that of the calculated and fixes it to the thimble holder.

Diameter of the nozzle, dn (mm) providing average iso-kinetic flow rate of 25 lpm at meter conditions

$$D_n = \left\{ \frac{25 \times 1000 \times 4 \times Pm \times Ts}{(1- Bw) \times 60 \times V \times \pi_{Avg} \times Tm \times Ps} \right\}^{0.5}$$

m & S … At Meter and Stack conditions respectively

V$_{avg}$ … Average Stack/Duct velocity, M/Sec.

Calculation of Iso-kinetic flow rates: Used the selected diameter nozzle and the calculated velocities at each traverse point calculated the iso-kinetic flowrates.

ISO-KINETIC FLOWRATE CALCULATIONS

AT STACK CONDITIONS

$$Q_{S,} \, lpm \, = \, V_1 \, (=V_n) \, . \, A_n \, . \, 60,000$$

STACK WALL

$$Q_m = Q_s \, . \, (1 - B_w) \, . \, \left[\dfrac{P_s \, . \, T_m}{P_m \, . \, T_s} \right]$$

V_n

V_1

AT METER CONDITIONS
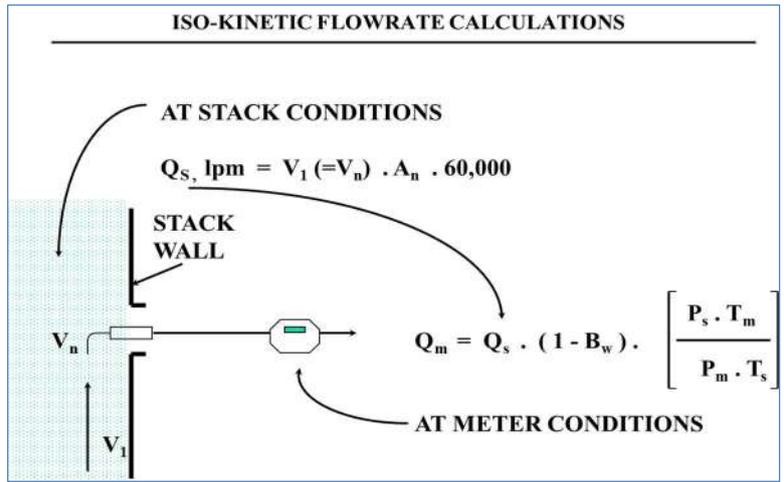
Thimble Holder and Probe: Fixed the prepared thimble in the thimble holder with proper gasket fittings so that no leakage of air is possible. Marked the traverse points on the probe connected to thimble holder as marked on pitot tube in case of velocity measurement. Inserted the probe into the duct through the sampling port and located a the centre of the duct for about 15mts so that the nozzle in the direction of the flow to bring he temperature of thimble holder to the temperature of the gas avoided the dust deposit in the nozzle. The heating of the thimble holder is essential to avoid thermal precipitation on the holder walls. The indicator metal strip at the end of the sampling probe is arranged accordingly.
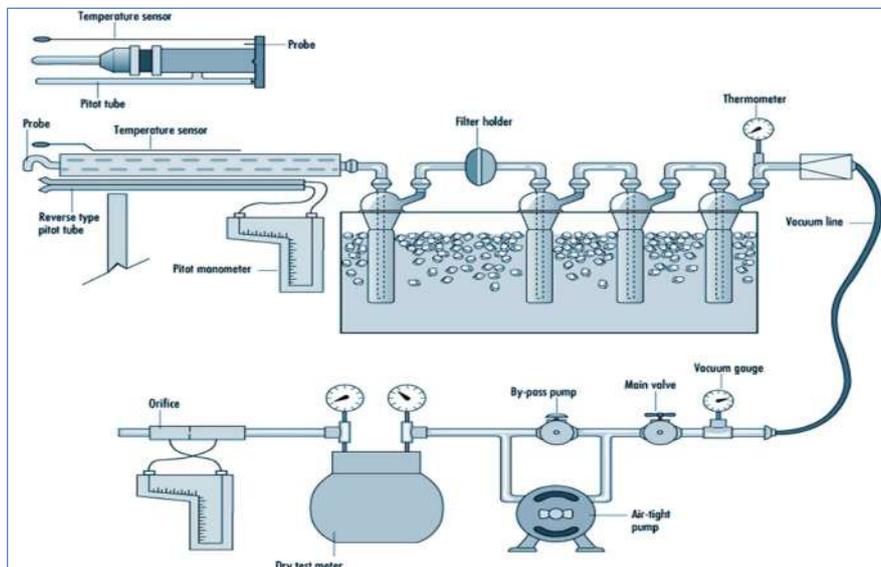
Dry Gas Meter Settings: Recorded the initial reading of the DGM in litres and arranged the pressure gauge reading at 0 mmHg.

Nitrogen monoxide (NO), Carbon dioxide (CO2), Carbon Monoxide (CO) and Oxygen (O2)

The measurement of the compounds NO, NO2, CO, CO2 and O2 was carried out using MRU Optima-7, Germany Portable Flue Gas Analyser.

Measurement of:	
O₂	0 ... 21,00 %
CO₂ calculated value	0 ... 20,00 %
CO low	0 ... 300 ppm
CO/H₂ compensated	0 ... 4.000 ppm
NO low	0 ... 300 ppm
NO	0 ... 1.000 ppm
NO₂	0 ... 200 ppm
NOₓ	0 ... 2.000 ppm
SO₂	0 ... 2.000 ppm
CO high	0 ... 2,0 %
CO very high	0 ... 10,00 %
Combustion air temperature	up to 100° C
Stack gas temperature	up to 1.100° C *
Stack draft measurement	± 100 hPa
Differential pressure	± 100 hPa
Differential temperature	up to 1.100° C *

Extraction and conditioning of the sample gas

o Extraction probe: High-grade steel head with connected glass-filter-case, heated at 120 [°C]

o Dust filter: Stuffed quartz-wool

o Sample gas connection tubes: Teflon; 6 [m] length and heated at 120 [°C] between extraction probe and cooler; 2 [m] length and unheated between cooler and analyzer

Sulfur Dioxide (SO2)

Extractive Measurement

Additionally, to the used continuous method with dilution the sulfur dioxide concentration was measured with a discontinuous method. The used method is described in EPA Method - 6

SCOPE: The sample collector consists of two midget impingers. The SO_2 is removed in this two midget impingers, which contain 100 ml each of 3% Hydrogen peroxide solutions. SO_2 is absorbed in the impingers and converted to form H_2SO_4.

PRINCIPLE AND APPLICABILITY:

The Sulfur dioxide is then absorbed in a 3% Hydrogen peroxide solution and eventually is determined quantitatively by titration with 0.1N Barium Perchlorate solution. Thorin is used as a colour indicator for this titration.

REAGENTS:

1. Deionized distilled water

2. Hydrogen Peroxide, (3% solution): Prepare by diluting 100ml of 30% hydrogen peroxide to 1 litter with dolonized water. Caution: the 30% H_2O_2 is a strong skin irritant which is not noticeable until a few minutes after the injury occurs. This solution must be prepared daily.

3. Isopropyl alcohol, (80% solution); Prepare by mixing 80 ml of isopropyl alcohol with 20 ml of deionized water. This solution is stable.

4. Thorin indicator: [1-(0-arsonophenylazo) -2-naphthol-3, 6-disulfonic acid, disodiuin salt (or equivalent)]. Prepare by dissolving 0.2 grams in 100 ml of deionized distilled water. It should be stored in a polyethylene container since it tends to, deteriorate if stored in glass.

5. Barium perchlorate (0.01N): Prepare by dissolving 1.95 grams of barium perchlorate, $Ba(ClO_4)_2$ $3H_2O$ in 200 ml of deionized water. Then dilute to 1 liter using isopropyl alcohol. Alternatively, dissolve 1.22 grams of barium chloride, $BaCl_2.2H_2O$, in 200 ml deionized water and then dilute to 1 liter with the isopropyl alcohol. The normality of this solution should be standardized with standard sulfuric acid.

SAMPLING PROCEDURE:

This method determines only the concentration in the gas stream. The volumetric flow rate of the stack must be determined according to EPA methods 1 and 2. The same sampling port which in used for the velocity monitoring can be used for the gaseous sampling. Even though the gas composition in uniform across the cross section of the duct, It is advised to collect the sample at the centroid of the duct or not closer then 200mm to the duct wall.

The sampling train is assembled, and leak tested by plugging the probe inlet and pulling 300mmHg vacuum. Observing the dry gas meter, the leakage rate should not exceed 1% of the desired sampling rate. If the leakage is severe each joint of the train should be inspected, and the leak test performed again. A thin film of silicone grease often helps to make the joints leak tight.

The impingers are filled with the absorbing reagents. The initial reading of the DGM is recorded and a sampling flow rate of 2 lpm is maintained at the rotameter. In case of unsteady source conditions, "proportionate sampling" is implemented by introducing the Pitot tube in to the duct along with the sampling probe and the sampling flow rate varies with the variations in the velocity of the gas stream. Gas samples are collected for a minimum period of 20 to 30 minutes and the final DGM reading, meter temperature and pressure are recorded.

At the end of the sampling disconnect the sampling probe from impingers and flush the impingers with about 10 litres of atmospheric air by turning on the vacuum pump. It is necessary to transfer the entrapped SO_2 in the first impinger and absorbed in the following impingers. Transfer the contents of the impingers into the polythene bottles and continue sampling for next set of samples. A minimum of two samples have to be collected to get consistent and representative data.

ANALYTICAL PROCEDURES:

Sulfur Dioxide (SO₂): Transfer the samples from the two midget impingers in to two 100ml volumetric flasks separately and make upto the mark with distilled water. The SO_2 has been oxidized to SO_3 with H_2O_2 and hydrolysed to form sulfuric acid in the impingers. Follow the same analytical for the samples in both the impingers separately to cheek the absorption efficiency and to ensure that there is no escape of SO_2 along with the gas.

$$Qn = Qm \; \frac{Tn \times Pm}{Tm \times Pn}$$

Where

Qn   Volume of gas sample under normal condition, Nm^3

Qm   Volume of gas sample under meter conditions, m^3

Tn   The absolute gas temperature at normal conditioned, 298^oK

Tm   The absolute dry gas meter temperature, ^oK

Pn   The absolute pressure at normal conditions, 760 mmHg

Pm   The absolute pressure at the gas meter, mmHg

SO₂ CONCENTRATION:

The concentration of SO_2 in the gases is determined using the same expression for SO_3 by replacing the equivalent weight with 32 gm/gm mole. The average concentration of SO_2 is estimated by considering the arithmetic average of both the impinger reading.

Concentration of SO_2 in the sample gas, mg/Nm^3

$$= \frac{(A\text{-}B) \times V_{sample} \times N \times 32 \times 1000 \times Pn \times Tm}{V_{ali} \times Q \times Pm \times Tn}$$

2. MOISTURE CONTENT

The moisture content was measured with a special psychrometer according to the recommendations in <Lit.2,3>. The extraction system contains a heated extraction probe with dust filter and a heated connection tube (temperature: 120 [°C]).

The flue gas is allowed to pass through a set of midget glass impingers, which are cooled in an ice bath. With the quantity of water condensed in the impingers for a particular amount of flue gas passed through the moisture content is calculated. The density of the gases get affected predominantly, when moisture content is more than 2.0 gms/Nm^3.

Moisture Content Sampling Train Condensation Method (EPA - 4)
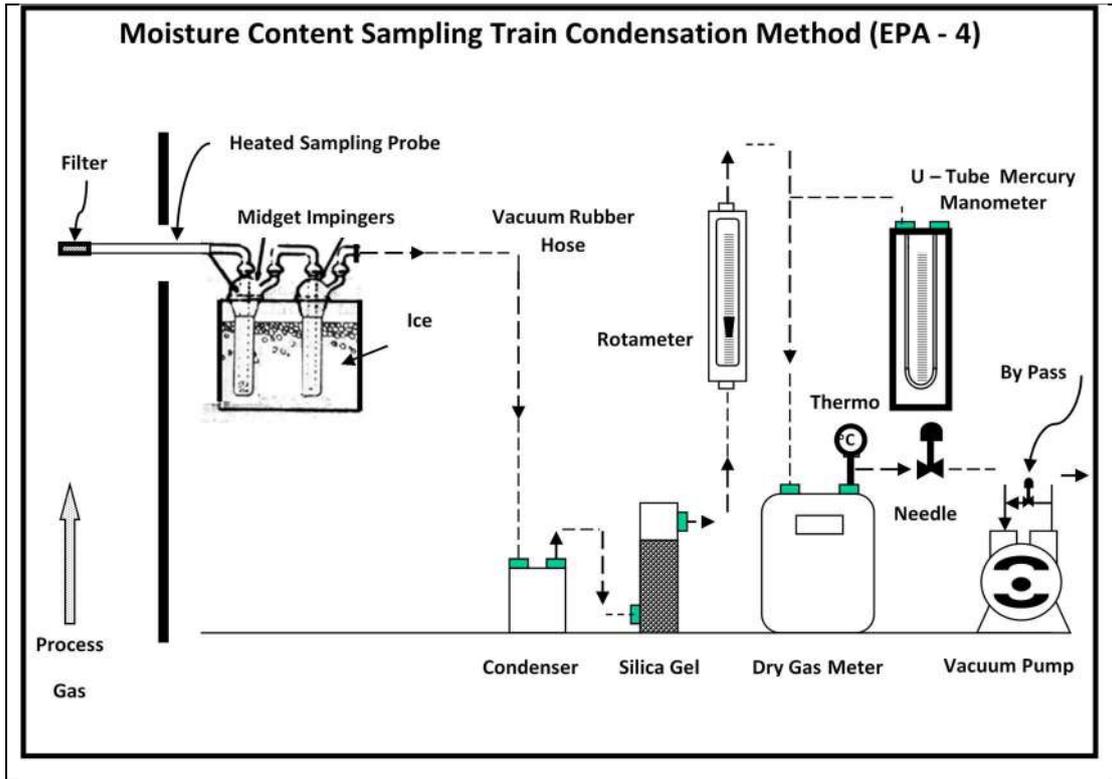
9.0 DETAILS OF RESULTS AND DISCUSSIONS STACK EMISSION RESULTS
STACK EMISSION - THERMAL BOILER UNIT-1

	LOCATION – THERMAL BOILER UNIT-I				
S.NO	POLLUTANT	UNIT	RESULT AT EFFECTIVE OXYGEN LEVEL	RESULT AT 6% OXYGEN LEVEL	AS PER CPCB LIMIT
1	Stack Temperature	K	401	NA	NA
2	Velocity	m/sec	6.5	NA	NA
3	Volume of Gas Discharge	Nm^3/hr	627475	NA	NA
4	Oxygen as O_2	%	9.5	NA	NA
5	Carbon Monoxide as CO	mg/Nm^3	75	NA	NA
6	Carbon Dioxide as CO_2	%	10.8	NA	NA
7	Particulate Matter	mg/Nm^3	25.9	34	50
8	Sulphur Dioxide as SO_2	mg/Nm^3	679	886	600
9	Oxides of Nitrogen as NO_2	mg/Nm^3	267	348	600

LOCATION – THERMAL BOILER UNIT-II					
S.NO	POLLUTANT	UNIT	RESULT AT EFFECTIVE OXYGEN LEVEL	RESULT AT 6% OXYGEN LEVEL	AS PER CPCB LIMIT
1	Stack Temperature	K	339	NA	NA
2	Velocity	m/sec	6.8	NA	NA
3	Volume of Gas Discharge	Nm^3/hr	776388	NA	NA
4	Oxygen as O_2	%	11.2	NA	NA
5	Carbon Monoxide as CO	mg/Nm^3	70	NA	NA
6	Carbon Dioxide as CO_2	%	9.2	NA	NA
7	Particulate Matter	mg/Nm^3	30	46	50
8	Sulphur Dioxide as SO_2	mg/Nm^3	779	1192	600
9	Oxides of Nitrogen as NO_2	mg/Nm^3	341	522	600

CONCLUSION:

In Stack Emission monitoring at thermal boiler both the stacks are not complying for Sulphur Dioxide Concentration of 886mg/Nm^3 & 1192mg/Nm^3 against the CPCB Emission Limit value of 600mg/Nm^3 and rest all the parameters are complying with the CEPCB ELV.

10. METHODOLOGY FOR THE MEASUREMENT OF SOIL SAMPLING AND ANALYSIS

Principle

Soil testing is an essential component of soil resource management. Each sample collected must be a true representative of the area being sampled. Utility of the results obtained from the laboratory analysis depends on the sampling precision. Hence, collection of large number of samples is advisable so that sample of desired size can be obtained by sub-sampling. For soil survey work, samples are collected from a soil profile representative to the soil of the surrounding area.

Materials Required

1. Spade or auger (screw or tube or post hole type)
2. Scoop
3. Core sampler
4. Sampling bags
5. Plastic tray or bucket

Procedure

1. Divided the field into different homogenous units based on the visual observation and surrounding peoples experience.

2. Removed the surface litter at the sampling spot.

3. Drive the auger to a plough depth of 15 cm and drawn the soil sample.

4. Collected around 10 to 15 kgs of samples on 3 locations on the same area

5. Removed thick slices of soil from top to bottom of exposed face of the 'V' shaped cut and placed in a clean container.

6. Mix the samples thoroughly and remove foreign materials like roots, stones, pebbles and gravels.

7. Reduced the bulk to about half to one kilogram by quartering or compartmentalization.

8. Quartering is done by dividing the thoroughly mixed sample into four equal parts. The two opposite quarters are discarded and the remaining two quarters are remixed and the process repeated until the desired sample size is obtained.

9. Compartmentalization is done by uniformly spreading the soil over a clean hard surface and dividing into smaller compartments by drawing lines along and across the length and breadth. From each compartment a pinch of soil is collected. This process is repeated till the desired quantity of sample is obtained.

10. Collected the sample in a clean polythene zip lock bag.

11. Label the bag with information like name of the location, GPS Coordinates, description of location, date of collection, name of the sampler *etc*.

Processing and storage

1. Assigned the sample number and preserved in the cooler box with gel ice pack to maintain the temperature of 10oC.

2. Then the samples will be transported to the laboratory and enter it in the LIMS for registration and further analysis.

3. Dried the sample collected from the field in shade by spreading on a clean sheet of paper after breaking the large lumps.

4. Spreaded the soil on a polythene sheet on a hard surface and powdered the sample by breaking the clods to its ultimate soil particle using a wooden mallet.

5. Sieved the soil material through 2 mm sieve.

6. Repeated powdering and sieving until only materials of >2 mm (no soil or clod) are left on the sieve.

7. Collected the material passing through the sieve and store in a clean polythene bag with proper labelling for laboratory analysis.

8. Field moisture content has been estimated in un-dried sample or to be preserved in a sealed polythene bag immediately after collection.

9. Estimated the moisture content of sample before every analysis to express the results on dry weight basis.

5.0 Testing Procedure :

5.1   Preparation of Standard Solutions :

5.1.1   Stock Standard Solution :

Merck standard solution individual Metals 1000 mg/l in 100 ml .

5.1.2   Intermediate standard solution:

Prepare intermediate standard (conc 25 ppm) by transferring each 1.25 ml of each of 1000 ppm standard stock solution into a 50 mL volumetric flask and makeup with 2% nitric acid and store the solution in a refrigerator at 2-8°C.

5.1.3   Working standard solution:

Prepare working standard (conc 2.0 ppm) by transferring each 4.0 ml of of 25 ppm mix intermediate standard solution into a 50 mL volumetric flask and makeup with 2% nitric acid and store the solution in a refrigerator at 2-8°C.

5.1.1   Stock Standard Solution mercury :

Merck standard solution individual Metals 1000 mg/l in 100 ml .

5.1.2   Intermediate standard solution Mercury:

Prepare intermediate standard (conc 25 ppm) by transferring each 1.25 ml of each of 1000 ppm standard stock solution into a 50 mL volumetric flask and makeup with 2% nitric acid and store the solution in a refrigerator at 2-8°C.

5.1.3   Working standard solution Mercury:

Prepare working standard (conc 1.0 ppm) by transferring each 2.0 ml of of 25 ppm mix intermediate standard solution into a 50 mL volumetric flask and makeup with 2% nitric acid and store the solution in a refrigerator at 2-8°C.

6.0   Preparation of Solvent Calibration Curve Standards:

Working Standard Solution Conc	Volume of Working Fortification Standard	Volume of Diluent 2% HNO3	Final Volume	Label
(ppb)	(uL)	ml	(mL)	ppb
2000	0	10.00	25	Blank
2000	20	9.98	25	2
2000	50	9.95	25	5
2000	100	9.90	25	10
2000	150	9.85	25	15
2000	250	9.75	25	25
2000	500	9.50	25	50
2000	1000	9.00	25	100

6.1   Preparation of Sample :

Type of sample : Soil

7.0   EXTRACTION PROCEDURE

7.1 Preparation of Method Blank :

Prepare a method blank without sample (Millipore Water)

7.1.1.1 Take 0.5 g of Soil sample add 6 ml of nitric acid and 2 ml of Hcl were added in microwave digestor vessel and kept for digestion.

7.1.1.2 Digestor programme:

Stage	wattage	Time(min)
1	600W	5.30
2	350W	4.30

7.2   Preparation of Spike Sample :

7.2.1   Negative Control :

Blank sample material previously analysed and no metals detected. Also called "Blank".

7.2.2   Quality Check :

Negative control samples spiked with the analytes to be determined at the beginning of the analytical procedure. Also called "Spikes". Used for calibration and quantification of target analytes in the samples.

Weigh of the sample were spiked with metals on a before analysis the sample. The addition of the spike was set at 0.04 mg/kg. After spiked the sample kept for 5 minutes and digestion done in microwave digestor and directly analyzed in ICPMS.

7.3   Sequence Procedure :

Inject the blank, sample and standard solutions (prepared above) as per the sequence given in Table – 1 under the given instrumental conditions. Determine the area of each analyte in the sample and calculate the concentration as per given formula. Report the results as ug/l.

Table – 1 : Injection Sequence

Sr. No.	Sample Name	No. of Injections
1	Blank	1
2	Reagent Blank	1
3	Calibration Standards in Solvent (5 points)	1
4	Blank	1
5	Samples batches of 20 along with duplicate & spike	1
6	Blank	1
7	One Standard from Calibration point at QC Check	1
8	Blank	1

7.4 Instrument Conditions :

Instrument : Agilent ICPMS 7800 series

Plasma gas flow	8 L/min
Auxiliary gas flow	0.5 L/min
Nebulizer gas flow	0.2 L/min
RF Power	1150 Watts
Pump Speed	45 rpm
Pump Tubing	Orange-white (inlet) for sample Orange-blue (inlet) for reductant White-white (outlet) (1.65 mm id)
Replicate Read Time	30 s
Fast Pump	Off
Rinse Time	30 s
Sample Mode	Manual
Background Correction	Fitted
Number of Replicates	3
Plasma view	Axial
Read parameters	Auto
Peristaltic pump flow rate	3.0 mL/min
Processing Peak	Counts Per Seconds
Calibration	Linear Calculated Intercept
Quartz torch	1- slot

Element	Wavelength (nm)
Aluminum (Al)	396.10
Arsenic (As)	189.04
Antimony (Sb)	206.83
Barium (Ba)	493.40
Boron (B)	249.70
Cadmium (Cd)	226.50

8.0   Calculations :

Calculate the concentration of metals in the test sample as follows :-

$$\text{Metal Concentration, mg/L} = \frac{C \times V}{\text{Volume of Sample in g}}$$

Where,

C = Concentration of metal in digested solution

V = Final volume of digested solution

9.0   Reference :

9.1   EPA 3051 and EPA 3051A

11. DETAILS OF RESULTS AND DISCUSSIONS SOIL
SOIL SAMPLE -1 – PUMP HOUSE SEA WATER SEDIMENTATION TANK -1

	LOCATION – PUMP HOUSE SEA WATER SEDIMENTATION TANK -1		
S.NO	POLLUTANT	UNIT	RESULT
1	Antimony as Sb	mg/kg	BLQ(LOQ:2.0)
2	Arsenic as As	mg/kg	2.84
3	Zinc as Zn	mg/kg	10.89
4	Cobalt as Co	mg/kg	2.82
5	Cadmium as Cd	mg/kg	BLQ(LOQ:2.0)
6	Molybdenum as Mo	mg/kg	BLQ(LOQ:2.0)
7	Nickel as Ni	mg/kg	6.57
8	Chromium as Cr	mg/kg	20.31
9	Mercury as Hg	mg/kg	BLQ(LOQ:2.0)
10	Copper as Cu	mg/kg	3.58
11	Hexavalent Chromium as Cr^{6+}	mg/kg	BDL(DL:5.0)
12	Iron as Fe	mg/kg	7761.9
13	Lead as Pb	mg/kg	2.98
14	Manganese as Mn	mg/kg	104.35

SOIL SAMPLE -2 – PUMP HOUSE SEA WATER SEDIMENTATION TANK -II

LOCATION – PUMP HOUSE SEA WATER SEDIMENTATION TANK -II			
S.NO	**POLLUTANT**	**UNIT**	**RESULT**
1	Antimony as Sb	mg/kg	BLQ(LOQ:2.0)
2	Arsenic as As	mg/kg	9.48
3	Zinc as Zn	mg/kg	30.52
4	Cobalt as Co	mg/kg	7.22
5	Cadmium as Cd	mg/kg	BLQ(LOQ:2.0)
6	Molybdenum as Mo	mg/kg	BLQ(LOQ:2.0)
7	Nickel as Ni	mg/kg	28.8
8	Chromium as Cr	mg/kg	75.05
9	Mercury as Hg	mg/kg	BLQ(LOQ:2.0)
10	Copper as Cu	mg/kg	14.35
11	Hexavalent Chromium as Cr^{6+}	mg/kg	BDL(DL:5.0)
12	Iron as Fe	mg/kg	24595.3
13	Lead as Pb	mg/kg	9.63
14	Manganese as Mn	mg/kg	154.78

SOIL SAMPLE -3 – PUMP HOUSE

LOCATION – PUMP HOUSE			
S.NO	**POLLUTANT**	**UNIT**	**RESULT**
1	Antimony as Sb	mg/kg	BLQ(LOQ:2.0)
2	Arsenic as As	mg/kg	4.19
3	Zinc as Zn	mg/kg	114.01
4	Cobalt as Co	mg/kg	6.44
5	Cadmium as Cd	mg/kg	BLQ(LOQ:2.0)
6	Molybdenum as Mo	mg/kg	11.03
7	Nickel as Ni	mg/kg	16.84
8	Chromium as Cr	mg/kg	59.5
9	Mercury as Hg	mg/kg	BLQ(LOQ:2.0)
10	Copper as Cu	mg/kg	78.35
11	Hexavalent Chromium as Cr^{6+}	mg/kg	BDL(DL:5.0)
12	Iron as Fe	mg/kg	25880.83
13	Lead as Pb	mg/kg	23.91
14	Manganese as Mn	mg/kg	118.92

SOIL SAMPLE -4 – HEJAMADY VILLAGE

	LOCATION – HEJAMADY VILLAGE		
S.NO	**POLLUTANT**	**UNIT**	**RESULT**
1	Antimony as Sb	mg/kg	BLQ(LOQ:2.0)
2	Arsenic as As	mg/kg	BLQ(LOQ:2.0)
3	Zinc as Zn	mg/kg	8.54
4	Cobalt as Co	mg/kg	BLQ(LOQ:2.0)
5	Cadmium as Cd	mg/kg	BLQ(LOQ:2.0)
6	Molybdenum as Mo	mg/kg	BLQ(LOQ:2.0)
7	Nickel as Ni	mg/kg	5.08
8	Chromium as Cr	mg/kg	19.22
9	Mercury as Hg	mg/kg	BLQ(LOQ:2.0)
10	Copper as Cu	mg/kg	4.75
11	Hexavalent Chromium as Cr^{6+}	mg/kg	BDL(DL:5.0)
12	Iron as Fe	mg/kg	7027.96
13	Lead as Pb	mg/kg	3.55
14	Manganese as Mn	mg/kg	17.41

SOIL SAMPLE -5 – INNA VILLAGE

LOCATION – INNA VILLAGE			
S.NO	**POLLUTANT**	**UNIT**	**RESULT**
1	Antimony as Sb	mg/kg	BLQ(LOQ:2.0)
2	Arsenic as As	mg/kg	BLQ(LOQ:2.0)
3	Zinc as Zn	mg/kg	17.97
4	Cobalt as Co	mg/kg	2.58
5	Cadmium as Cd	mg/kg	BLQ(LOQ:2.0)
6	Molybdenum as Mo	mg/kg	BLQ(LOQ:2.0)
7	Nickel as Ni	mg/kg	10.63
8	Chromium as Cr	mg/kg	69.25
9	Mercury as Hg	mg/kg	BLQ(LOQ:2.0)
10	Copper as Cu	mg/kg	18.28
11	Hexavalent Chromium as Cr^{6+}	mg/kg	BDL(DL:5.0)
12	Iron as Fe	mg/kg	17878.38
13	Lead as Pb	mg/kg	9.3
14	Manganese as Mn	mg/kg	24.83

SOIL SAMPLE -6 – JM NANDIKOOR VILLAGE

S.NO	POLLUTANT	UNIT	RESULT
	LOCATION – JM NANDIKOOR VILLAGE		
1	Antimony as Sb	mg/kg	BLQ(LOQ:2.0)
2	Arsenic as As	mg/kg	BLQ(LOQ:2.0)
3	Zinc as Zn	mg/kg	13.13
4	Cobalt as Co	mg/kg	BLQ(LOQ:2.0)
5	Cadmium as Cd	mg/kg	BLQ(LOQ:2.0)
6	Molybdenum as Mo	mg/kg	BLQ(LOQ:2.0)
7	Nickel as Ni	mg/kg	6.53
8	Chromium as Cr	mg/kg	31.73
9	Mercury as Hg	mg/kg	BLQ(LOQ:2.0)
10	Copper as Cu	mg/kg	7.59
11	Hexavalent Chromium as Cr^{6+}	mg/kg	BDL(DL:5.0)
12	Iron as Fe	mg/kg	5094.5
13	Lead as Pb	mg/kg	7.04
14	Manganese as Mn	mg/kg	15.05

SOIL SAMPLE -7 – NEAR FIRE STATION

	LOCATION – NEAR FIRE STATION		
S.NO	**POLLUTANT**	**UNIT**	**RESULT**
1	Antimony as Sb	mg/kg	BLQ(LOQ:2.0)
2	Arsenic as As	mg/kg	BLQ(LOQ:2.0)
3	Zinc as Zn	mg/kg	5.14
4	Cobalt as Co	mg/kg	BLQ(LOQ:2.0)
5	Cadmium as Cd	mg/kg	BLQ(LOQ:2.0)
6	Molybdenum as Mo	mg/kg	BLQ(LOQ:2.0)
7	Nickel as Ni	mg/kg	3.21
8	Chromium as Cr	mg/kg	43.1
9	Mercury as Hg	mg/kg	BLQ(LOQ:2.0)
10	Copper as Cu	mg/kg	7.37
11	Hexavalent Chromium as Cr^{6+}	mg/kg	BDL(DL:5.0)
12	Iron as Fe	mg/kg	17163.08
13	Lead as Pb	mg/kg	5.13
14	Manganese as Mn	mg/kg	25.48

SOIL SAMPLE -8 – MADRANGDI VILLAGE

	LOCATION – MADRANGDI VILLAGE		
S.NO	**POLLUTANT**	**UNIT**	**RESULT**
1	Antimony as Sb	mg/kg	BLQ(LOQ:2.0)
2	Arsenic as As	mg/kg	8.0
3	Zinc as Zn	mg/kg	77.03
4	Cobalt as Co	mg/kg	3.58
5	Cadmium as Cd	mg/kg	BLQ(LOQ:2.0)
6	Molybdenum as Mo	mg/kg	2.07
7	Nickel as Ni	mg/kg	9.44
8	Chromium as Cr	mg/kg	92.95
9	Mercury as Hg	mg/kg	BLQ(LOQ:2.0)
10	Copper as Cu	mg/kg	20.72
11	Hexavalent Chromium as Cr^{6+}	mg/kg	BDL(DL:5.0)
12	Iron as Fe	mg/kg	394060.76
13	Lead as Pb	mg/kg	14.09
14	Manganese as Mn	mg/kg	271.23

SOIL SAMPLE -9 – R & R ADAMAR VILLAGE

LOCATION – R & R ADAMAR VILLAGE
S.NO	POLLUTANT	UNIT	RESULT
1	Antimony as Sb	mg/kg	BLQ(LOQ:2.0)
2	Arsenic as As	mg/kg	3.00
3	Zinc as Zn	mg/kg	13.37
4	Cobalt as Co	mg/kg	4.30
5	Cadmium as Cd	mg/kg	BLQ(LOQ:2.0)
6	Molybdenum as Mo	mg/kg	BLQ(LOQ:2.0)
7	Nickel as Ni	mg/kg	9.46
8	Chromium as Cr	mg/kg	29.56
9	Mercury as Hg	mg/kg	BLQ(LOQ:2.0)
10	Copper as Cu	mg/kg	10.2
11	Hexavalent Chromium as Cr^{6+}	mg/kg	BDL(DL:5.0)
12	Iron as Fe	mg/kg	21130.16
13	Lead as Pb	mg/kg	9.26
14	Manganese as Mn	mg/kg	145.11

SOIL SAMPLE -10 – K.S.ULLOORU

	LOCATION – K.S.ULLOORU		
S.NO	**POLLUTANT**	**UNIT**	**RESULT**
1	Antimony as Sb	mg/kg	BLQ(LOQ:2.0)
2	Arsenic as As	mg/kg	4.14
3	Zinc as Zn	mg/kg	7.57
4	Cobalt as Co	mg/kg	BLQ(LOQ:2.0)
5	Cadmium as Cd	mg/kg	BLQ(LOQ:2.0)
6	Molybdenum as Mo	mg/kg	BLQ(LOQ:2.0)
7	Nickel as Ni	mg/kg	4.83
8	Chromium as Cr	mg/kg	79.08
9	Mercury as Hg	mg/kg	BLQ(LOQ:2.0)
10	Copper as Cu	mg/kg	7.99
11	Hexavalent Chromium as Cr^{6+}	mg/kg	BDL(DL:5.0)
12	Iron as Fe	mg/kg	17981.21
13	Lead as Pb	mg/kg	6.61
14	Manganese as Mn	mg/kg	18.52

CONCLUSION:

In Soil sample collected ten locations. The sampling locations are Pump House Sea Water Sedimentation Tank -I, Pump House Sea Water Sedimentation Tank –II, Pump House, Hejamady Village, Inna Village, JM Nandikoor Village, Near Fire Station, Madrangdi Village, R & R Adamar Village and K.S.Ullooru.

- Arsenic as As: Soil sample measurement values of Arsenic are ranging from 2.84 to 9.48 mg/kg.

- Zinc as Zn: Soil sample measurement values of Zinc are ranging from 5.14 to 114.01 mg/kg.

- Cobalt as Co: Soil sample measurement values of Cobalt are ranging from 2.58 to 7.22 mg/kg.

- Molybdenum as Mo: Soil sample measurement values of Molybdenum are ranging from 2.07 to 11.03 mg/kg.

- Nickel as Ni: Soil sample measurement values of Nickel are ranging from 3.21 to 28.8 mg/kg.

- Chromium as Cr: Soil sample measurement values of Chromium are ranging from 19.22 to 92.95 mg/kg.

- Copper as Cu: Soil sample measurement values of Copper are ranging from 3.58 to 78.35 mg/kg.

- Iron as Fe: Soil sample measurement values of Iron are ranging from 5094.5 to 394060.76 mg/kg.

- Lead as Pb: Soil sample measurement values of Lead are ranging from 2.98 to 23.91 mg/kg.

- Manganese as Mn: Soil sample measurement values of Manganese are ranging from 15.05 to 271.23 mg/kg.

- Antimony , Cadmium, Mercury and Hexavalent Chromium metals are below detection limit.

The levels of heavy metals in the soil were highest for Fe and Mn followed by Zn, Cr and Cu. In the soil samples, the Fe content ranged from 5094.5 to 394060.76 mg/kg dry soil, Mn ranged from 15.05 to 271.23, Zn ranged from 5.14 to 114.01 mg/kg, Cr ranged from 19.22 to 92.95 mg/kg and Cu ranged from 3.58 to 78.35 mg/kg. Following heavy metals in the soil were lowest for Ni followed by Pb, Mo, As and Co. In the soil samples, the Ni content ranged from 3.21 to 28.80 mg/kg, Pb ranged from 2.98 to 23.91 mg/kg, Mo ranged from 2.07 to 11.03 mg/kg, As ranged from 2.98 to 23.91 mg/kg and Co ranged from 3.21 to 28.8 mg/kg.

12. METHODOLOGY FOR THE MEASUREMENT OF WATER SAMPLING AND ANALYSIS

1. **Sampling Procedure for Water**:

   Ensured that all sampling equipment's are clean and quality-assured before use. Used the sample containers that are clean and free of contaminants.

2. **Sample Labelling**

   Make a record of every sample collected and identify every bottle with a unique sample number, preferably by attaching an appropriately inscribed tag or label.

   Labelled the sample container properly, preferably by attaching an appropriately inscribed tag or label. Alternatively, the bottle was labelled directly with a water-proof marker. Information on the sample container or the tag was included:

   - Sample code number (identifying location)

   - Date and time of sampling

   - Source and type of sample

   - Pre-treatment or preservation carried out on the sample

   - Any special notes for the analyst

   - Sampler's name

   Potable Water Samples taken from tap

   - Taps used for sampling must be free of aerators, strainers, hose, attachments, mixing type faucets and purification devices. Avoided leaky taps.

   - Samples are collected from cold water tap.

   - Flushed tap by running water (to waste) for 2-3 minutes; this will allowed for adequate flushing of the pipe between water main and tap.

Aseptic Sampling Procedure

- Washed hands prior to sampling and careful not to touch sides or inside lid of bottle to anything. These measures will prevent sample from becoming contaminated.

- Samples collected in a container without overfill and make sure that there is approximately 1 inch of air space at top of container to allow for adequate shaking prior to analysis.

- Samples are kept on ice/ice packs during transit to laboratory to maintain temperature below 10 °C in a cooler box.

- Torsen PE bottles are used as containers for holding the sample and add HNO3 acid to fix the pH is less than 2 for Heavy metal determination.

6.0   Testing Procedure :

6.1   Preparation of Standard Solutions :

6.1.1   Stock Standard Solution :

Merck standard solution individual Metals 1000 mg/l in 100 ml .

6.1.2   Intermediate standard solution:

Prepared the intermediate standard (conc 25 ppm) by transferring each 1.25 ml of each of 1000 ppm standard stock solution into a 50 mL volumetric flask and makeup with 2% nitric acid and store the solution in a refrigerator at 2-8°C.

6.1.3   Working standard solution:

Prepared the working standard (conc 2.0 ppm) by transferring each 4.0 ml of of 25 ppm mix intermediate standard solution into a 50 mL volumetric flask and makeup with 2% nitric acid and store the solution in a refrigerator at 2-8°C.

9.1.1   Stock Standard Solution mercury :

Merck standard solution individual Metals 1000 mg/l in 100 ml .

9.1.2   Intermediate standard solution Mercury:

Prepared the intermediate standard (conc 25 ppm) by transferring each 1.25 ml of each of 1000 ppm standard stock solution into a 50 mL volumetric flask and makeup

with 2% nitric acid and store the solution in a refrigerator at 2-8°C.

9.1.3   Working standard solution Mercury:

Prepared the working standard (conc 1.0 ppm) by transferring each 2.0 ml of of 25 ppm mix intermediate standard solution into a 50 mL volumetric flask and makeup with 2% nitric acid and store the solution in a refrigerator at 2-8°C.

10.0   Preparation of solvent calibration curve standards:

Working standard solution conc	Volume of Working Fortification Standard	Volume of Diluent 2% HNO3	Final Volume	Label
(ppb)	(uL)	ml	(mL)	ppb
2000	0	10.00	25	Blank
2000	20	9.98	25	2
2000	50	9.95	25	5
2000	100	9.90	25	10
2000	150	9.85	25	15
2000	250	9.75	25	25
2000	500	9.50	25	50
2000	1000	9.00	25	100

10.1   Preparation of Sample :

Type of sample : Waste Water

11.0   EXTRACTION PROCEDURE

11.1 Preparation of Method Blank :

Prepare a method blank without sample (Millipore Water).

11.1 Sample Digestion Procedure for the Metals :

11.2 Colorless, transparent samples primarily waste water having a turbidity of <1 NTU, no odor may be analyzed directly by ICPMS with 2% of nitric acid (in the sample matrix).

11.3 Take 5 ml of sample add 2% nitric acid and directly analyzed in ICPMS.

11.4 Color, non-transparent samples of waste water having a turbidity of <1 NTU, any odor contains ,it was analysed and directly by ICPMS with 2% of nitric acid (in the sample matrix).

11.5 **Take 5 ml of waste water sample add 2 ml of nitric acid and 1 ml of Hcl were added in microwave digestor vessel and kept for digestion.**

11.6 **Digestor programme:**

Stage	wattage	Time(min)
	665W	10
	290W	10

11.7 **Preparation of Spike Sample :**

11.7.1 **Negative Control :** Blank sample material previously analysed and no metals detected. Also called "Blank".

11.7.2 Quality Check :

Negative control samples spiked with the analytes to be determined at the beginning of the analytical procedure. Also called "Spikes". Used for calibration and quantification of target analytes in the samples.

Weigh of the sample were spiked with metals on a before analysis the sample. The addition of the spike was set at 0.04 mg/kg. After spiked the sample shaked and directly analyzed in ICPMS.

11.8 **Sequence Procedure :**

Inject the blank, sample and standard solutions (prepared above) as per the sequence given in Table – 1 under the given instrumental conditions. Determine the area of each analyte in the sample and calculate the concentration as per given formula. Report the results as ug/l.

Table – 1 : Injection Sequence

Sr. No.	Sample Name	No. of Injections
1	Blank	1
2	Reagent Blank	1
3	Calibration Standards in Solvent (5 points)	1
4	Blank	1
5	Samples batches of 20 along with duplicate & spike	1
6	Blank	1
7	One Standard from Calibration point at QC Check	1
8	Blank	1

11.9   Instrument Conditions :

Instrument : Agilent ICPMS 7800 series

Plasma gas flow	8 L/min
Auxiliary gas flow	0.5 L/min
Nebulizer gas flow	0.2 L/min
RF Power	1150 Watts
Pump Speed	45 rpm
Pump Tubing	Orange-white (inlet) for sample Orange-blue (inlet) for reductant White-white (outlet) (1.65 mm id)
Replicate Read Time	30 s
Fast Pump	Off
Rinse Time	30 s

Sample Mode	Manual
Background Correction	Fitted
Number of Replicates	3
Plasma view	Axial
Read parameters	Auto
Peristaltic pump flow rate	3.0 mL/min
Processing Peak	Counts Per Seconds
Calibration	Linear Calculated Intercept
Quartz torch	1- slot

Element	Wavelength (nm)
Aluminum (Al)	396.10
Arsenic (As)	189.04
Antimony (Sb)	206.83
Barium (Ba)	493.40
Boron (B)	249.70
Cadmium (Cd)	226.50
Copper (Cu)	324.70
Iron (Fe)	238.20
Manganese (Mn)	257.60
Lead (Pb)	220.30
Mercury (Hg)	184.90

Nickel (Ni)	221.60
Chromium (Cr)	283.50
Cobalt (Co)	228.60
Selenium (Se)	196.09
Silver (Ag)	328.00
Zinc (Zn)	202.50
Strontium (Sr)	421.50
Molybdenum (Mo)	202.03
Tin (Sn)	189.90
Vanadium(V)	189.90

12.0   Calculations :

Calculate the concentration of metals in the test sample as follows :-

$$\text{Metal concentration, mg/L} = \frac{C \times V}{\text{Volume of Sample in ml}}$$

Where,

C = Concentration of metal in digested solution

V = Final volume of digested solution

13.0   Reference :

- APHA, 23rd Edition, 2017, 3500 & 3120.
- EPA-3015A
- IS 3025 (Part -2) .
- IS 3025 (Part – 65).

13. DETAILS OF RESULTS AND DISCUSSIONS GROUND WATER

GROUND WATER SAMPLE -1 – INNA VILLAGE

LOCATION – INNA VILLAGE			
S.NO	**POLLUTANT**	**UNIT**	**RESULT**
1	Aluminium as Al	mg/L	0.035
2	Barium as Ba	mg/L	0.063
3	Boron as B	mg/L	BLQ(LOQ:0.002)
4	Copper as Cu	mg/L	BLQ(LOQ:0.002)
5	Manganese as Mn	mg/L	0.178
6	Selenium as Se	mg/L	BLQ(LOQ:0.002)
7	Silver as Ag	mg/L	BLQ(LOQ:0.002)
8	Zinc as Zn	mg/L	0.028
9	Cadmium as Cd	mg/L	BLQ(LOQ:0.002)
10	Lead as Pb	mg/L	BLQ(LOQ:0.002)
11	Molybdenum as Mo	mg/L	BLQ(LOQ:0.002)
12	Nickel as Ni	mg/L	0.006
13	Arsenic as As	mg/L	BLQ(LOQ:0.002)
14	Chromium as Cr	mg/L	BLQ(LOQ:0.002)
15	Iron as Fe	mg/L	BLQ(LOQ:0.002)
16	Magnesium as Mg	mg/L	2.0

GROUND WATER SAMPLE -2 – UPCL ASH POND

S.NO	POLLUTANT	UNIT	RESULT
	LOCATION – UPCL ASH POND		
1	Aluminium as Al	mg/L	0.021
2	Barium as Ba	mg/L	0.054
3	Boron as B	mg/L	BLQ(LOQ:0.002)
4	Copper as Cu	mg/L	0.081
5	Manganese as Mn	mg/L	0.424
6	Selenium as Se	mg/L	BLQ(LOQ:0.002)
7	Silver as Ag	mg/L	BLQ(LOQ:0.002)
8	Zinc as Zn	mg/L	3.868
9	Cadmium as Cd	mg/L	BLQ(LOQ:0.002)
10	Lead as Pb	mg/L	0.041
11	Molybdenum as Mo	mg/L	BLQ(LOQ:0.002)
12	Nickel as Ni	mg/L	BLQ(LOQ:0.002)
13	Arsenic as As	mg/L	BLQ(LOQ:0.002)
14	Chromium as Cr	mg/L	BLQ(LOQ:0.002)
15	Iron as Fe	mg/L	0.041
16	Magnesium as Mg	mg/L	5.0

GROUND WATER SAMPLE -3 – JM NANDIKOOR VILLAGE

S.NO	POLLUTANT	UNIT	RESULT
	LOCATION – JM NANDIKOOR VILLAGE		
1	Aluminium as Al	mg/L	0.07
2	Barium as Ba	mg/L	0.158
3	Boron as B	mg/L	0.067
4	Copper as Cu	mg/L	0.004
5	Manganese as Mn	mg/L	0.160
6	Selenium as Se	mg/L	BLQ(LOQ:0.002)
7	Silver as Ag	mg/L	BLQ(LOQ:0.002)
8	Zinc as Zn	mg/L	0.025
9	Cadmium as Cd	mg/L	BLQ(LOQ:0.002)
10	Lead as Pb	mg/L	BLQ(LOQ:0.002)
11	Molybdenum as Mo	mg/L	BLQ(LOQ:0.002)
12	Nickel as Ni	mg/L	BLQ(LOQ:0.002)
13	Arsenic as As	mg/L	BLQ(LOQ:0.002)
14	Chromium as Cr	mg/L	BLQ(LOQ:0.002)
15	Iron as Fe	mg/L	BLQ(LOQ:0.002)
16	Magnesium as Mg	mg/L	10

GROUND WATER SAMPLE -4 – HEJAMADY VILLAGE

	LOCATION – HEJAMADY VILLAGE		
S.NO	POLLUTANT	UNIT	RESULT
1	Aluminium as Al	mg/L	0.114
2	Barium as Ba	mg/L	0.107
3	Boron as B	mg/L	0.015
4	Copper as Cu	mg/L	0.007
5	Manganese as Mn	mg/L	0.133
6	Selenium as Se	mg/L	BLQ(LOQ:0.002)
7	Silver as Ag	mg/L	BLQ(LOQ:0.002)
8	Zinc as Zn	mg/L	0.035
9	Cadmium as Cd	mg/L	BLQ(LOQ:0.002)
10	Lead as Pb	mg/L	BLQ(LOQ:0.002)
11	Molybdenum as Mo	mg/L	BLQ(LOQ:0.002)
12	Nickel as Ni	mg/L	0.003
13	Arsenic as As	mg/L	BLQ(LOQ:0.002)
14	Chromium as Cr	mg/L	0.003
15	Iron as Fe	mg/L	BLQ(LOQ:0.002)
16	Magnesium as Mg	mg/L	6.5

GROUND WATER SAMPLE -5 – PUMP HOUSE

S.NO	POLLUTANT	UNIT	RESULT
	LOCATION – PUMP HOUSE		
1	Aluminium as Al	mg/L	4.797
2	Barium as Ba	mg/L	0.218
3	Boron as B	mg/L	0.104
4	Copper as Cu	mg/L	0.012
5	Manganese as Mn	mg/L	0.278
6	Selenium as Se	mg/L	0.006
7	Silver as Ag	mg/L	BLQ(LOQ:0.002)
8	Zinc as Zn	mg/L	BLQ(LOQ:0.002)
9	Cadmium as Cd	mg/L	BLQ(LOQ:0.002)
10	Lead as Pb	mg/L	BLQ(LOQ:0.002)
11	Molybdenum as Mo	mg/L	BLQ(LOQ:0.002)
12	Nickel as Ni	mg/L	0.013
13	Arsenic as As	mg/L	BLQ(LOQ:0.002)
14	Chromium as Cr	mg/L	0.005
15	Iron as Fe	mg/L	0.003
16	Magnesium as Mg	mg/L	56

GROUND WATER SAMPLE -6 – K.S.ULLOORU

S.NO	POLLUTANT	UNIT	RESULT
	LOCATION – K.S.ULLOORU		
1	Aluminium as Al	mg/L	0.009
2	Barium as Ba	mg/L	0.380
3	Boron as B	mg/L	0.02
4	Copper as Cu	mg/L	BLQ(LOQ:0.002)
5	Manganese as Mn	mg/L	1.003
6	Selenium as Se	mg/L	BLQ(LOQ:0.002)
7	Silver as Ag	mg/L	BLQ(LOQ:0.002)
8	Zinc as Zn	mg/L	BLQ(LOQ:0.002)
9	Cadmium as Cd	mg/L	BLQ(LOQ:0.002)
10	Lead as Pb	mg/L	BLQ(LOQ:0.002)
11	Molybdenum as Mo	mg/L	BLQ(LOQ:0.002)
12	Nickel as Ni	mg/L	BLQ(LOQ:0.002)
13	Arsenic as As	mg/L	BLQ(LOQ:0.002)
14	Chromium as Cr	mg/L	BLQ(LOQ:0.002)
15	Iron as Fe	mg/L	BLQ(LOQ:0.002)
16	Magnesium as Mg	mg/L	16

GROUND WATER SAMPLE -7– MUDRANGADI VILLAGE

	LOCATION – MUDRANGADI VILLAGE		
S.NO	**POLLUTANT**	**UNIT**	**RESULT**
1	Aluminium as Al	mg/L	0.034
2	Barium as Ba	mg/L	0.053
3	Boron as B	mg/L	BLQ(LOQ:0.002)
4	Copper as Cu	mg/L	0.007
5	Manganese as Mn	mg/L	0.234
6	Selenium as Se	mg/L	BLQ(LOQ:0.002)
7	Silver as Ag	mg/L	BLQ(LOQ:0.002)
8	Zinc as Zn	mg/L	0.152
9	Cadmium as Cd	mg/L	BLQ(LOQ:0.002)
10	Lead as Pb	mg/L	BLQ(LOQ:0.002)
11	Molybdenum as Mo	mg/L	BLQ(LOQ:0.002)
12	Nickel as Ni	mg/L	0.004
13	Arsenic as As	mg/L	BLQ(LOQ:0.002)
14	Chromium as Cr	mg/L	0.004
15	Iron as Fe	mg/L	BLQ(LOQ:0.002)
16	Magnesium as Mg	mg/L	4.0

GROUND WATER SAMPLE -8– R & R ADAMAR VILLAGE

LOCATION – R & R ADAMAR VILLAGE

S.NO	POLLUTANT	UNIT	RESULT
1	Aluminium as Al	mg/L	BLQ(LOQ:0.002)
2	Barium as Ba	mg/L	0.095
3	Boron as B	mg/L	0.042
4	Copper as Cu	mg/L	BLQ(LOQ:0.002)
5	Manganese as Mn	mg/L	0.095
6	Selenium as Se	mg/L	BLQ(LOQ:0.002)
7	Silver as Ag	mg/L	BLQ(LOQ:0.002)
8	Zinc as Zn	mg/L	0.006
9	Cadmium as Cd	mg/L	BLQ(LOQ:0.002)
10	Lead as Pb	mg/L	BLQ(LOQ:0.002)
11	Molybdenum as Mo	mg/L	BLQ(LOQ:0.002)
12	Nickel as Ni	mg/L	BLQ(LOQ:0.002)
13	Arsenic as As	mg/L	BLQ(LOQ:0.002)
14	Chromium as Cr	mg/L	BLQ(LOQ:0.002)
15	Iron as Fe	mg/L	BLQ(LOQ:0.002)
16	Magnesium as Mg	mg/L	9.0

CONCLUSION:

In Ground Water sample collected ten locations. The sampling locations are Inna Village , Upcl Ash Pond , Jm Nandikoor Village , Hejamady Village , Pump House, K.S.Ullooru , Mudrangadi Village and R & R Adamar Village.

- Aluminium as Al: Ground Water sample measurement values of Aluminium are ranging from 0.009 to 4.797 mg/L. Highest value of 4.797mg/L is obtained. While the Permissible limit is 0.2 mg/L (IS 10500 standard). **Pump House ground water location sample exceeding the limit** and rests of the location sample within the limit.

- Barium as Ba: Ground Water sample measurement values of Barium are ranging from 0.053 to 0.38 mg/L. Highest value of 0.38mg/L is obtained. While the Acceptable limit is 0.7 mg/L (IS 10500 standard). All ground water location samples within the limit.

- Boron as B: Ground Water sample measurement values of Boron are ranging from 0.015 to 0.104 mg/L. Highest value of 0.104 mg/L is obtained. While the Permissible limit is 2.4 mg/L (IS 10500 standard). All ground water location samples within the limit.

- Copper as Cu: Ground Water sample measurement values of Copper are ranging from 0.004 to 0.081 mg/L. Highest value of 0.018mg/L is obtained. While the Permissible limit is 1.5 mg/L (IS 10500 standard).All ground water location samples within the limit.

- Manganese as Mn: Ground Water sample measurement values of Manganese are ranging from 0.095 to 1.003 mg/L. Highest value of 1.003mg/L is obtained.While the Permissible limit is 0.3 mg/L (IS 10500 standard). **UPCL Ash Pond and K.S.Ullooru ground water location sample exceeding the limit** and rests of the location sample within the limit.

- Selenium as Se: Ground Water sample measurement values of Selenium are ranging from 0.006 to 0.006 mg/L. While the Acceptable limit is 0.01 mg/L (IS 10500 standard).All ground water location samples within the limit.

- Zinc as Zn: Ground Water sample measurement values of Zinc are ranging from 0.006 to 3.864 mg/L. Highest value of 3.864mg/L is obtained. While the Permissible limit is 15 mg/L (IS 10500 standard). All ground water location samples within the limit.

- Lead as Pb: Ground Water sample measurement values of Lead are ranging from 0.041 to 0.041 mg/L. While the Acceptable limit is 0.01 mg/L (IS 10500 standard). **UPCL Ash Pond ground water location sample exceeding the limit** and rests of the location sample within the limit.

- Nickel as Ni: Ground Water sample measurement values of Nickel are ranging from 0.003 to 0.013 mg/L. Highest value of 0.013mg/L is obtained. While the Acceptable limit is 0.02 mg/L (IS 10500 standard). All ground water location samples within the limit.

- Chromium as Cr: Ground Water sample measurement values of Chromium are ranging from 0.003 to 0.005 mg/L. Highest value of 0.005mg/L is obtained. While the Acceptable limit is 0.05 mg/L (IS 10500 standard). All ground water location samples within the limit.

- Iron as Fe: Ground Water sample measurement values of Iron are ranging from 0.003 to 0.041 mg/L. Highest value of 0.041mg/L is obtained. While the Acceptable limit is 1.0 mg/L (IS 10500 standard). All ground water location samples within the limit.

- Magnesium as Mg: Ground Water sample measurement values of Magnesium are ranging from 2.0 to 56 mg/L. Highest value of 56mg/L is obtained. While the Permissible limit is 100 mg/L (IS 10500 standard). All ground water location samples within the limit.

- Silver, Cadmium, Molybdenum and Arsenic metals are below detection limit. All ground water location samples within the limit.

The levels of heavy metals in the Ground Water were highest for Mg and Al followed by Zn, Mn, Ba and B. In the Ground Water samples, the Mg content ranged from 2 to 56 mg/L, Al ranged from 0.009 to 4.797mg/L, Zn ranged from 0.006 to 3.868 mg/L, Mn ranged from 0.095 to 1.003 mg/L, Ba ranged from 0.053 to 0.38 mg/L, B ranged from 0.015 to 0.104 mg/L. Following heavy metals in the Ground Water were lowest for Cu followed by Fe, Pb, Ni, Se and Cr. In the Ground Water samples, the Cu content ranged from 0.004 to 0.081 mg/L, Fe ranged from 0.003 to 0.041 mg/L, Pb ranged from 0.041 to 0.041 mg/L, Ni ranged from 0.003 to 0.013 mg/L and Se ranged from 0.006 to 0.006 mg/L, Cr ranged from 0.003 to 0.005 mg/L.

14. DETAILS OF RESULTS AND DISCUSSIONS SURFACE WATER

SURFACE WATER SAMPLE - R & R ADAMAR VILLAGE

LOCATION – R & R ADAMAR VILLAGE			
S.NO	POLLUTANT	UNIT	RESULT
1	Arsenic as As	mg/L	BLQ(LOQ:0.002)
2	Cadmium as Cd	mg/L	BLQ(LOQ:0.002)
3	Copper as Cu	mg/L	0.003
4	Chromium as Cr	mg/L	BLQ(LOQ:0.002)
5	Nickel as Ni	mg/L	0.003
6	Lead as Pb	mg/L	BLQ(LOQ:0.002)
7	Mercury as Hg	mg/L	BLQ(LOQ:0.002)
8	Selenium as Se	mg/L	BLQ(LOQ:0.002)
9	Zinc as Zn	mg/L	0.035
10	Hexavalent Chromium as Cr^{6+}	mg/L	BLQ(LOQ:0.03)

15. DETAILS OF RESULTS AND DISCUSSIONS POND WATER

POND WATER SAMPLE – UPCL GUARD POND

LOCATION – UPCL GUARD POND			
S.NO	POLLUTANT	UNIT	RESULT
1	Arsenic as As	mg/L	BLQ(LOQ:0.002)
2	Cadmium as Cd	mg/L	BLQ(LOQ:0.002)
3	Copper as Cu	mg/L	0.003
4	Chromium as Cr	mg/L	BLQ(LOQ:0.002)
5	Nickel as Ni	mg/L	BLQ(LOQ:0.002)
6	Lead as Pb	mg/L	BLQ(LOQ:0.002)
7	Mercury as Hg	mg/L	BLQ(LOQ:0.002)
8	Selenium as Se	mg/L	BLQ(LOQ:0.002)
9	Zinc as Zn	mg/L	0.027
10	Hexavalent Chromium as Cr^{6+}	mg/L	BLQ(LOQ:0.03)

16. DETAILS OF RESULTS AND DISCUSSIONS COOLING TOWER WATER

COOLING TOWER WATER – UPCL COOLING TOWER DISPOSAL WATER

LOCATION – UPCL COOLING TOWER DISPOSAL WATER			
S.NO	**POLLUTANT**	**UNIT**	**RESULT**
1	Arsenic as As	mg/L	BLQ(LOQ:0.005)
2	Cadmium as Cd	mg/L	BLQ(LOQ:0.005)
3	Copper as Cu	mg/L	BLQ(LOQ:0.005)
4	Chromium as Cr	mg/L	BLQ(LOQ:0.005)
5	Nickel as Ni	mg/L	BLQ(LOQ:0.005)
6	Lead as Pb	mg/L	BLQ(LOQ:0.005)
7	Mercury as Hg	mg/L	BLQ(LOQ:0.005)
8	Selenium as Se	mg/L	BLQ(LOQ:0.005)
9	Zinc as Zn	mg/L	0.013
10	Hexavalent Chromium as Cr^{6+}	mg/L	BLQ(LOQ:0.03)

17. DETAILS OF RESULTS AND DISCUSSIONS SEA WATER

SEA WATER SAMPLE – PUMP HOUSE – SEDIMENTATION TANK

LOCATION – PUMP HOUSE – SEDIMENTATION TANK			
S.NO	**POLLUTANT**	**UNIT**	**RESULT**
1	Arsenic as As	mg/L	BLQ(LOQ:0.005)
2	Cadmium as Cd	mg/L	BLQ(LOQ:0.005)
3	Copper as Cu	mg/L	BLQ(LOQ:0.005)
4	Chromium as Cr	mg/L	BLQ(LOQ:0.005)
5	Nickel as Ni	mg/L	BLQ(LOQ:0.005)
6	Lead as Pb	mg/L	BLQ(LOQ:0.005)
7	Mercury as Hg	mg/L	BLQ(LOQ:0.005)
8	Selenium as Se	mg/L	BLQ(LOQ:0.005)
9	Zinc as Zn	mg/L	BLQ(LOQ:0.005)
10	Hexavalent Chromium as Cr^{6+}	mg/L	BLQ(LOQ:0.03)

SEA WATER SAMPLE – INTAKE SEA WATER

LOCATION – INTAKE SEA WATER			
S.NO	**POLLUTANT**	**UNIT**	**RESULT**
1	Arsenic as As	mg/L	BLQ(LOQ:0.005)
2	Cadmium as Cd	mg/L	BLQ(LOQ:0.005)
3	Copper as Cu	mg/L	BLQ(LOQ:0.005)
4	Chromium as Cr	mg/L	BLQ(LOQ:0.005)
5	Nickel as Ni	mg/L	BLQ(LOQ:0.005)
6	Lead as Pb	mg/L	BLQ(LOQ:0.005)
7	Mercury as Hg	mg/L	BLQ(LOQ:0.005)
8	Selenium as Se	mg/L	BLQ(LOQ:0.005)
9	Zinc as Zn	mg/L	0.014
10	Hexavalent Chromium as Cr^{6+}	mg/L	BLQ(LOQ:0.03)

SEA WATER SAMPLE – OUT TAKE SEA WATER

S.NO	POLLUTANT	UNIT	RESULT
— LOCATION – OUT TAKE SEA WATER			
1	Arsenic as As	mg/L	BLQ(LOQ:0.005)
2	Cadmium as Cd	mg/L	BLQ(LOQ:0.005)
3	Copper as Cu	mg/L	BLQ(LOQ:0.005)
4	Chromium as Cr	mg/L	BLQ(LOQ:0.005)
5	Nickel as Ni	mg/L	BLQ(LOQ:0.005)
6	Lead as Pb	mg/L	BLQ(LOQ:0.005)
7	Mercury as Hg	mg/L	BLQ(LOQ:0.005)
8	Selenium as Se	mg/L	BLQ(LOQ:0.005)
9	Zinc as Zn	mg/L	BLQ(LOQ:0.005)
10	Hexavalent Chromium as Cr^{6+}	mg/L	BLQ(LOQ:0.03)

CONCLUSION:

In Sea water sample collected three locations. The sampling locations are Pump House – Sedimentation Tank, Intake Sea Water and Out Take Sea Water.

- Zinc as Zn: Sea Water sample measurement values of Zinc are ranging from 0.014 to 0.014 mg/L. Highest value of 0.014mg/L is obtained.

- Arsenic, Cadmium, Copper, Chromium, Nickel, Lead, Mercury, Selenium and Hexavalent Chromium metals are below detection limit.

18. METHODOLOGY FOR THE MEASUREMENT OF TCLP SAMPLING AND ANALYSIS

SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

Soil samples should be collected in wide-mouth glass containers with Teflon-lined caps. From the time of sample collection until after analysis, samples must be refrigerated at 4 ± 2 degrees Celsius (ºC) for periods specified by the the EPA.

The TCLP extract will be submitted to the proper laboratory section for the required testing within one day of the extraction being completed. All TCLP extracts will be stored at 4 ± 2 ºC. Extracts or portions of extracts for metallic analyte determinations must be acidified with nitric acid to a pH <2, unless precipitation occurs. In the event of precipitation, the extract will not be acidified to pH <2.

EQUIPMENT/APPARATUS

The following are standard materials and equipment required for soil pH determination:

- Agitation Apparatus - The agitation apparatus will be capable of rotating the extraction vessels in an end over end fashion at 30 ± 2 rpm.

- *Extraction Vessels*

- Inorganic Analytes - Borosilicate glass bottles or polyethylene bottles shall be used for either organic or inorganic analytes.

- Organic Analytes - Borosilicate glass bottles shall be used for organic analytes.

- Filtration Device, a 316 stainless steel or polytetrafluoroethylene (PTFE) lined pressure filtration device (filter holder) will be used to filter all samples and extracts. This device will be capable of holding an internal pressure of 100 psi.

- Vacuum/Pressure Pump, a dedicated vacuum/pressure pump for each filtration device. The pressure pump will be used to provide 60 ± 5 psi to the filtration device for pressure filtering of all samples and extracts.

- Filters, 0.7 μm borosilicate glass. When evaluating the mobility of metals, each filter shall be acid-washed prior to use by rinsing with 1N nitric acid followed by three consecutive rinses with deionized distilled water (a minimum of 1 L per rinse). Glass fiber filters are fragile and should be handled with care.

- pH Meter, accurate to $\pm$ 0.05 units at 25°C

- Laboratory balance, accurate to within $\pm$ 0.01 grams

- Beakerlenmeyer flask, glass, 500 mL

- Watch glasses, appropriate diameter to cover beaker or Erlenmeyer flask.

- Magnetic Stirrer

- Extraction Fluid Containers, 20-Liter, glass construction for inorganic or organic analysis. Polyethylene containers may only be used for inorganic analytes.

REAGENTS

Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, all chemicals will conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society (ACS), where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

- Deionized (DI) water, prepared using an appropriate filtration purification system, capable of producing American Society of Testing and Materials (ASTM) Type II water or equivalent

- Hydrochloric acid (1N) HCl, made from ACS reagent grade

- Nitric acid (1N) HNO3, made from ACS reagent grade

- Sodium Hydroxide (1N), NaOH, made from ACS reagent grade

- Glacial acetic acid, CH3CH2OOH, ACS reagent grade

- Extraction Fluid, prepared in 1-L batches or it may be made in larger batches as required by the total number of extractions required. For larger batches, the following procedures should be scaled by the total number of required extractions.

- Extraction Fluid #1 - Add 5.7 mL of glacial CH_3CH_2OOH to 500 mL of reagent water. Add 64.3 ml of 1N NaOH, and dilute to a volume of 1L. When correctly prepared, the pH of this fluid will be 4.93 ± 0.05.

- Extraction Fluid #2 - Dilute 5.7 mL of glacial CH_3CH_2OOH with reagent water to a volume of 1 L. When correctly prepared, the pH of this fluid will be 2.88 ± 0.05.

PROCEDURES

7.1 Preliminary Evaluations

Preliminary evaluations shall be performed on a minimum 100 gram aliquot of waste. This aliquot may not actually undergo extraction. These preliminary evaluations include: (1) determination of the percent solids (2) determination of whether the waste contains insignificant solids and is, therefore, its own extract after filtration (3) determination of whether the solid portion of the waste requires particle size reduction and (4) determination of which of the two extraction fluids are to be used for the TCLP extraction of the waste.

1. *Preliminary determination of percent solids*: Percent solids is defined as that fraction of a waste sample (as a percentage of the total sample) from which no liquid may be forced out by an applied pressure, as described below.

- If the waste will obviously yield no liquid when subjected to pressure filtration (i.e., is 100% solids).
- If the sample is liquid or multi-phase, liquid/solid separation to make a preliminary determination of percent solids.
- Pre-weigh the filter and the container that will receive the filtrate.
- Assemble the filter holder and filter following the manufacturers' directions. Place the filter on the support screen and secure.
- Weigh out a sub-sample of the waste (100 gram minimum) and record the weight.
- Allow slurries to stand to permit the solid phase to settle. Wastes that settle slowly may be centrifuged prior to filtration. Centrifugation is to be used only as an aid to filtration. If used, the liquid should be decanted and filtered followed by filtration of the solid portion of the waste through the same filtration system.
- Transfer the waste sample to the filter holder (liquid and solid phases). Spread the sample evenly over the surface of the filter. If filtration of the waste at 4 oC reduces

the amount of expressed liquid over what would be expressed at room temperature, then allow the sample to warm to room temperature in the device before filtering.

▪ Gradually apply gentle pressure of 1-10 psi, until air or pressurizing gas moves through the filter. If this point is not reached under 10 psi, and if no additional liquid has passed through the filter in any 2 minute interval, slowly increase the pressure in 10 psi increments to a maximum of 50 psi. After each incremental increase of 10 psi, if the pressurizing gas has not passed through the filter, and if no additional liquid has passed through the filter in any 2 minute interval, proceed to the next 10 psi increment. When the pressurizing gas begins to move through the filter, or when liquid flow has ceased at 50 psi (i.e., filtration does not result in any additional filtrate within any 2 minute period), stop the filtration.

NOTE: Instantaneous application of high pressure can degrade the glass fiber filter and may cause premature plugging.

▪ The material in the filter holder is defined as the solid phase of the waste, and the filtrate is defined as the liquid phase.

NOTE: Some wastes, such as oily wastes and some paint wastes, will obviously contain some material that appears to be a liquid. Even after applying pressure filtration, as outlined in Section 7.1.1.7, this material may not filter. If this is the case, the material within the filtration device is defined as a solid. Do not replace the original filter with a fresh filter under any circumstances. Use only one filter.

▪ Determine the weight of the liquid phase by subtracting the weight of the filtrate container (see Section 7.1.1.3) from the total weight of the filtrate filled container. Determine the weight of the solid phase of the waste sample by subtracting the weight of the liquid phase from the total waste sample, as determined in 7.1.1.5.

Record the weight of the liquid and solid phases. Calculate the percent solids as follows:

$$\text{Percent Solids} = \frac{\text{Weight of Solid}}{\text{Total Weight of Waste}} \times 100$$

2. If the percent solids determined in Section 7.1.1.9 is equal to or greater than 0.5%, then proceed to Section 7.1.3 to determine whether the solid material requires particle size reduction. If the percent solids determined in Section 7.1.1.9 is less than 0.5% then proceed to Section 7.2.9 to perform the TCLP.

3. Determination of whether the waste requires particle size reduction - Any material which does not pass through a 9.5mm (0.375 inch) standard sieve requires size reduction. The material should be prepared for extraction by crushing, cutting or grinding the waste to a particle size as described above.

4. Determination of appropriate extraction fluid - If the solid content of the waste is greater than or equal to 0.5%, determine the extraction fluid as follows:

- Weigh out a small sub-sample of the solid phase of the waste, reduce the solid to a particle size of approximately 1mm or less, and transfer 5.0 grams of the solid phase of the waste to a 500 mL beaker or Erlenmeyer flask.

- Add 96.5 mL of reagent water to the beaker, cover with a watch glass, and stir vigorously for 5 minutes using a magnetic stirrer. Measure and record the pH. If the pH is <5.0, use extraction fluid #1.

- If the pH is >5.0, add 3.5 mL 1N HCl, slurry briefly, cover with a watch glass, heat to 50 °C, and hold at 50 °C for 10 minutes.

- Let the solution cool to room temperature and record the pH. If the pH is <5.0, use extraction fluid #1. If the pH is >5.0, use extraction fluid #2.

Procedure When Volatiles are Not Involved

A minimum sample size of 100 grams (solid and liquid phases) is recommended. In some cases, a larger sample may be appropriate, depending on the solids content of the waste

sample (percent solids) whether the initial liquid phase of the waste will be miscible with the aqueous extract of the solid, and whether inorganics, semi-volatile organics, pesticides, and herbicides are all analytes of concern. Enough solids should be generated for extraction such that the volume of TCLP extract will be sufficient to support all of the analyses required. If the amount of extract generated by a single TCLP will not be sufficient to perform all of the analyses, more than one extraction may be performed and the extracts from each combined and aliquoted for analysis.

Transfer the waste sample to the filter holder (liquid and solid phases). Spread the sample evenly over the surface of the filter. If filtration of the waste at 4 °C reduces the amount of expressed liquid over what would be expressed at room temperature, then allow the sample to warm to room temperature in the device before filtering.

Gradually apply gentle pressure of 1-10 psi, until air or pressurizing gas moves through the filter. If this point is not reached under 10 psi, and if no additional liquid has passed through the filter in any 2 minute interval, slowly increase the pressure in 10 psi increments to a maximum of 50 psi. After each incremental increase of 10 psi, if the pressurizing gas has not passed through the filter, and if no additional liquid has passed through the filter in any 2 minute interval, proceed to the next 10 psi increment. When the pressurizing gas begins to move through the filter, or when liquid flow has ceased at 50 psi (i.e., filtration does not result in any additional filtrate within any 2 minute period), stop the filtration.

Prepare the solid portion of the waste for extraction by crushing, cutting, or grinding the waste to a particle size as described. When the particle size has been appropriately altered, transfer the solid material into an extractor bottle. Include the filter used to separate the initial liquid from the solid phase.

Determine the amount of extraction fluid to add to the extractor vessel as follows:

$$\text{Weight of Extraction Fluid} = \frac{20 \times \% \text{ Solids} \times \text{Weight of Waste Filtered}}{100}$$

Slowly add this amount of appropriate extraction fluid to the extractor vessel. Apply Teflon tape to the threads of the bottle, and close tightly. Secure in the rotary agitation device, and rotate at 30 ± 2 rpm for 18 ± 2 hours. Ambient temperature of the room shall be maintained at 23 ± 2 °C during the extraction period.

19. DETAILS OF RESULTS AND DISCUSSIONS TCLP
COAL – UPCL COAL YARD

S.NO	POLLUTANT	UNIT	RESULT
LOCATION – UPCL COAL YARD			
1	Arsenic as As	mg/L	BLQ(LOQ:0.1)
2	Barium as Ba	mg/L	3.92
3	Cadmium as Cd	mg/L	BLQ(LOQ:0.1)
4	Chromium as Cr	mg/L	BLQ(LOQ:0.1)
5	Mercury as Hg	mg/L	BLQ(LOQ:0.1)
6	Copper as Cu	mg/L	BLQ(LOQ:0.1)
7	Cobalt as Co	mg/L	0.18
8	Lead as Pb	mg/L	BLQ(LOQ:0.1)
9	Nickel as Ni	mg/L	0.2
10	Zinc as Zn	mg/L	0.21
11	Manganese as Mn	mg/L	11.92
12	Iron as Fe	mg/L	41.2
13	Fluoride as F	mg/L	27.97

COAL – UPCL BOTTOM ASH BIN

LOCATION – UPCL BOTTOM ASH BIN			
S.NO	**POLLUTANT**	**UNIT**	**RESULT**
1	Arsenic as As	mg/L	3.15
2	Barium as Ba	mg/L	6.37
3	Cadmium as Cd	mg/L	BLQ(LOQ:0.1)
4	Chromium as Cr	mg/L	0.37
5	Mercury as Hg	mg/L	BLQ(LOQ:0.1)
6	Copper as Cu	mg/L	1.48
7	Cobalt as Co	mg/L	0.64
8	Lead as Pb	mg/L	BLQ(LOQ:0.1)
9	Nickel as Ni	mg/L	2.12
10	Zinc as Zn	mg/L	51.60
11	Manganese as Mn	mg/L	26.13
12	Iron as Fe	mg/L	39.79
13	Fluoride as F	mg/L	10.31

FLY ASH – UPCL FLY ASH

S.NO	POLLUTANT	UNIT	RESULT
	LOCATION – UPCL FLY ASH		
1	Arsenic as As	mg/L	6.77
2	Barium as Ba	mg/L	1.57
3	Cadmium as Cd	mg/L	BLQ(LOQ:0.1)
4	Chromium as Cr	mg/L	0.44
5	Mercury as Hg	mg/L	BLQ(LOQ:0.1)
6	Copper as Cu	mg/L	2.96
7	Cobalt as Co	mg/L	1.18
8	Lead as Pb	mg/L	BLQ(LOQ:0.1)
9	Nickel as Ni	mg/L	1.85
10	Zinc as Zn	mg/L	1.52
11	Manganese as Mn	mg/L	18.73
12	Iron as Fe	mg/L	1.78
13	Fluoride as F	mg/L	9.40

FLY ASH – UPCL POND ASH

S.NO	POLLUTANT	UNIT	RESULT
— LOCATION – UPCL POND ASH			
1	Arsenic as As	mg/L	7.29
2	Barium as Ba	mg/L	6.41
3	Cadmium as Cd	mg/L	BLQ(LOQ:0.1)
4	Chromium as Cr	mg/L	3.04
5	Mercury as Hg	mg/L	BLQ(LOQ:0.1)
6	Copper as Cu	mg/L	0.12
7	Cobalt as Co	mg/L	1.24
8	Lead as Pb	mg/L	BLQ(LOQ:0.1)
9	Nickel as Ni	mg/L	14.35
10	Zinc as Zn	mg/L	1.47
11	Manganese as Mn	mg/L	17.25
12	Iron as Fe	mg/L	0.81
13	Fluoride as F	mg/L	0.70

CONCLUSION:

In TCLP sample collected four locations. The sampling locations are UPCL Coal Yard, UPCL Bottom Ash Bin, UPCL Fly Ash, UPCL Pond Ash.

- Arsenic as As: Coal and Ash sample measurement values of Arsenic are ranging from 3.51 to 7.29 mg/L. Highest value of 7.29mg/L is obtained. While the Permissible limit is 5.0 mg/L (TCLP standard). **UPCL Fly Ash and UPCL Pond Ash Coal and Ash location sample exceeding the limit** and rests of the location sample within the limit.

- Barium as Ba: Coal and Ash sample measurement values of Barium are ranging from 1.57 to 6.41 mg/L. Highest value of 6.41mg/L is obtained. While the Permissible limit is 100 mg/L (TCLP standard). All location samples within the limit.

- Chromium as Cr: Coal and Ash sample measurement values of Chromium are ranging from 0.37 to 3.04 mg/L. Highest value of 3.04mg/L is obtained. While the Permissible limit is 5.0 mg/L (TCLP standard). All location samples within the limit.

- Copper as Cu: Coal and Ash sample measurement values of Copper are ranging from 0.12 to 2.96 mg/L. Highest value of 2.96mg/L is obtained.

- Cobalt as Co: Coal and Ash sample measurement values of Cobalt are ranging from 0.18 to 1.24 mg/L. Highest value of 1.24mg/L is obtained.

- Nickel as Ni: Coal and Ash sample measurement values of Nickel are ranging from 0.2 to 14.35 mg/L. Highest value of 1.24mg/L is obtained.

- Zinc as Zn: Coal and Ash sample measurement values of Zinc are ranging from 0.21 to 51.6 mg/L. Highest value of 51.6mg/L is obtained.

- Manganese as Mn: Coal and Ash sample measurement values of Manganese are ranging from 11.92 to 26.13 mg/L. Highest value of 26.13mg/L is obtained.

- Iron as Fe: Coal and Ash sample measurement values of Iron are ranging from 0.81 to 41.2 mg/L. Highest value of 41.2mg/L is obtained.

- Fluoride as F: Coal and Ash sample measurement values of Fluoride are ranging from 0.7 to 27.97 mg/L. Highest value of 27.97mg/L is obtained.

- Cadmium, Lead and Mercury metals are below detection limit. All Coal and Ash location samples within the limit. As per TCLP limit Cd – 1.0 mg/L,Pb-5.0mg/L,Hg-0.2mg/L.

The levels of heavy metals in the TCLP were highest for Zn and Fe followed by F, Mn and Ni. In the TCLP samples, the Zn content ranged from 0.21 to 51 mg/L, Fe ranged from 0.81 to 41.2, F ranged from 0.7 to 27.97 mg/L, Mn ranged from 11.92 to 26.13 mg/L, Ni ranged from 0.2 to 14.35 mg/L. Following heavy metals in the TCLP were lowest for As followed by Ba, Cr, Cu and Co. In the soil samples, the As content ranged from 3.15 to 7.29 mg/L, Ba ranged from 1.57 to 6.41 mg/L, Cr ranged from 0.37 to 3.04 mg/L, Cu ranged from 0.12 to 2.96 mg/L and Co ranged from 0.18 to 1.24 mg/L.

20. DISPERSION MODELLING OF STACKS EMISSIONS:

Dispersion models are deterministic models, based upon physical theories, that use source emission data, meteorology, and topography to create maps of pollutant concentrations. Such maps can be used to predict source-specific exposures.

The basic Gaussian plume-diffusion model is steady-state and hypothesizes that all meteorological, orographic and surface parameters are uniform and constant throughout the air layer into which the pollutants are discharged. The pollutants are released at a height above the ground that is given by the physical stack height and the rise of the plume due to its momentum and buoyancy.

The degree of dilution is inversely proportional to the wind speed and pollutant material reaching the ground level is reflected back into the atmosphere. The pollutant field is conservative; thus, it does not undergo any chemical reactions, transformation or decay.

AERMOD is a steady-state plume dispersion model for the assessment of pollutant concentrations from point, volume, and area sources. The model employs hourly sequential preprocessed meteorological data to estimate concentrations by averaging times from one hour to one year.

Sources may be located in rural or urban areas, and receptors may be located in simple or complex terrain. Complex terrain is defined as terrain in which ground elevations are above the stack tip or release height and the complex terrain capabilities of AERMOD are of particular interest. It employs continuous variables to characterize atmospheric conditions, rather than a fixed number of categories used by traditional Gaussian models.

The AERMOD modeling system consists of two preprocessors and a core dispersion model. AERMET is the meteorological preprocessor for the AERMOD while AERMAP is the terrain preprocessor that characterizes the terrain, generates receptor grids, and facilitates the generation of hill height scales. Input data can come from hourly cloud cover observations, surface meteorological observations, and upper air soundings and may include surface meteorological observations and parameters and vertical profiles of several atmospheric parameters.

The model is very sensitive to land use parameters and complex coastal terrains. AERMOD is recommended by the EPA as the preferred dispersion model for general industrial modelling scenarios. Its performance was evaluated against observed concentrations for impacts emitted from EMPRI Monitoring, Bangalore. For our simulations, the required source data input includes source type, emission rate, location, stack height, stack gas exit velocity, stack inside diameter, stack gas temperature and elevation.

The AERMOD model was applied to study the diffusion of pollutants from EMPRI Monitoring, Bangalore and other sources in three days from 08.02.2021 to 31.03.2021. Among the discrete receptors, we included the locations of air quality monitoring stations around the plant area to compare model output and measured values. This enables to compare the maximum values provided by the model with the maximum measurements of monitoring stations. These simulations could allow understanding cause-effect ratio related to plant sources of their pollutants.

Dispersion of pollutants is not only terrain morphology but also its dynamic and thermal effects on the atmospheric flow. The vertical structure of the atmospheric boundary layer (ABL), and therefore the vertical profiles of meteorological variables, are mainly determined by the surface turbulent fluxes of momentum, heat and moisture.

Wind: The speed and direction of the wind is governed by three forces; the **pressure** gradient force (PGF), the Coriolis Force and **friction**. In general, **wind** speed increases with height as you go up in the atmosphere. This is because friction from the ground slows down the air at the surface. The **wind** often **changes** in **direction** as height increases as well.

Coriolis Force	**Balance of Forces During Wind Movement**
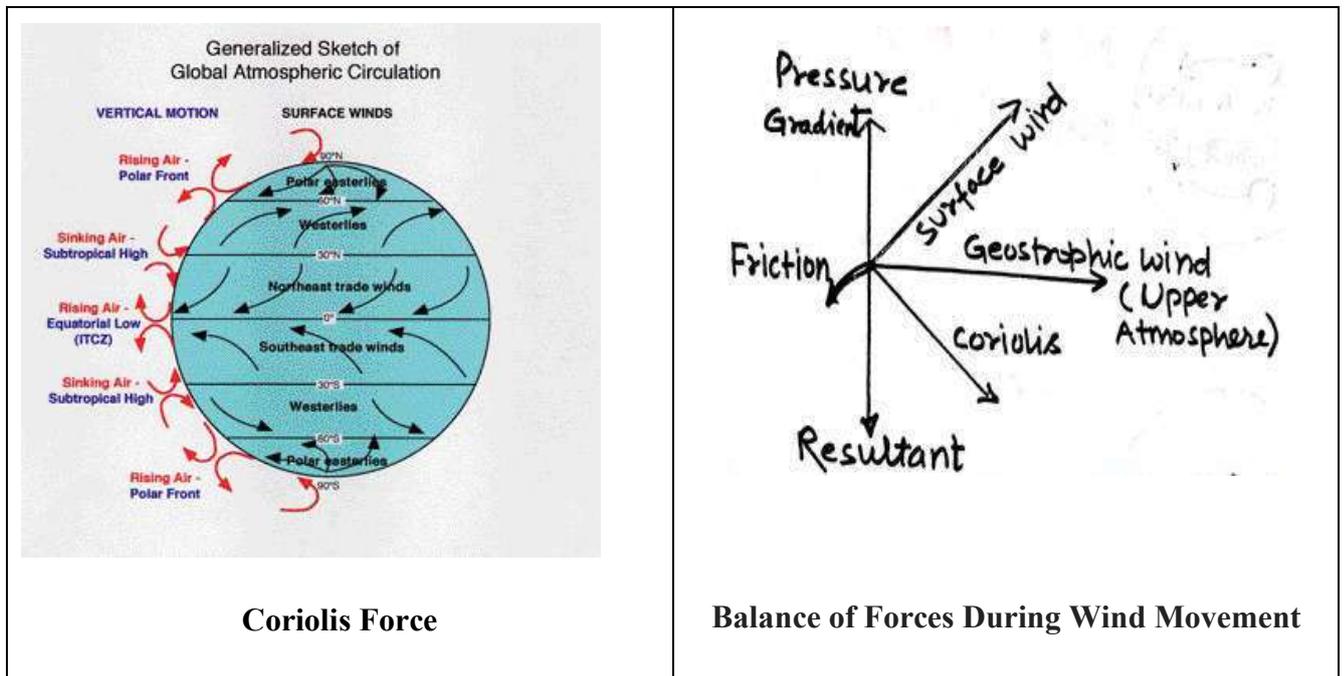
 Pressure Gradient Force

Pressure Gradient Force is created due to the difference in the atmospheric pressure, and it is directed from the high pressure to the low pressure. PGF is the primary cause behind the wind.

STACK EMISSIONS AND DISPERSION MODELLING USING AERMOD 5.2

Thermal Boiler Unit-1

Particulate matter:

Stack Height, m	-	275
Exit Velocity, m/Sec	-	6.5
PM Concentration, mg/m3	-	25.9
Emission load, gm/Sec	-	4.51433
Plume rise, m	-	3

Sulphur dioxide as SO2:

Stack Height, m	-	275
Exit Velocity, m/Sec	-	6.5
SO_2 Concentration, mg/m3	-	679
Emission load, gm/Sec	-	118.348
Plume rise, m	-	3

Oxides of Nitrogen as NO2:

Stack Height, m	-	275
Exit Velocity, m/Sec	-	6.5
NOx Concentration, mg/m3	-	267
Emission load, gm/Sec	-	46.53
Plume rise, m	-	3

Carbon Monoxide as CO:

Stack Height, m	-	275
Exit Velocity, m/Sec	-	6.5
CO Concentration, mg/m3	-	75
Emission load, gm/Sec	-	13.072
Plume rise, m	-	3

Thermal Boiler Unit-II

Particulate matter:

Stack Height, m	-	275
Exit Velocity, m/Sec	-	6.5
PM Concentration, mg/m3	-	25.9
Emission load, gm/Sec	-	4.51433
Plume rise, m	-	3

Sulphur dioxide as SO2:

Stack Height, m	-	275
Exit Velocity, m/Sec	-	6.5
SO_2 Concentration, mg/m3	-	679
Emission load, gm/Sec	-	118.348
Plume rise, m	-	3

Oxides of Nitrogen as NO2:

Stack Height, m	-	275
Exit Velocity, m/Sec	-	6.5

NOx Concentration, mg/m3   -   267

Emission load, gm/Sec   -   46.53

Plume rise, m   -   3

Carbon Monoxide as CO:

Stack Height, m   -   275

Exit Velocity, m/Sec   -   6.5

CO Concentration, mg/m3   -   75

Emission load, gm/Sec   -   13.072

Plume rise, m   -   3

STACK EMISSION DISPERSION MODELLING – UPCL Thermal Boiler Unit-1 @ 2 & 5KM – Particulate matter

Concentration at Source (Milligm/m^3)	Distance Travelled to reach GLC (km)	Maximum GLC (Microgm/m^3)	Average Concentration at 2 km (Microgm/m^3)	Average Concentration at 5 km (Microgm/m^3)
25.9	0.8	5.64	0.76	0.00878

UPCL Thermal boiler unit-1 emission of Particulate matter concentration is 25.9mg/m3 and dispersed at the effective stack height of 275m (Stack height 275m + Plume Height 3.0m) with exit velocity of 6.5m/sec and the flue gas temperature are 25ºC. All the modelling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.8km at the concentration of 5.64µg/m3 at 2km dispersion Particulate matter is 0.76µg/m3 and at 5km dispersion Particulate matter is 0.00878µg/m3 and the predominant wind direction is WNW.

STACK EMISSION DISPERSION MODELLING – UPCL Thermal Boiler Unit-1 @ 2 & 5KM – Sulphur Dioxide

Concentration at Source (Milligm/m^3)	Distance Travelled to reach GLC (km)	Maximum GLC (Microgm/m^3)	Average Concentration at 2 km (Microgm/m^3)	Average Concentration at 5 km (Microgm/m^3)
679	0.83	149	2.34	0.289

EMPRI Thermal boiler unit-1 emission of Sulphur Dioxide concentration is 679mg/m3 and dispersed at the effective stack height of 275m (Stack height 275m + Plume Height 3.0m) with exit velocity of 6.5m/sec and the flue gas temperature are 25°C. All the modelling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.83km at the concentration of 149µg/m3 at 2km dispersion Sulphur Dioxide is 2.34µg/m3 and at 5km dispersion Sulphur Dioxide is 0.289µg/m3 and the predominant wind direction is WNW.
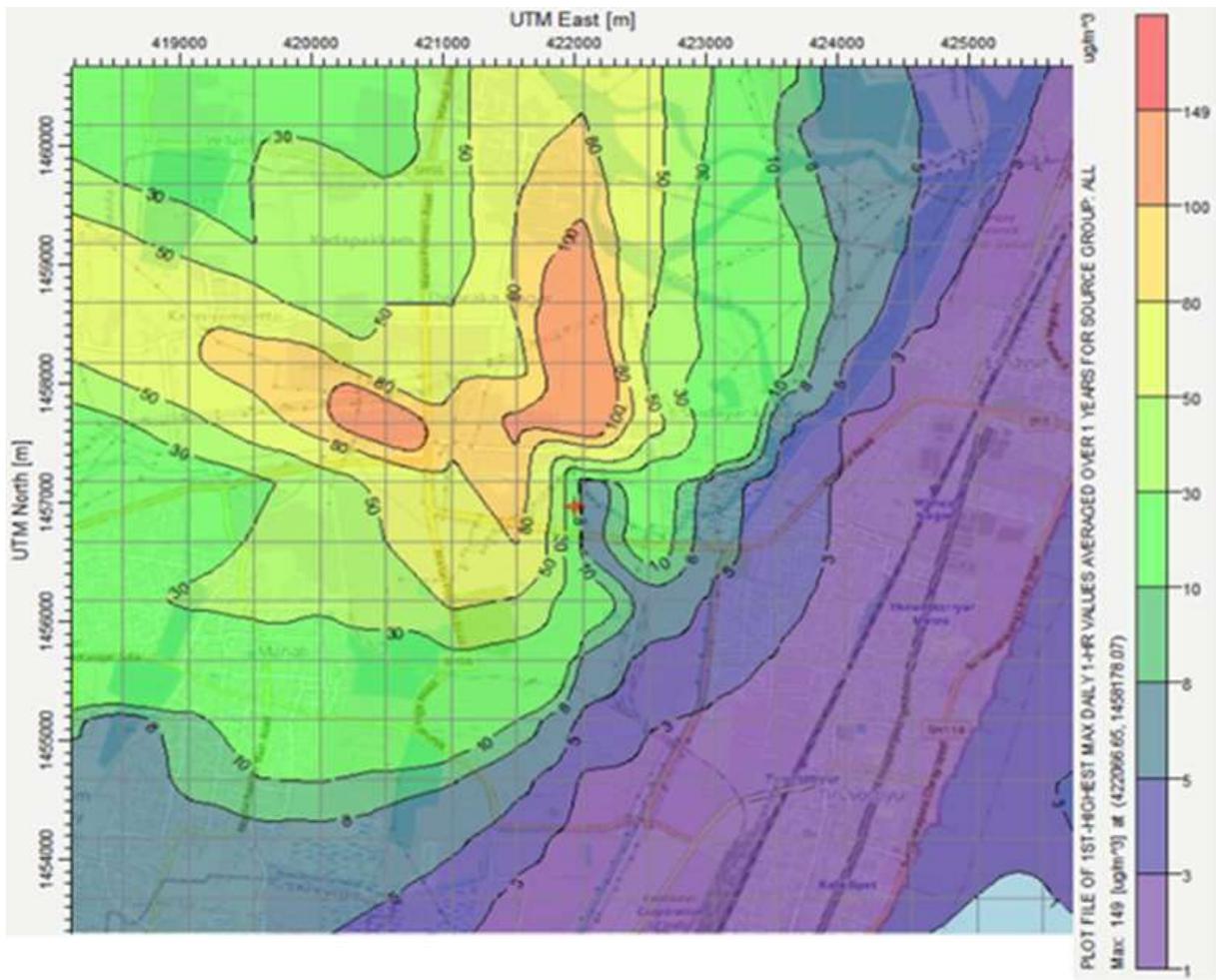
STACK EMISSION DISPERSION MODELLING – UPCL Thermal Boiler Unit-1 @ 2 & 5KM – Nitrogen Dioxide

Concentration at Source (Milligm/m^3)	Distance Travelled to reach GLC (km)	Maximum GLC (Microgm/m^3)	Average Concentration at 2 km (Microgm/m^3)	Average Concentration at 5 km (Microgm/m^3)
267	0.81	58.1	0.89	0.0989

EMPRI Thermal boiler unit-1 emission of Nitrogen Dioxide concentration is 267mg/m3 and dispersed at the effective stack height of 275m (Stack height 275m + Plume Height 3.0m) with exit velocity of 6.5m/sec and the flue gas temperature are 25°C. All the modelling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.81km at the concentration of 58.1μg/m3 at 2km dispersion Nitrogen Dioxide is 0.89μg/m3 and at 5km dispersion Nitrogen Dioxide is 0.0989μg/m3 and the predominant wind direction is WNW.
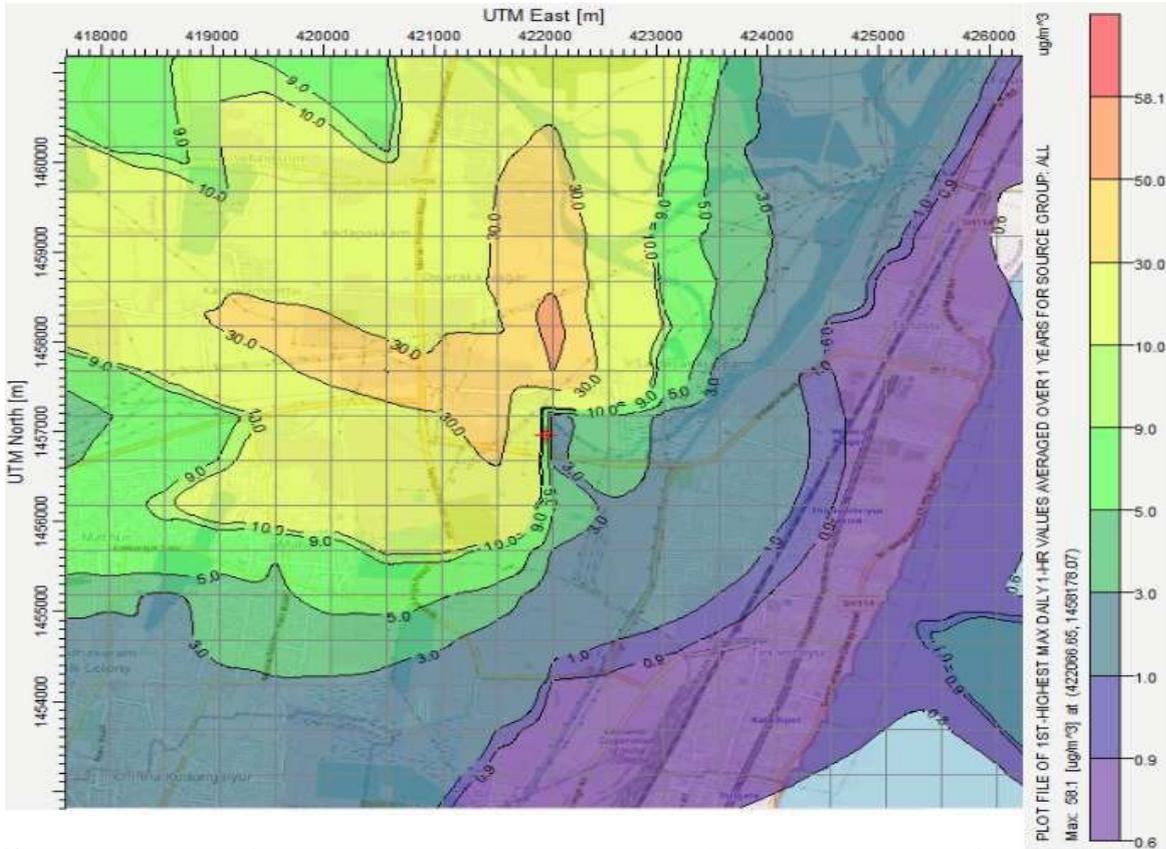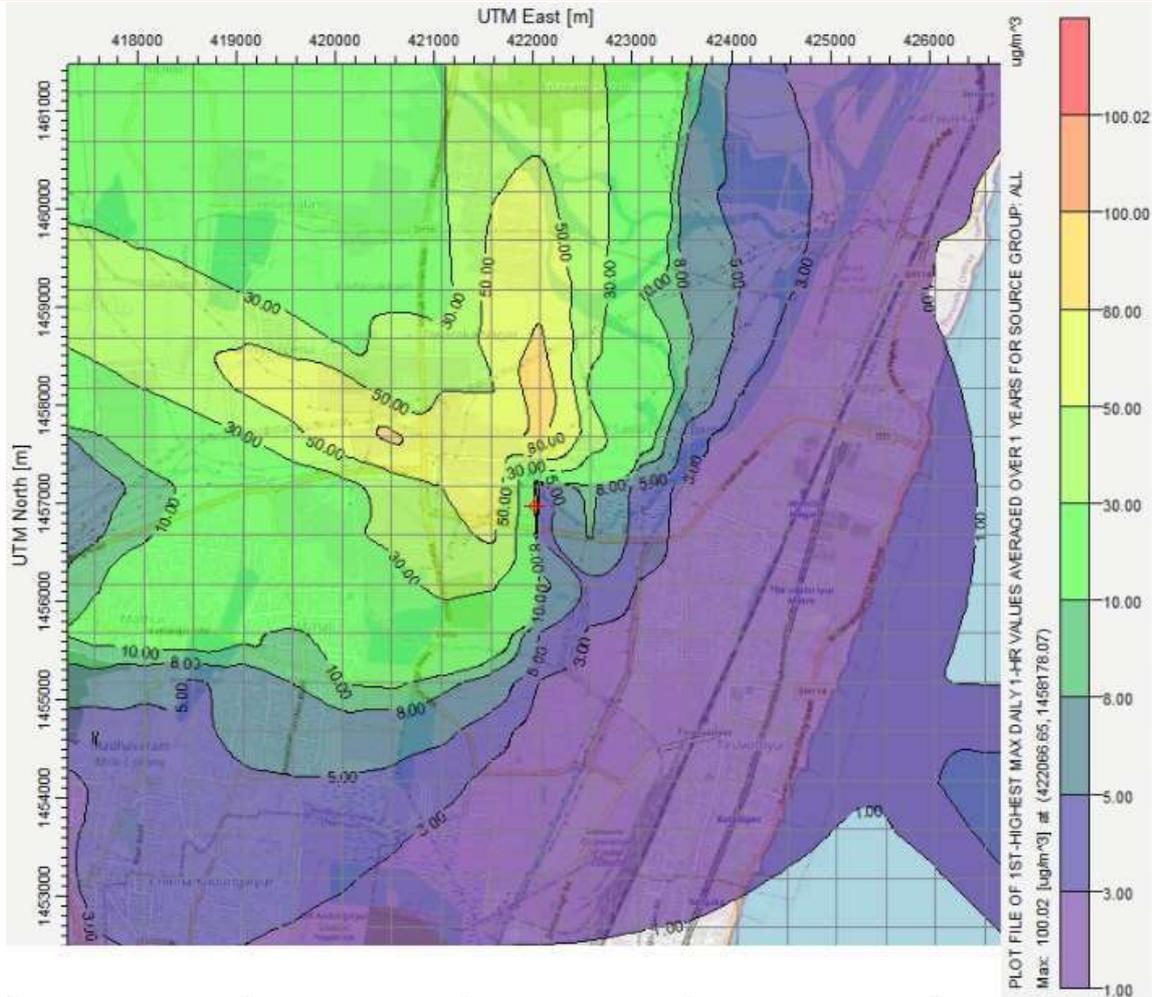
STACK EMISSION DISPERSION MODELLING – UPCL Thermal Boiler Unit-1 @ 2 & 5KM – Carbon monoxide

Concentration at Source (Milligm/m^3)	Distance Travelled to reach GLC (km)	Maximum GLC (Microgm/m^3)	Average Concentration at 2 km (Microgm/m^3)	Average Concentration at 5 km (Microgm/m^3)
75	0.77	100.02	1.21	0.123

EMPRI Thermal boiler unit-1 emission of Carbon monoxide concentration is 75mg/m3 and dispersed at the effective stack height of 275m (Stack height 275m + Plume Height 3.0m) with exit velocity of 6.5m/sec and the flue gas temperature are 25ºC. All the modelling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.77km at the concentration of 100.02µg/m3 at 2km dispersion Carbon monoxide is 1.21µg/m3 and at 5km dispersion Carbon monoxide is 0.123µg/m3 and the predominant wind direction is WNW.

STACK EMISSION DISPERSION MODELLING – UPCL Thermal Boiler Unit-II @ 2 & 5KM – Particulate matter

Concentration at Source (Milligm/m^3)	Distance Travelled to reach GLC (km)	Maximum GLC (Microgm/m^3)	Average Concentration at 2 km (Microgm/m^3)	Average Concentration at 5 km (Microgm/m^3)
30	0.86	8.1	2.21	0.24

EMPRI Thermal boiler unit-II emission of Particulate matter concentration is 30mg/m3 and dispersed at the effective stack height of 275m (Stack height 275m + Plume Height 3.0m) with exit velocity of 6.8m/sec and the flue gas temperature are 25°C. All the modelling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.86km at the concentration of 8.1μg/m3 at 2km dispersion Particulate matter is 2.21μg/m3 and at 5km dispersion Particulate matter is 0.24μg/m3 and the predominant wind direction is WNW.
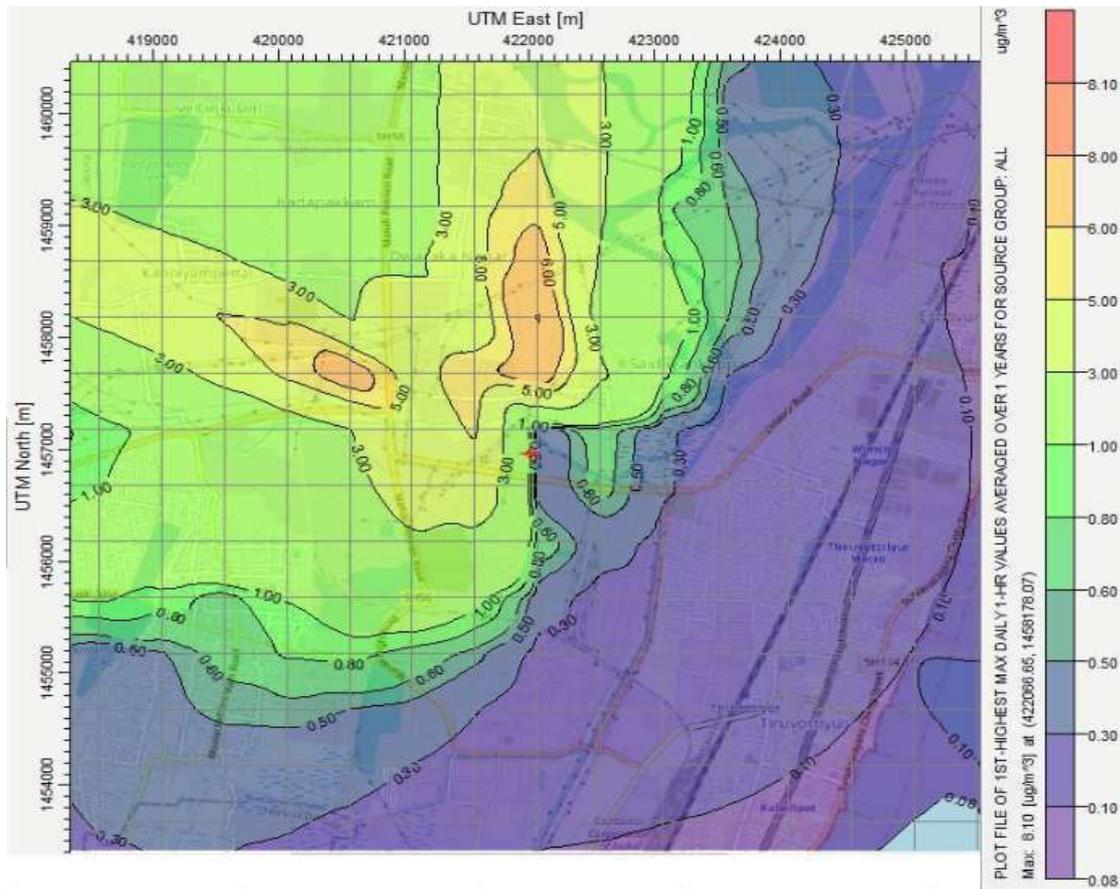
STACK EMISSION DISPERSION MODELLING – UPCL Thermal Boiler Unit-II @ 2 & 5KM – Sulphur Dioxide

Concentration at Source (Milligm/m^3)	Distance Travelled to reach GLC (km)	Maximum GLC (Microgm/m^3)	Average Concentration at 2 km (Microgm/m^3)	Average Concentration at 5 km (Microgm/m^3)
779	0.81	210	12.11	0.897

EMPRI Thermal boiler unit-1 emission of Sulphur Dioxide concentration is 779mg/m3 and dispersed at the effective stack height of 275m (Stack height 275m + Plume Height 3.0m) with exit velocity of 6.8m/sec and the flue gas temperature are 25°C. All the modelling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.81km at the concentration of 210μg/m3 at 2km dispersion Sulphur Dioxide is 12.11μg/m3 and at 5km dispersion Sulphur Dioxide is 0.897μg/m3 and the predominant wind direction is WNW.
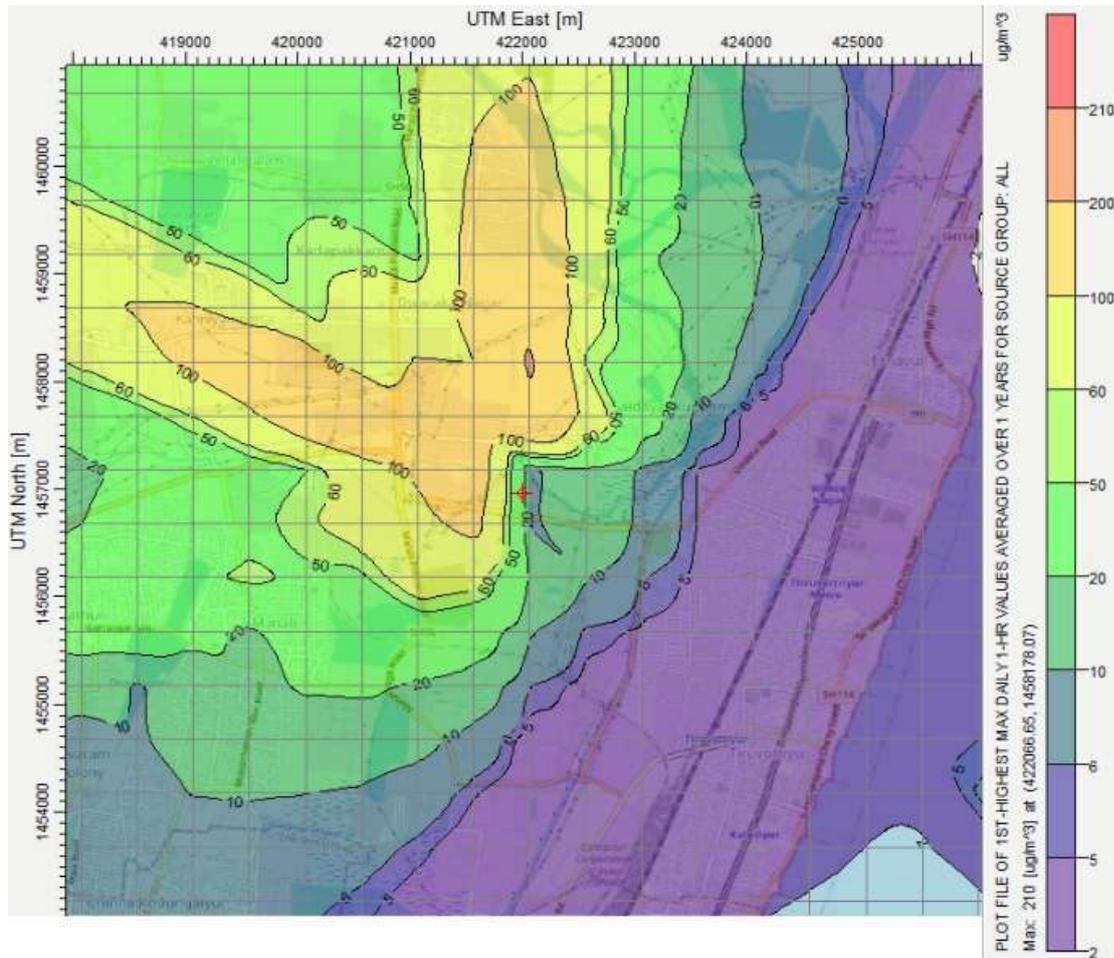
STACK EMISSION DISPERSION MODELLING –UPCL Thermal Boiler Unit-II @ 2 & 5KM – Nitrogen Dioxide

Concentration at Source (Milligm/m^3)	Distance Travelled to reach GLC (km)	Maximum GLC (Microgm/m^3)	Average Concentration at 2 km (Microgm/m^3)	Average Concentration at 5 km (Microgm/m^3)
341	0.76	91.8	14.11	6.76

EMPRI Thermal boiler unit-II emission of Nitrogen Dioxide concentration is 341mg/m3 and dispersed at the effective stack height of 275m (Stack height 275m + Plume Height 3.0m) with exit velocity of 6.8m/sec and the flue gas temperature are 25°C. All the modelling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.76km at the concentration of 91.8µg/m3 at 2km dispersion Nitrogen Dioxide is 14.11µg/m3 and at 5km dispersion Nitrogen Dioxide is 6.76µg/m3 and the predominant wind direction is WNW.
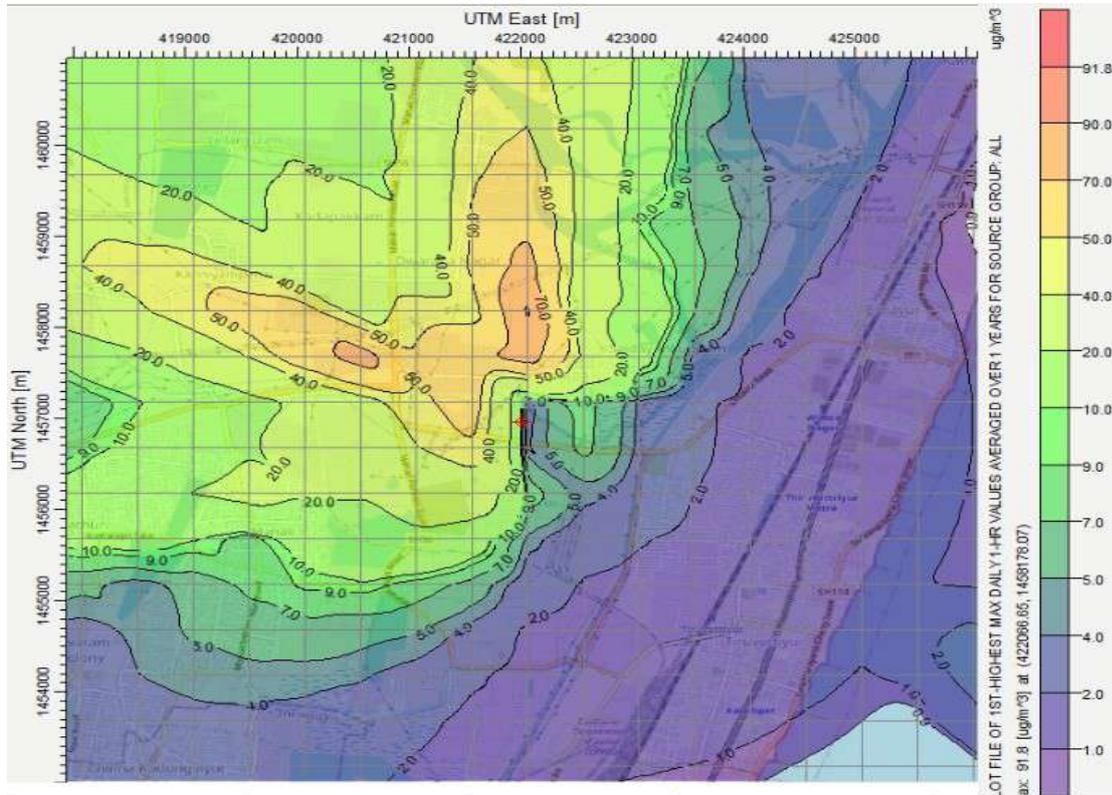
STACK EMISSION DISPERSION MODELLING –UPCL Thermal Boiler Unit-II @ 2 & 5KM – Carbon monoxide

Concentration at Source (Milligm/m^3)	Distance Travelled to reach GLC (km)	Maximum GLC (Microgm/m^3)	Average Concentration at 2 km (Microgm/m^3)	Average Concentration at 5 km (Microgm/m^3)
70	0.84	18.8	0.38	0.0871

EMPRI Thermal boiler unit-1 emission of Carbon monoxide concentration is 70mg/m3 and dispersed at the effective stack height of 275m (Stack height 275m + Plume Height 3.0m) with exit velocity of 6.8m/sec and the flue gas temperature are 25°C. All the modelling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.84km at the concentration of 18.8μg/m3 at 2km dispersion Carbon monoxide is 0.38μg/m3 and at 5km dispersion Carbon monoxide is 0.0871μg/m3 and the predominant wind direction is WNW.

CONCLUSION

AAQ DAY -1

In Ambient Air Quality monitoring seven sampling locations were identified to assess the GLC of point source emission of Gaseous and Particulate matter. The sampling locations are Top of the fire station, Mudurangadi village, UPCL Sea Water Pump House (Thenka-Yermal Village), Hejamady Village, Inna- Village and Nandikoor Village.

- *Sulphur Dioxide as SO$_2$:* Ambient Air Quality measurement values of SO$_2$ are ranging from 6.7 to 12.4µg/m^3. Highest value of 12.4µg/m^3 is obtained and however the values are within the NAAQM standards.

- *Nitrogen Dioxide as NO$_2$:* Ambient Air Quality values of NO$_2$ are ranging from 11.7 to 15.5µg/m^3. Highest value of 15.5µg/m^3 is obtained and however the values are within the NAAQM standards.

- *Particulate Matter (PM$_{10}$):* Ambient Air Quality values of PM$_{10}$ are ranging from 45.5 to 56.6µg/m^3. Highest value of 56.6µg/m^3 is obtained and however the values are within the NAAQM standards.

- *Particulate Matter (PM$_{2.5}$):* Ambient Air Quality values of PM$_{2.5}$ are ranging from 16.4 to 24.2µg/m^3. Highest value of 26.4µg/m^3 is obtained and however the values are within the NAAQM standards.

AAQ DAY-2

In Ambient Air Quality monitoring seven sampling locations were identified to assess the GLC of point source emission of Gaseous and Particulate matter. The sampling locations are Top of the fire station, Mudurangadi village, UPCL Sea Water Pump House (Thenka-Yermal Village), Hejamady Village, Inna- Village and Nandikoor Village.

- *Sulphur Dioxide as SO$_2$:* Ambient Air Quality measurement values of SO$_2$ are ranging from 7.3 to 13.2µg/m^3. Highest value of 13.2µg/m^3 is obtained and however the values are within the NAAQM standards.

- *Nitrogen Dioxide as NO$_2$:* Ambient Air Quality values of NO$_2$ are ranging from 9.5 to 14.2µg/m^3. Highest value of 14.2µg/m^3 is obtained and however the values are within the NAAQM standards.

- *Particulate Matter (PM₁₀):* Ambient Air Quality values of PM_{10} are ranging from 49.4 to 58.8μg/m³. Highest value of 58.8μg/m³ is obtained and however the values are within the NAAQM standards.

- *Particulate Matter (PM₂.₅):* Ambient Air Quality values of $PM_{2.5}$ are ranging from 18.9 to 26.4μg/m³. Highest value of 26.4μg/m³ is obtained and however the values are within the NAAQM standards.

STACK

In Stack Emission monitoring at thermal boiler both the stacks are not complying for Sulphur Dioxide Concentration of 886mg/Nm³ & 1192mg/Nm³ against the CPCB Emission Limit value of 600mg/Nm³ and rest all the parameters are complying with the CEPCB ELV.

STACK THERMAL BOILER UNIT-I

UPCL Thermal boiler unit-1 emission of Particulate matter concentration is 25.9mg/m3 and dispersed at the effective stack height of 275m (Stack height 275m + Plume Height 3.0m) with exit velocity of 6.5m/sec and the flue gas temperature are 25ºC. All the modelling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.8km at the concentration of 5.64μg/m3 at 2km dispersion Particulate matter is 0.76μg/m3 and at 5km dispersion Particulate matter is 0.00878μg/m3 and the predominant wind direction is WNW.

UPCL Thermal boiler unit-1 emission of Sulphur Dioxide concentration is 679mg/m3 and dispersed at the effective stack height of 275m (Stack height 275m + Plume Height 3.0m) with exit velocity of 6.5m/sec and the flue gas temperature are 25ºC. All the modelling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.83km at the concentration of 149μg/m3 at 2km dispersion Sulphur Dioxide is 2.34μg/m3 and at 5km dispersion Sulphur Dioxide is 0.289μg/m3 and the predominant wind direction is WNW.

UPCL Thermal boiler unit-1 emission of Nitrogen Dioxide concentration is 267mg/m3 and dispersed at the effective stack height of 275m (Stack height 275m + Plume Height 3.0m)

with exit velocity of 6.5m/sec and the flue gas temperature are 25ºC. All the modelling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.81km at the concentration of 58.1µg/m3 at 2km dispersion Nitrogen Dioxide is 0.89µg/m3 and at 5km dispersion Nitrogen Dioxide is 0.0989µg/m3 and the predominant wind direction is WNW.

UPCL Thermal boiler unit-1 emission of Carbon monoxide concentration is 75mg/m3 and dispersed at the effective stack height of 275m (Stack height 275m + Plume Height 3.0m) with exit velocity of 6.5m/sec and the flue gas temperature are 25ºC. All the modelling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.77km at the concentration of 100.02µg/m3 at 2km dispersion Carbon monoxide is 1.21µg/m3 and at 5km dispersion Carbon monoxide is 0.123µg/m3 and the predominant wind direction is WNW.

THERMAL BOILER UNIT –II

UPCL Thermal boiler unit-II emission of Particulate matter concentration is 30mg/m3 and dispersed at the effective stack height of 275m (Stack height 275m + Plume Height 3.0m) with exit velocity of 6.8m/sec and the flue gas temperature are 25ºC. All the modelling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.86km at the concentration of 8.1µg/m3 at 2km dispersion Particulate matter is 2.21µg/m3 and at 5km dispersion Particulate matter is 0.24µg/m3 and the predominant wind direction is WNW.

UPCL Thermal boiler unit-1 emission of Sulphur Dioxide concentration is 779mg/m3 and dispersed at the effective stack height of 275m (Stack height 275m + Plume Height 3.0m) with exit velocity of 6.8m/sec and the flue gas temperature are 25ºC. All the modelling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.81km at the concentration of 210µg/m3 at 2km dispersion Sulphur Dioxide is 12.11µg/m3 and at 5km dispersion Sulphur Dioxide is 0.897µg/m3 and the predominant wind direction is WNW.

UPCL Thermal boiler unit-II emission of Nitrogen Dioxide concentration is 341mg/m3 and dispersed at the effective stack height of 275m (Stack height 275m + Plume Height 3.0m) with exit velocity of 6.8m/sec and the flue gas temperature are 25ºC. All the modelling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.76km at the concentration of 91.8µg/m3 at 2km dispersion Nitrogen Dioxide is 14.11µg/m3 and at 5km dispersion Nitrogen Dioxide is 6.76µg/m3 and the predominant wind direction is WNW.

UPCLThermal boiler unit-1 emission of Carbon monoxide concentration is 70mg/m3 and dispersed at the effective stack height of 275m (Stack height 275m + Plume Height 3.0m) with exit velocity of 6.8m/sec and the flue gas temperature are 25ºC. All the modelling parameters are considered like location, base elevation, stack height, stack diameter, stack gas exit velocity, stack gas exit temperature, and contaminant emission rate. These stacks typically operate on a continuous basis with relatively emission rates. Based on the dispersion parameters the GLC reached at 0.84km at the concentration of 18.8µg/m3 at 2km dispersion Carbon monoxide is 0.38µg/m3 and at 5km dispersion Carbon monoxide is 0.0871µg/m3 and the predominant wind direction is WNW.

SOIL

In Soil sample collected ten locations. The sampling locations are Pump House Sea Water Sedimentation Tank -I, Pump House Sea Water Sedimentation Tank –II, Pump House, Hejamady Village, Inna Village, JM Nandikoor Village, Near Fire Station, Madrangdi Village, R & R Adamar Village and K.S.Ullooru.

- Arsenic as As: Soil sample measurement values of Arsenic are ranging from 2.84 to 9.48 mg/kg. Highest value of 9.48mg/kg is obtained.

- Zinc as Zn: Soil sample measurement values of Zinc are ranging from 5.14 to 114.01 mg/kg. Highest value of 114.01mg/kg is obtained.

- Cobalt as Co: Soil sample measurement values of Cobalt are ranging from 2.58 to 7.22 mg/kg. Highest value of 7.22mg/kg is obtained.

- Molybdenum as Mo: Soil sample measurement values of Molybdenum are ranging

from 2.07 to 11.03 mg/kg. Highest value of 11.03mg/kg is obtained.

- Nickel as Ni: Soil sample measurement values of Nickel are ranging from 3.21 to 28.8 mg/kg. Highest value of 28.8 mg/kg is obtained.

- Chromium as Cr: Soil sample measurement values of Chromium are ranging from 19.22 to 92.95 mg/kg. Highest value of 92.95 mg/kg is obtained.

- Copper as Cu: Soil sample measurement values of Copper are ranging from 3.58 to 78.35 mg/kg. Highest value of 78.35 mg/kg is obtained.

- Iron as Fe: Soil sample measurement values of Iron are ranging from 5094.5 to 394060.76 mg/kg. Highest value of 394060.76 mg/kg is obtained.

- Lead as Pb: Soil sample measurement values of Lead are ranging from 2.98 to 23.91 mg/kg. Highest value of 23.91 mg/kg is obtained.

- Manganese as Mn: Soil sample measurement values of Manganese are ranging from 15.05 to 271.23 mg/kg. Highest value of 271.23mg/kg is obtained.

- Antimony , Cadmium , Mercury and Hexavalent Chromium metals are below detection limit.

The levels of heavy metals in the soil were highest for Fe and Mn followed by Zn,Cr and Cu. In the soil samples, the Fe content ranged from 5094.5 to 394060.76 mg/kg dry soil, Mn ranged from 15.05 to 271.23, Zn ranged from 5.14 to 114.01 mg/kg, Cr ranged from 19.22 to 92.95 mg/kg and Cu ranged from 3.58 to 78.35 mg/kg. Following heavy metals in the soil were lowest for Ni followed by Pb, Mo, As and Co. In the soil samples, the Ni content ranged from 3.21 to 28.80 mg/kg, Pb ranged from 2.98 to 23.91 mg/kg, Mo ranged from 2.07 to 11.03 mg/kg, As ranged from 2.98 to 23.91 mg/kg and Co ranged from 3.21 to 28.8 mg/kg.

Ground Water

In Ground Water sample collected ten locations. The sampling locations are Inna Village , Upcl Ash Pond , Jm Nandikoor Village , Hejamady Village , Pump House, K.S.Ullooru , Mudrangadi Village and R & R Adamar Village.

- Aluminium as Al: Ground Water sample measurement values of Aluminium are

ranging from 0.009 to 4.797 mg/L. Highest value of 4.797mg/L is obtained. While the Permissible limit is 0.2 mg/L (IS 10500 standard). **Pump House ground water location sample exceeding the limit** and rests of the location sample within the limit.

- Barium as Ba: Ground Water sample measurement values of Barium are ranging from 0.053 to 0.38 mg/L. Highest value of 0.38mg/L is obtained. While the Acceptable limit is 0.7 mg/L (IS 10500 standard). All ground water location samples within the limit.

- Boron as B: Ground Water sample measurement values of Boron are ranging from 0.015 to 0.104 mg/L. Highest value of 0.104 mg/L is obtained. While the Permissible limit is 2.4 mg/L (IS 10500 standard). All ground water location samples within the limit.

- Copper as Cu: Ground Water sample measurement values of Copper are ranging from 0.004 to 0.081 mg/L. Highest value of 0.018mg/L is obtained. While the Permissible limit is 1.5 mg/L (IS 10500 standard).All ground water location samples within the limit.

- Manganese as Mn: Ground Water sample measurement values of Manganese are ranging from 0.095 to 1.003 mg/L. Highest value of 1.003mg/L is obtained.While the Permissible limit is 0.3 mg/L (IS 10500 standard). **UPCL Ash Pond and K.S.Ullooru ground water location sample exceeding the limit** and rests of the location sample within the limit.

- Selenium as Se: Ground Water sample measurement values of Selenium are ranging from 0.006 to 0.006 mg/L. While the Acceptable limit is 0.01 mg/L (IS 10500 standard).All ground water location samples within the limit.

- Zinc as Zn: Ground Water sample measurement values of Zinc are ranging from 0.006 to 3.864 mg/L. Highest value of 3.864mg/L is obtained. While the Permissible limit is 15 mg/L (IS 10500 standard). All ground water location samples within the limit.

- Lead as Pb: Ground Water sample measurement values of Lead are ranging from 0.041 to 0.041 mg/L. While the Acceptable limit is 0.01 mg/L (IS 10500 standard). **UPCL Ash Pond ground water location sample exceeding the limit** and rests of the location sample within the limit.

- Nickel as Ni: Ground Water sample measurement values of Nickel are ranging from 0.003 to 0.013 mg/L. Highest value of 0.013mg/L is obtained. While the Acceptable limit is 0.02 mg/L (IS 10500 standard). All ground water location samples within the limit.

- Chromium as Cr: Ground Water sample measurement values of Chromium are ranging from 0.003 to 0.005 mg/L. Highest value of 0.005mg/L is obtained. While the Acceptable limit is 0.05 mg/L (IS 10500 standard). All ground water location samples within the limit.

- Iron as Fe: Ground Water sample measurement values of Iron are ranging from 0.003 to 0.041 mg/L. Highest value of 0.041mg/L is obtained. While the Acceptable limit is 1.0 mg/L (IS 10500 standard). All ground water location samples within the limit.

- Magnesium as Mg: Ground Water sample measurement values of Magnesium are ranging from 2.0 to 56 mg/L. Highest value of 56mg/L is obtained. While the Permissible limit is 100 mg/L (IS 10500 standard). All ground water location samples within the limit.

- Silver, Cadmium, Molybdenum and Arsenic metals are below detection limit. All ground water location samples within the limit.

The levels of heavy metals in the Ground Water were highest for Mg and Al followed by Zn, Mn, Ba and B. In the Ground Water samples, the Mg content ranged from 2 to 56 mg/L, Al ranged from 0.009 to 4.797mg/L, Zn ranged from 0.006 to 3.868 mg/L, Mn ranged from 0.095 to 1.003 mg/L, Ba ranged from 0.053 to 0.38 mg/L, B ranged from 0.015 to 0.104 mg/L. Following heavy metals in the Ground Water were lowest for Cu followed by Fe, Pb, Ni, Se and Cr. In the Ground Water samples, the Cu content ranged from 0.004 to 0.081 mg/L, Fe ranged from 0.003 to 0.041 mg/L, Pb ranged from 0.041 to 0.041 mg/L, Ni ranged from 0.003 to 0.013 mg/L and Se ranged from 0.006 to 0.006 mg/L, Cr ranged from 0.003 to 0.005 mg/L.

Sea water

In Sea water sample collected three locations. The sampling locations are Pump House – Sedimentation Tank, Intake Sea Water and Out Take Sea Water.

- Zinc as Zn: Sea Water sample measurement values of Zinc are ranging from 0.014 to 0.014 mg/L. Highest value of 0.014mg/L is obtained.

- Arsenic, Cadmium, Copper, Chromium, Nickel, Lead, Mercury, Selenium and Hexavalent Chromium metals are below detection limit.

TCLP

In TCLP sample collected four locations. The sampling locations are UPCL Coal Yard, UPCL Bottom Ash Bin, UPCL Fly Ash, UPCL Pond Ash.

- Arsenic as As: Coal and Ash sample measurement values of Arsenic are ranging from 3.51 to 7.29 mg/L. Highest value of 7.29mg/L is obtained. While the Permissible limit is 5.0 mg/L (TCLP standard). **UPCL Fly Ash and UPCL Pond Ash Coal and Ash location sample exceeding the limit** and rests of the location sample within the limit.

- Barium as Ba: Coal and Ash sample measurement values of Barium are ranging from 1.57 to 6.41 mg/L. Highest value of 6.41mg/L is obtained. While the Permissible limit is 100 mg/L (TCLP standard). All location samples within the limit.

- Chromium as Cr: Coal and Ash sample measurement values of Chromium are ranging from 0.37 to 3.04 mg/L. Highest value of 3.04mg/L is obtained. While the Permissible limit is 5.0 mg/L (TCLP standard). All location samples within the limit.

- Copper as Cu: Coal and Ash sample measurement values of Copper are ranging from 0.12 to 2.96 mg/L. Highest value of 2.96mg/L is obtained.

- Cobalt as Co: Coal and Ash sample measurement values of Cobalt are ranging from 0.18 to 1.24 mg/L. Highest value of 1.24mg/L is obtained.

- Nickel as Ni: Coal and Ash sample measurement values of Nickel are ranging from 0.2 to 14.35 mg/L. Highest value of 1.24mg/L is obtained.

- Zinc as Zn: Coal and Ash sample measurement values of Zinc are ranging from 0.21 to 51.6 mg/L. Highest value of 51.6mg/L is obtained.]

- Manganese as Mn: Coal and Ash sample measurement values of Manganese are ranging from 11.92 to 26.13 mg/L. Highest value of 26.13mg/L is obtained.

- Iron as Fe: Coal and Ash sample measurement values of Iron are ranging from 0.81 to 41.2 mg/L. Highest value of 41.2mg/L is obtained.

- Fluoride as F: Coal and Ash sample measurement values of Fluoride are ranging from 0.7 to 27.97 mg/L. Highest value of 27.97mg/L is obtained.

- Cadmium, Lead and Mercury metals are below detection limit. All Coal and Ash location samples within the limit. As per TCLP limit Cd – 1.0 mg/L,Pb-5.0mg/L,Hg-0.2mg/L.

The levels of heavy metals in the TCLP were highest for Zn and Fe followed by F, Mn and Ni. In the TCLP samples, the Zn content ranged from 0.21 to 51 mg/L, Fe ranged from 0.81 to 41.2, F ranged from 0.7 to 27.97 mg/L, Mn ranged from 11.92 to 26.13 mg/L, Ni ranged from 0.2 to 14.35 mg/L. Following heavy metals in the TCLP were lowest for As followed by Ba, Cr, Cu and Co. In the soil samples, the As content ranged from 3.15 to 7.29 mg/L, Ba ranged from 1.57 to 6.41 mg/L, Cr ranged from 0.37 to 3.04 mg/L, Cu ranged from 0.12 to 2.96 mg/L and Co ranged from 0.18 to 1.24 mg/L.

BEFORE THE NATIONAL GREEN TRIBUNAL,
PRINCIPAL BENCH, NEW DELHI
O. A. 606/2018

IN THE MATTER OF

COMPLIANCE OF MUNICIPAL SOLID WASTE MANAGEMENT RULE, 2016

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2.	ANNEXURE-I:HON'BLE NATIONAL GREEN TRIBUNAL (NGT) ORDER DATED 24.04.2019.	

DIVYA SINHA
SCIENTIST "E",
CENTRAL POLLUTION CONTROL BOARD
PARIVESH BHAWAN, EAST ARJUN NAGAR,
DELHI-110032

PLACE: DELHI
DATED: 09.09.2019

METHODOLOGY FOR ASSESSMENT OF ENVIRONMENT CARRYING CAPACITY

Carrying capacity is a concept which limits the potential ability of natural resources and species to withstand human intervention. It may be described as a test of the ability of land, water and air to keep itself usable and toxicity free despite pollution and effluent discharges and harmful developments over it.

Carrying capacity also refers to the number of individuals who can be supported in a given area within the limits of natural resources, and without degrading the social, cultural and economic environment for the present and future generations. The carrying capacity for any given area is not fixed. It can be extended to a certain level by improved technology, but mostly it is changed for the worse by pressures which accompany a population increase. As the environment is degraded, carrying capacity actually shrinks, leaving the environment with no ability to support even the number of people who could formerly have lived in the area on a sustainable basis.

Human activities may not be unsustainable in themselves but the thin line that separates them from being beneficial to mankind and becoming harmful is the environmental recognition of the concept of carrying capacity. If taken beyond carrying capacity, the activities may prove disastrous

$$Carrying\ Capcity = f \begin{pmatrix} Environmental\ impacts\ and\ natural\ resources; \\ Infrastructure\ and\ urban\ services; \\ Public\ Perception; \\ Institution\ Setting; \\ Society\ Supporting\ Capacity \end{pmatrix}$$

Methodology and Framework for Calculating Environmental Carrying Capacity: Indicator Benchmark Comparison method:

For calculating the Carrying Capacity, Indicator Benchmark Comparison method will be used; this method is the conventional procedure of many UCC assessment models, e.g. (Clarke, 1996; Graymore et al., 2010; Liu, 2012; Oh et al., 2005; Shi et al., 2013; Yu & Mao, 2002). In practice, carrying capacities values are compared with the threshold, acceptable, minimum, or recommended standards of UCC (Joardar, 1998; Liu & Borthwick, 2011). Initially, a set of indicators for measuring sustainability is identified. The sustainability standard for each indicator is established. Then, each determining factor is evaluated for carrying capacity assessment, by comparing human activity impacts to thresholds or targets (Graymore et al., 2010).

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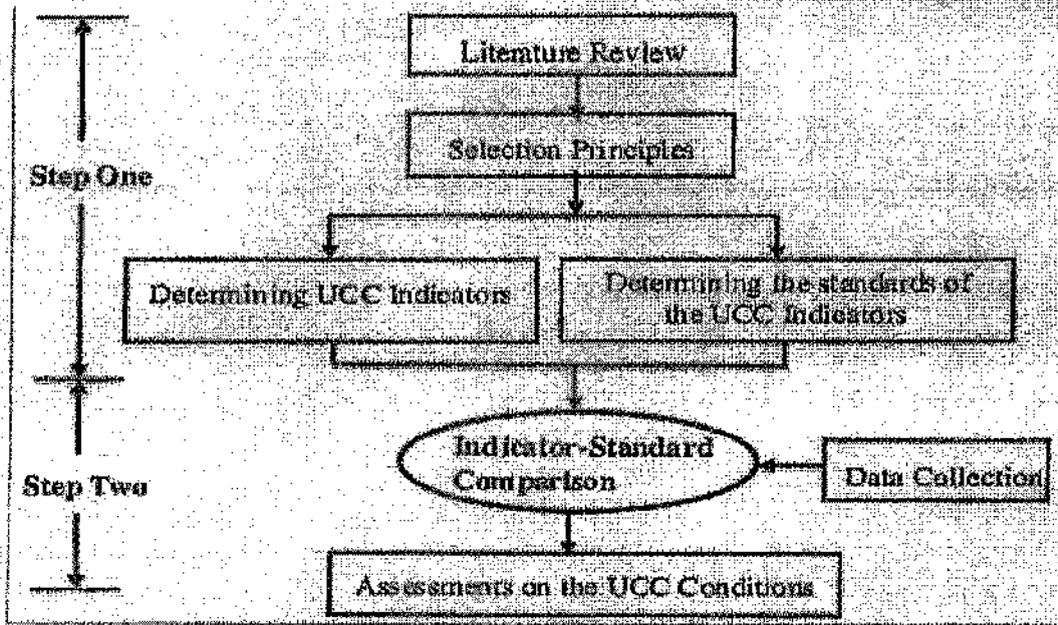
Figure 1: Flow chart for Urban Carrying Capacity (*Source: Yigang wei et al., 2015*)

Framework Description for Calculating Environmental Carrying Capacity
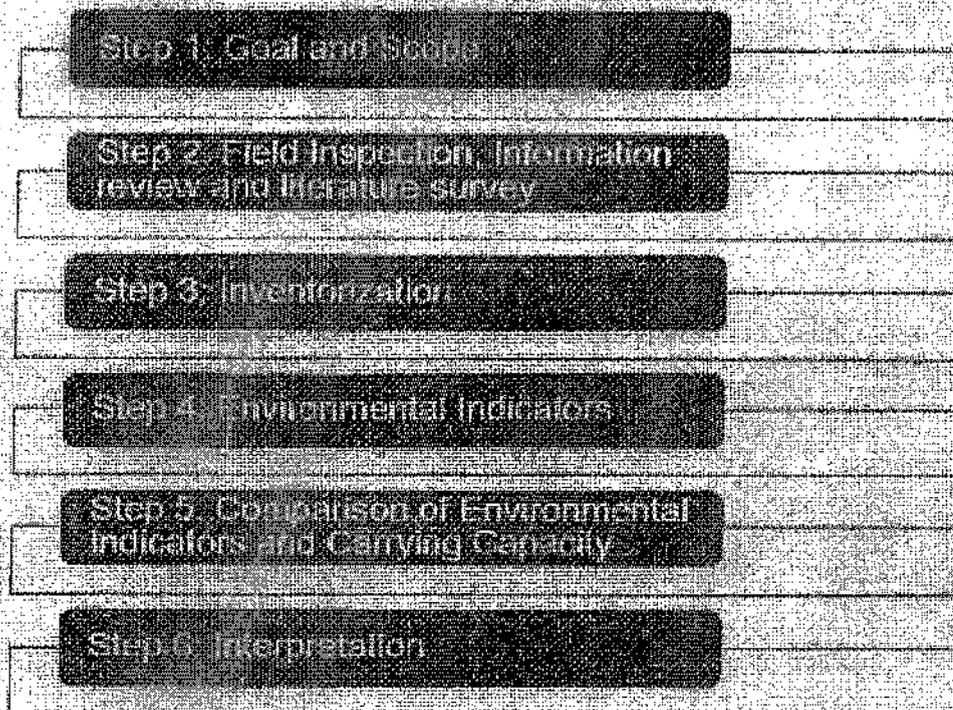
Figure 2. Schematic of Framework for Environment Sustainability Assessment

Step 1: Goal and Scope - Aim of the study and scope comprising of system boundary, functional unit, and environmental indicators shall be defined.

Step 2: Field Inspection, Information review - Information concerning the system, will be obtained through field inspection, survey, literature review etc.

Step 3: Inventory - Systematic accounting of major resource, material, activity and waste flows within the region's system boundary will be performed.

Step 4: Environmental Indicators - Specified Indicators will be evaluated.

Step 5: Carrying Capacity - Carrying capacity of the region concerning different environmental aspects will be evaluated.

Step 6: Comparison of Environmental Indicators and Carrying Capacity - Environmental indicators providing status of current environmental condition will be compared with the carrying capacity of the region.

Step 7: Interpretation - Obtained results and information limitations will be discussed. Conclusion and recommendations will be drawn based on the results and information.

In the report, system boundary will represent area under study

Approach For Quantifying Carrying Capacity

Step 1: Goal and Scope

Macro-level assessment of major resource and waste flows within the system boundary. The region will be assessed for the direct resource use and waste flows. Environmental indicators will be identified in terms of specific resources and waste flows. Most common Environmental Indicators under study are land use, water use, solid waste, waste water and air emissions. Status of environmental indicators for current year and projection until year 2035 should be evaluated.
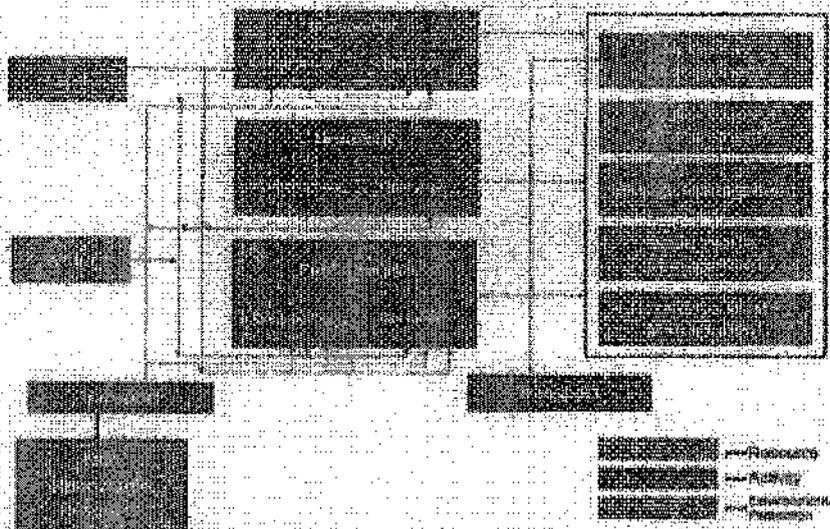
Figure 3.: System boundary for region under study

Step 2: Field Inspection, Information review

Field Inspection to collect the relevant information about area under study. In this, field inspection includes survey of industries, commercial areas, residential areas, dumpsites, landfill sites, sewage treatment plants, water treatment plants, discussion with government officials, discussion with local residents, migrants and tourists etc. to get real scenario of the region

Step 3: Inventory

To illustrates the major resource flows from within and outside the boundary region to various activities, and waste flows from activity to various waste management systems. Inventory for the system is to be developed based on information provided in development plan, discussion with authorities, literature values and field inspection.

Population: Population of the region is to be evaluated by data extrapolation using the census data. Changes in population are influenced by three factors: birth rate, death rate and population Migration numbers (Qin et al. 2011). Birth rate and death rate can be deduced from historical information and empirical data. Population migration rate will be predicted based on the analysis of labor supply and demand balance, namely the difference between the local labor force and labor demand.

Tourist Inflow: Tourist Inflow is to be calculated by data extrapolation of peak tourist inflow in peak season.

Water Resource

a) Identify the source of water supply i.e. Ground water or surface water

b) Quantify the Total water supply to residents and industries and other commercial zone

c) Calculate the water balance of the region under study

Water supply for region is to be collected for calculating the total water available per capita to civil population, commercial activities and Industrial area.

Land Resource: Land use classifications mainly based on Non developable area (A_{ND}) and Area for infrastructure development (A_{IF})

* Non developable area (A_{ND}) consists of forests, agriculture, waste lands and nallahs
* Area for infrastructure development (A_{IF}) consists of area required for commercial, industrial, public, governmental and transportation activities and organized open spaces

For Domestic Establishments and Public services:

Water consumption: Calculate the amount of water consumption in the region. As per MOHUA, average requirement of water is 135L/day/person (MOUD, 2012) and 180L/day/person (MOUD, 1999) for tourists.

Solid waste generation: Calculate the amount of solid waste generation in the region. Municipal solid waste generated in the range 0.2 - 0.6kg/day/person, MOUD, 2016.

Waste water generation: Calculate the amount of waste water generation in the region Approx. 80% of total water use is assumed for waste water generation rate.

Traffic volume: Survey is to be carried out during weekends and weekdays to:

a) Assess the mode wise traffic composition at hotspot area of the region.

b) Estimate the number of vehicles manually and with videography if feasible.

c) Origin and Destination Survey is to be carried out in the area to estimate the extent of traffic demand from zone to other.

d) Fuel Station Survey is to be carried in the study area road network to identify the type of fuel, fuel saving, quantity and frequency of fuel filling and their mileage, type of engine, age profile and the composition of fuel types (petrol, diesel, (CNG) in total fleets.

e) Meteorological survey

Calculate the number of vehicle inflow and number of local vehicles.

f) Calculate the average vehicle trip lengths for different vehicle categories (truck, car, and two-wheeler) by mapping the distance for general probable stops covered by the vehicles.

g) Types of vehicles

h) Type of fuel consumption,

i) Travel time data

Air Emission: Inventorization of air emission sources like biomass burning, open waste burning, stubble burning and construction activities

For Commercial Establishments: In this part all the commercial establishment will come like factories, hotels, restaurants and Dhabas etc.

Industries: Inventorization of legal and illegal industries and type of industries

Transport: Calculate the number of commercial vehicles, type of vehicles, fuel used and average trip length

Water consumption: Find out the source of water consumption, Calculate the water consumption per establishment.

Waste Water Generation: Calculate the waste water generation, evaluate the capacity for treatment of waste water

Solid waste generation: Calculate the amount of solid waste generation from the commercial establishments.

Air emission sources:

a) Inventorzation of coal based tandoors are being used in the hotels, restaurants and dhabas and other areas specific area.

b) Inventorization of type of fuel being used in the industries in the boilers and for heating purpose.

c) Inventorization of Municipal Waste Incinerators, Biomedical Incinerators and Hazardous waste incinerators and evaluate their efficiency.

d) Inventorization of Construction activities in the region.

e) Inventorization of Road dust and unpaved road.

Step 4: *Environmental Indicators:*

1. Population (residents)+ Migration rate
2. Tourist Inflow
3. Traffic volume
4. Urban land
5. Water available: Ground water + Surface water
6. Water use : For domestic purpose , industrial use , agricultural use & others
7. Solid waste
8. Sewage
9. Air Emission: Industrial Emissions, DG set emission, emission from coal based tandoors, construction activities, open burning, transport (commercial & local) Biomass burning, road dust, crematoria's, residential and incinerators.

Step 5: Assessment of Carrying Capacity:

Carrying capacity of the region will be evaluated for urban land, water resource, atmospheric assimilation and waste carrying capacity of the region.

Urban Land Carrying Capacity

ULCC may be evaluated based on methodology presented in Urban Carrying Capacity Report by IIT Guwahati (IIT Guwahati, 2012).

$$A_R = [A_U - (A_{ND} + A_{IF})] * FAR/S$$

where, A_R = area for residential requirements

A_U = total urban area

A_{ND} = non developable area

A_{IF} = area for infrastructure development

FAR = Floor Area Ratio

S = Floor area requirement per head

Non developable area (A$_{ND}$) consists of forests, agriculture, waste lands and nallahs. Area for infrastructure development (A$_{IF}$) consists of area required for commercial, industrial, public, governmental and transportation activities and organized open spaces.

As per IIT Guwahati 2012 report,

FAR need to be determined by considering various aspects like, provision of intended free space, safe bearing capacity of soil, economy of people for affording earthquake resilient structures, drainage and transportation requirement and so on. While the proposed "SAFE" method itself will determine an acceptable FAR, one need to provide an initial value of FAR. This value can be given from guidelines provided by different organization including ULB. In absence of any such guidelines, **a value of 1.5** can be used for initial trial value. This value is suggested based on the general trend observed so far in Indian condition.

Floor area requirement per head: Based on analysis of socio- economic status of the present population and considering future possible matrix of different classes, an average logical area requirement is to be calculated

Water Resource Carrying Capacity

Amount of available water resources (AWR), and the amount of surface water withdrawal (SWW). These can be estimated by the following equations:

$$AWR = AGWR + ASWR + OAWR$$

- AGWR is the available ground water resource,
- ASWR is the available surface water resource,
- OAWR is other available water resources, mainly wastewater reuse and collection of rainwater.

$$SWW = TWS - GWS - OSWS$$

- TWS is total water supply,
- GWS is ground water supply,
- OSWS is other sources of water.

Water demand:

Gross water amount consumed by all types of water users. The gross amount of water demand includes the conveyance loss of water, domestic water demand, industrial water demand, agricultural water demand, and "other" water demand (Water Resources Bulletin of Tieling 2011).

- *Domestic water* demand includes urban domestic water demand, made up of the residential use of water and the public use of water (including the water use by tertiary industry and the construction industry).
- *Industrial water demand* consists of the demand for fresh water, excluding water recycling within enterprises.
- *Agricultural water demand* is made up of irrigation water demand water recharge.
- *Other water demand* consists mainly of the demand for sanitation water in the urban area and the water restoration requirements of rivers, lakes and wetlands.

Water resource carrying capacity (WRCC) depends on the water availability and water demand, and is given as,

$$WRCC = WA/WD$$

Where, WA = water availability

WD = water demand

Widodo et al., 2015 stated that for WRCC < 1 capacity is overshoot, WRCC 1 - 3 capacity is conditionally safe and WRCC > 3 capacity is safe.

Water Environmental Carrying Capacity (WECC):

Surface Water Carrying Capacity:

Rivers:

The water environmental capacity is the maximum pollutant loading that the water body can hold under a certain water environment quality target. The dominant water pollutant is BOD. The length and width of the computed river is relatively large, so we can ignore the horizontal changes of pollutant concentration, and only take into account changes of pollutant concentration along the river, so we select one-dimensional water quality model to calculate the Surface water environmental capacity. The water environment capacity can be calculated with following equation as per Qingchun Yang et al; 2019

Assuming stream and waste water discharge are at steady state and instantaneous full mixing of all flows.

$$W_R = \left[C_s - C_o \, exp\left(\frac{-KL}{u}\right) X \, Q \right]$$

- W_R represents the river's pollutant carrying capacity, g/s;
- Cs represents the water quality target concentration at the downstream cross-section of the river, mg/L;

- C_0 represents the actual water quality concentration at the upstream cross-section of the river, mg/L;
- K represents the pollutant degradation coefficient, d^{-1};
- L represents the length of river, m; u represents the average flow velocity at the river's cross section, m/s;
- Q represents the designed flow at the river's cross section, m3 /s

Note: As per Yingrong Wen et al; 2017, the reported range for laboratory-measured k values is from 0.3 to 0.5 day^{-1} at a temperature of 20 °C, which is considered representative of field conditions

Lakes

Pollutant carrying capacity of the lake:

Considering, Lake is of small size with equilibrium of multi-year average in flowing water and outflowing water, it is desirable to adopt the uniform mixture model to calculate the pollutant carrying capacity.

Based on the material balance equation, the pollutant carrying capacity

$$W_L = (C_s - C_0)V + KC_sV + C_sq_{out}$$

In this equation,

- W_L represents the pollutant carrying capacity of the lake, t/a;
- Cs represents the water quality target concentration, mg/L;
- C_0 represents the actual water quality concentration, mg/L;
- V represents the average storage capacity of the lake in dry seasons, m^3;
- q_{out} represents multi-year outflowing water of the lake in dry seasons, m^3 /a;
- K represents the pollutant degradation coefficient, d^{-1} mainly BOD parameters under consideration

Ground Water

For estimating the level of groundwater pollution with low-hazard pollutants the following formula can be used as per Anna Belousova, 2006

$$\frac{C_1}{MPC_1} + \frac{C_2}{MPC_2} \pm - - - - - - \mp \frac{C_n}{MPC_n} = 1$$

Where C_1, C_n are concentration of separate pollutants, and MPC_1, MPC_n represent maximum permissible concentration.

If the sum of the concentration ratios is more than 1, then the groundwater is polluted. For all cases, pH must not be outside the limit 6.5–8.5.

Atmospheric Assimilation Capacity:

Various approaches are described in the literature for estimating the atmospheric assimilative capacity of a region. (Goyal et al. (2006) propose two approaches, one based on a ventilation coefficient, the other through pollution potential. SEPA (2003) recommend an A-P value method and multi-source simulation model to estimate atmospheric assimilative capacity in China.

Here we are discussing the atmospheric assimilative capacity using simple Box Model:

A simple box model based on mass balance and assuming that all pollutants in the box are uniformly mixed (Figure 2) is used for preliminary estimates for step (ii) in Fig 1(a). It is a simple model and has several limitations; however, for the purpose of demonstrating the framework and preliminary analysis, the model may provide broad estimates of carrying capacity. Mathematically, the model can be described as below:

Figure 4: Schematic of box model (De Nevers, 1995)

Mathematically,

$$V \frac{dc}{dt} = qC_{in} - qC_{out} + S - K_{dd} \, CLW - K_{cr} \, C_{out} V \qquad (1)$$

where, q = volumetric flow rate (m³/sec)

C_{in} = influent concentration of a pollutant (g/m³)

C_{out} = effluent concentration of a pollutant (g/m³)

K_{dd} = dry deposition velocity (m /sec)

K_{cr} = First order chemical reaction constant (1/sec)

S = source emission rate(g/sec)

K_{dd} C.L.W = the amount of pollutants removed by dry deposition (g/sec)

K_{cr} C.V = the amount of pollutants converted by chemical reaction (g/sec)

u = wind speed (m/sec)

In equation, V=L×W×H volume of City m³ (L: length (m), W: Width (m), H: height (m))

The model is further simplified with the following assumptions:

- Steady state condition (i.e. concentration is time invariant); $dc/dt = 0$
- Pollutant does not give any deposition in the box; $k_{dd} = 0$
- Pollutant does not undergo any chemical transformation: $K_{tr} = 0$

One can estimate the carrying capacity, Q_{cc} as per the following equation:

$$Q_{cc} = (C-C_0) \times u.W.H \qquad (2)$$

In this calculation,

Area (A) of system boundary, Width (W) of the System boundary, mixing height (H) (average for winter and summer) within the system boundary, Wind Speed (s) within the system boundary is required.

Background concentration (C_0) into the system boundary is also required.

Alternatively, the multi-source simulation model may be used to estimate atmospheric assimilative capacity based on air quality modeling which takes into consideration region-specific meteorological conditions, terrain characteristics, and emission loads from different sources. Following Goyal and Chalapati Rao (2007), the discharged emission load at which the maximum allowable concentration is reached under predefined critical conditions is taken to be the assimilative capacity of the region. Prediction of ground-level concentrations of pollutants is carried out using the US EPA approved ISCST-3 simulation model (EPA, 1995a, 1995b). It should be noted that the atmospheric assimilative capacity has a range of values, depending on the variation of emission characteristics with given meteorological and topographical conditions.

Solid Waste Carrying Capacity:

Considering per capita solid waste generation in case of local population of the study area and that of tourist population, calculate the waste generated in the the study area tons per day (TPD) during the base year. Out of the total waste generated, calculate the waste collected and transported to a dumping/ landfill site. Solid waste carrying capacity has been analyzed here from the standpoint of waste generation and management potential and public perception. Solid waste environment carrying capacity (SWECC) was first assessed using the following simple expression-

$$SWECC = \frac{SWM_{EF} \text{ (tons)} + RC \text{ (tons)}}{SWG \text{ (tons)}} \qquad \cdots\cdots (1)$$

where;

SWECC = Solid Waste Environment Carrying Capacity.

SWM_{EF} = Solid Waste Managed Environment-Friendly. Includes all SWM options (Recycling + Re-using + Reprocessing + Sanitary Land-filling + Incineration in compliance with emission norms, etc.). Collection of waste is the foremost requirement before wastes are sent for land-filling, recycling, incineration, etc.

RC = Remaining Capacity. Capacity left/available for managing more SW.

SWG = Solid Waste Generated in tons.

The foremost task is collection of the generated solid waste after which, the local authority can manage the waste by sending for recycling, land-filling, incineration, etc.

Threshold for assessment:

SWECC = 1 : Carrying Capacity on edge/break-point. CC may overshoot very soon.

SWECC > 1+ : Carrying Capacity exists. More the value, more the CC.

SWECC < 1 : CC overshoot.

Carrying Capacity of Sewage management:

Calculate the total sewage generation in the region based on the present population scenario and for projected population for next 20 years and evaluate the efficiency of the Treatment plants installed for treating sewage.

S.NO	Activities		Source
1	Extent to which waste water management facilities are available to individual properties across the city, whether through centralized underground sewerage, decentralized systems or on-site systems such as septic tanks. This should be computed for the number of properties recorded in municipal records and not households, and should include all residential, commercial, industrial and institutional properties $$\frac{\text{Total number of properties with connection to waste water management systems}}{\text{Total number of properties in the city}} \times 100 =$$	100% door to door collection (Service Level Benchmarks, MoUD)	MoUD Report on Methodology Collection and Computation of liveability Standards in Cities
2	The actual proportion of waste water generated in the city that is collected by the available sewerage Network $$\frac{\text{Total waste water collected per day}}{\text{Total waste water generated in the city per day}} \times 100 =$$	100% (Service Level Benchmarks, MoUD)	MoUD Report on Methodology

			Collection and Computation of liveability Standards in Cities
3	The proportion of waste water received at the treatment plant that is recycled or reused for various purposes. Treated waste water can be used for horticultural purposes in parks and gardens, irrigation of farmlands on city periphery, and/or supplied to power plants and industries $$\frac{Quantum\ of\ waste\ water\ recycled\ or\ reused\ per\ day}{Total\ waste\ water\ received\ at\ treatment\ plants\ per\ day} X100$$ $$=$$	20% or more (Service Level Benchmarks, MoUD)	MoUD Report on Methodology Collection and Computation of liveability Standards in Cities

Overall conclusion:

Case 1:

$$\frac{Total\ Sewage\ Gneration}{Available\ treatment\ Facility\ working} = 1 \text{------------ System is conditionally safe}$$

Subcase: Treated water must follow the prescribed standards

Case 2:

$$\frac{Total\ Sewage\ Generation}{Available\ treatment\ Facility\ working\ efficiently\ with\ recycling\ of\ water\ in\ the\ system} < 1 \text{------------ System is safe}$$

Case 3:

$$\frac{Toatl\ Sewage\ Generation}{Available\ treatment\ Facility\ working\ efficiently} > 1 \text{------Carrying capacity is overshooted}$$

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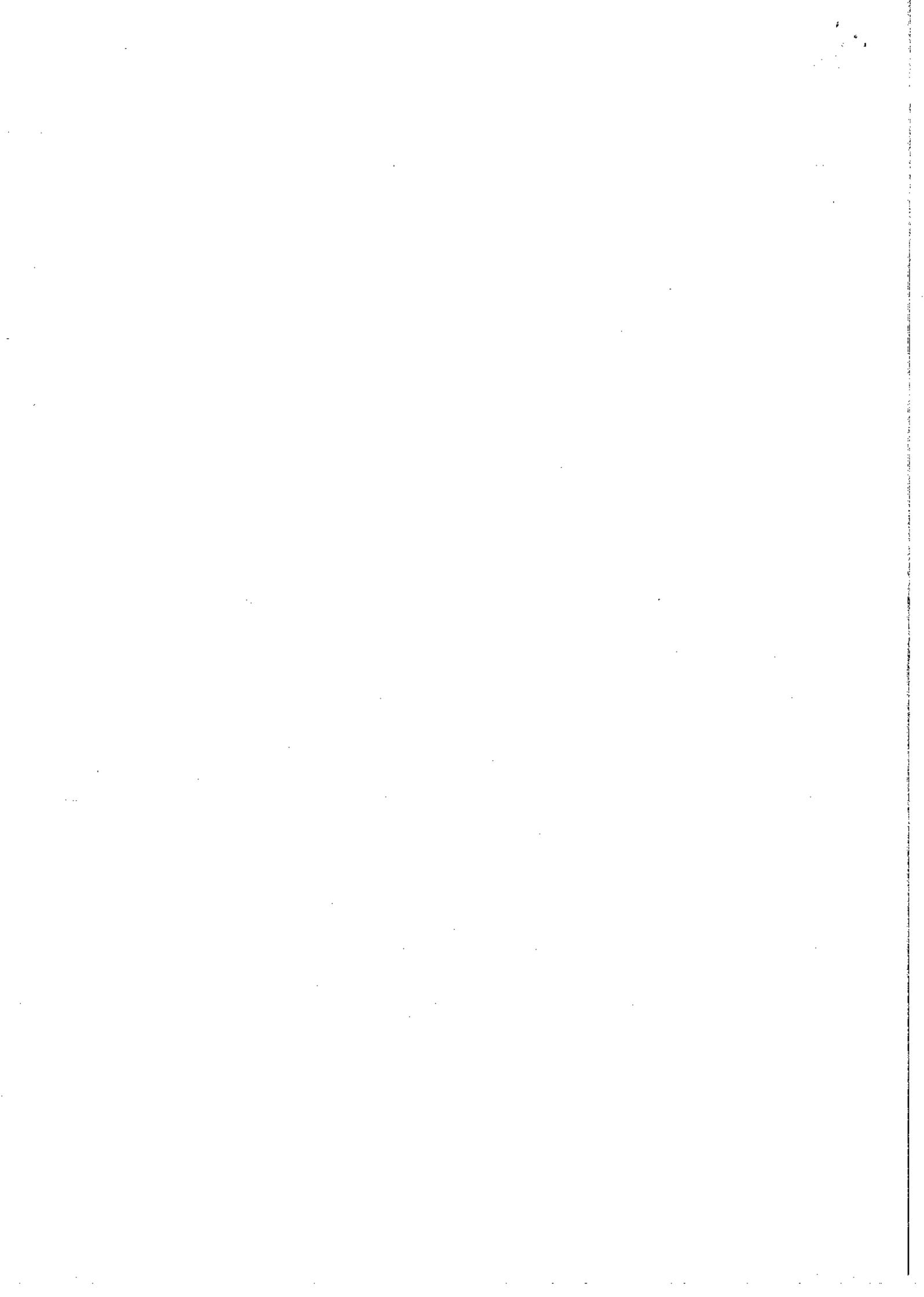
INTERIM REPORT

ON

The study of Environmental Carrying Capacity of erstwhile Udupi Taluk in relation to expansion of 2X600MW Udupi power Plant (UPCL).

SUBMITTED BY:

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1. INTRODUCTION:

The survival of human race depends upon the availaibilty of abundant natural resources in a healthy and safe environment. Rapid social and economic development has brought issues of resources and environment, such as excessive resources consumption, environmental degradation and pollution, and the issues have become increasingly prominent across the globe (Liu et al 2013 & Jameson, S.C. and Ammar, M.S.A. 2007).

Carrying capacity is a concept which limits the potential ability of natural resources and species to withstand human intervention. It may be described as a test of the ability of land, water and air to keep itself usable and toxicity free despite pollution and effluent discharges and harmful developments over it.

Carrying capacity also refers to the number of individuals who can be supported in a given area within the limits of natural resources, and without degrading the social, cultural and economic environment for the present and future generations. The carrying capacity for any given area is not fixed. It can be extended to a certain level by improved technology, but mostly it is changed for the worse by pressures which accompany a population increase. As the environment is degraded, carrying capacity actually shrinks, leaving the environment with no ability to support even the number of people who could formerly have lived in the area on a sustainable basis.

Human activities may not be unsustainable in themselves but the thin line that separates them from being beneficial to mankind and becoming harmful is the environmental recognition of the concept of carrying capacity. If taken beyond carrying capacity, the activities may prove disastrous

The carrying capacity of an environment is the maximum population size of a biological species that can be sustained in that specific environment, given the food, habitat, water, and other resources available for living. Therefore, the environment carrying capacity has become a great concern of research interest. Environmental carrying capacity includes multiple factors such as atmospheric environment, land environment, social economy and dilution related self-purification capacity of water environment, and reflects the threshold of supporting capacity in a region with specific natural resources and ecological environment. The studies indicated that environmental degradation, resource exploitation and utilization

have caused seriously adverse effects on ecological environment, and resource and environment carrying capacity has been substantially reduced.

1.1 THE CONNOTATION OF CARRYING CAPACITY

The concept of carrying capacity is rooted in demography, biology, and applied ecology (Clarke 2002). In ecology, carrying capacity is defined as the maximum population of a species that a habitat can support without permanently impairing the habitat's productivity (Rees 1997). Carrying capacity is an indicator of regional sustainability, and achieving regional sustainability is important because social institutions and ecological functions are closely linked at this scale (Graymore 2009). The concept of a sustainable carrying capacity is defined by a regional ecosystem's characteristics based on two premises. First, it must be possible to sustain the regional ecosystem's normal operations. Therefore, researchers must calculate the quantity of resources and environmental capacity required to sustain these functions. Second, it is necessary to evaluate the regional population and intensity of activities that the natural resources can support after considering the needs of the ecosystem. The theory of environmental carrying capacity has been widely applied in environment planning and management. The carrying capacity depends strongly on environmental resources. However, there have also emerged some theoretical studies of carrying capacity based on regional different resources because this capacity is most often included within the larger theory of sustainable development. For example, Falkenmark and Lundqvist (1998) used estimates of the maximum global use of water resources to study how carrying capacity is determined by regional water resources (Falkenmark, Lundqvist .1998). Another example is a study of the Florida Keys Basin's carrying capacity in the United States (NRC 2002), in which researchers modelled carrying capacity under different land-use scenarios.

$$\text{Carrying Capacity} = f \begin{cases} \text{Environmental impacts and natural resources;} \\ \text{Infrastructure and urban services;} \\ \text{Public Perception;} \\ \text{Institution Setting;} \\ \text{Society Supporting Capacity} \end{cases}$$

Therefore, studying the Environmental Carrying Capacity is always useful and acts as the basis for formulating sustainable development policies. It helps the policy makers to understand the ground reality of environment for a specific region and cause.

1.2 BACKGROUND

As per the directions of the Hon'ble National Green Tribunal, Principal Bench, New Delhi, in Janajagrithi Samithi versus Union of India & others, dated 14/03/2019 and 14/10/2019 in Original Application (O.A) Nos.578/2018, 579/2018, 580/2018, and appeal No. 176/2018 in relation to the expansion of Udupi Power Plant, the department of Forest Ecology and Environment, Government of Karnataka vide order no. FEE08 EAA 2019, dated 12/05/2020, has entrusted Environmental Management and Policy Research Institute (EMPRI) to study the Environmental Carrying Capacity of the project area viz., Udupi Power Corporation Limited erstwhile Udupi Taluk.

The Hon'ble National Green Tribunal, in its order dated 14/03/2019 in the Clause number 124 states that "Before embarking upon it, we deem it appropriate to direct the Ministry of Environment, Forest and Climate Change (MoEF&CC) to ensure that the project proponent carries out an additional EIA study, in terms of additional ToR prepared pursuant to our findings at paras 124 and 125 supra, followed by strict observance of procedure under Stage-III of EIA Notification, 2006 before being finally placed for appraisal by the EAC for consideration for grant of Environmental Clearance. Paras 124 and 125 referred to above are reproduced below for convenience: "124. The question that then requires determination is, should the EC be quashed and set aside? After careful consideration, we find that further studies are unavoidable in order to ensure that the EIA is complete. We, therefore, direct as follows:

 (i) Baseline data of the area in relation to the existing project of 2x600 MW shall be scrupulously collected;

 (ii) In addition to the above, the State of Karnataka shall get a carrying capacity study of the area carried out.

 (iii) The baseline data and the carrying capacity study shall be considered as components for studying the impact in relation to the proposed expansion;

 (iv) Fresh public hearing shall be conducted strictly in accordance with the procedure laid down in Appendix IV of EIA Notification, 2006 ensuring wide participation of the people affected by the project "which forms the basis for assigning of this study to EMPRI.

Carrying capacity is a function of environmental inputs, natural resources, infrastructure, urban services, public perception, industrial setting, societal support, the present study deals with base line data of water parameters, data of natural resources including biodiversity hotpots, conduction of public perception survey, etc.

Accordingly, the Environmental Management and Policy Research Institute (EMPRI) has taken up the Carrying Capacity with the following objectives

1.3 Objectives:

1. To collect the existing baseline data of Environmental Parameters and to assess the current environmental status duly considering the industrial and other land use activities.
2. To identify the critical ecosystems and biodiversity hotspots in the region.
3. To determine the carrying capacity of the project area viz Udupi Power Corporation Limited erstwhile Udupi Taluk for the industrial growth and development.

REVIEW OF LITERATURE:

Carrying capacity is an indicator of regional sustainability, and achieving regional sustainability is important because social institutions and ecological functions are closely linked at this scale (Graymore 2009). The concept of a sustainable carrying capacity is defined by a regional ecosystem's characteristics based on two premises. It must be possible to sustain the regional ecosystem's normal operations. Therefore, researchers must calculate the quantity of resources and environmental capacity required to sustain these functions. The concept of environmental carrying capacity in China was first presented in a report about comprehensive environmental research of the Meizhou developing zone in Fujian Province (Wang 1998), which interpreted that the ability of a region to support the threshold of human activities during a definite state or condition for a defined period of time. Since then, the theory of environmental carrying capacity has been widely applied in environment planning and management. The carrying capacity depends strongly on environmental water resources. However, there have also emerged some theoretical studies of carrying capacity based on regional water resources because this capacity is most often included within the larger theory of sustainable development. For example, used estimates of the maximum global use of water resources to study how carrying capacity is determined by regional water resources (Falkenmark and Lundqvist (1998). Another example is a study of the Florida Keys Basin's carrying capacity in the United States (NRC 2002). In which researchers modelled carrying capacity under different land-use scenarios. In China, severe environmental problems have forced the government to initiate a series of studies to determinate carrying capacity based on regional water resources in areas with severe water shortages, such as western China and the North China Plain (Xia J., Zhu Y Z. 2002, and Zhang 2006). These studies mainly focus on the scale of social and economic development that can be sustainably supported by a particular basin's or region's water resources without disturbing the ecosystem's normal operations Zhu et al 2009.

According to Avirneni and Bandlamudi (2013), fossil-fuel coal is abundantly available that is used for power generation in India. This coal is of low calorific value and has high ash content. Many of the coal-based thermal power plants installed in India lack the facility of automatic dry fly ash collecting system and hence the fly ash and bottom ash are discharged in the form of slurry to the ash pond, causing dangerous effects on the environment, economy and the society. The global studies have reported that the coal-based thermal power plants are known

to create hazardous effects on the environmental segments of the surrounding region (Pokale, 2012,). In a study conducted on the effect of pond ash on ground water quality (Suresh et al., 1998) observed that the fly ash leaching had an adverse effect on the water ecosystem while the solid particles were emitted to the atmosphere. Disposal of fly ash is done in wet slurry and in some cases through dry disposal process. In both the disposal methods, the fly ash is dumped in an open land that results in degradation of soil, and eventually causing air and water pollution, ultimately affecting the human health. In a similar study conducted in Kosova it was observed that underground water contamination was due to ash deposits (Avdullahi and Fejza 2010).

No matter how advanced science and technology becomes, human beings consistently rely on natural resources for survival and living. Expansive urbanization associated with rapid industrialization places enormous pressure on the Earth's resources, and humans' requirements for resources have surpassed the planet's regeneration capacity since the 1970s (WWF 2012). Unfortunately, the high ecological pressure in urban areas and almost fully loaded land carrying capacity are even more troublesome as cities continue to experience population expansion, consumption growth, resource overuse, and waste and emission accumulation (WWF 2010). Thus, it is essential to determine land carrying capacity (LCC) to ensure the safety of ecosystems and their sustainable development, or at least to slow down the degradation of natural capital. Currently, more and more regional science programs have been devoted to study the relationship between human beings and land-use situations.

The United States' NASA Land-Cover and Land-Use Change Program was designed to improve the understanding of human interactions with the environment. It is focused on providing foundational knowledge of sustainability, vulnerability, and resilience of land use and on addressing issues related to land-cover and land-use changes for the purpose of human welfare (Justice C, et al 2015).

There are several reasons to conduct a literature review at the beginning of any research projects/works; similarly, we have also done a brief literature review on various carrying capacity studies undertaken within India and in other countries. Carrying Capacity studies of Dakshina Kannada was initiated way back in late 1990's. The Frame Work for conducting Carrying Capacity Studies for Dakshina Kannada was submitted by Prof. D K Subramanian, IISc, Bengaluru under the chairmanship of Prof. Madhav Gadgil and other committee members.

2.1 LAND USE, LAND COVER CHANGES (LULC)

Land cover (LC) refers to the features present on the earth surface. Land cover configuration is stated as a unified reflection of the existing natural resources and natural processes that are dynamic in nature. Mapping, quantifying, and monitoring the physical characteristics of land cover has been widely recognized as a key element for natural resource management and

sustainable planning activities (Nemani & Running, 1996; Barlage et al., 2004). Land use refers to the human induced changes for agricultural, industrial, residential, recreational purposes. The main drivers of land use can be stated as land management policies, population, agricultural production and urban expansion. Land use change alters the homogeneous landscape into heterogeneous mosaic of patches. Almost 40 percent of Earth's land surface had been converted to cropland and permanent pasture by early 1990s. This conversion has occurred largely at the expense of forests and grassland (Ramachandra and Shruthi, 2007). LULC change influences the interaction of ecological, geographical, economic, and social factors (Zang and Huang, 2006; Geist and Lambin, 2006). The impacts of LULC changes on a landscape with respect to wind regime, temperature, soil moisture, water vapor, and cloud development has been accounted through numerous models (Adegoke et al., 2007; Narisma and Pitman, 2003; Gero and Pitman, 2006; Sen Roy et al., 2007; Sen Roy et al., 2011). The structure and composition of landscapes undergoes a rapid change as a result of human related activities. The changes in the mosaic of landscape elements are considered to influence significantly the processes and functions of ecological systems. Quantifying landscape spatial patterns and their changes provide important information for monitoring and assessing the effects of human induced changes on landscape.

Different land use types reflect different ecological sensitivity. Based on the landscape ecology, human activities tend to make the outline of a landscape patch. Thermal power plant and its surroundings are experiencing unprecedented changes in land use and land cover due to concentrated developmental activities due to industries development of the region. The study on rate of urbanization growth process along with LULC changes gives an idea in advance about the infrastructure planning and resource management of the study area. Ramachandra et al, 2012 carried out Land Use Dynamics at Padubidri, Udupi District with the Implementation of large scale Thermal power project. This paper focuses on a land use land cover changes that have occurred due to the establishment of a 1200 MW power plant at Padubidri in the coastal district of Udupi, Karnataka. The results indicate that the vegetation has decreased from 8.1 (2003) to 4.24% (2011) while the area under built-up has increased from 5.26 to 8.1%.

Naik et al. 2018, carried out Impact of Land use Land cover change on coastal tourism in Kundapura, Karnataka, using Multi-temporal remotely sensed data and GIS techniques. Tremendous changes, particularly in mixed urban and agricultural land and proved that RS/GIS have advantages over conventional techniques. Based on the multi-dated satellite data study, assist in decision making and help to take appropriate measures to monitor and regulate coastal development in order to achieve sustainable and integrated coastal

development.

Silambarasan et al., 2014, carried out a study tittled "Urban sprawl mapping and land use change detection in and around Udupi Town: A Remote sensing based approach". In which a significant increase in settlements and built-up land during the study period was observed. The settlement and built-up land increased from 16.7 sq.km to 41.9 sq.km showing an increment of 150% compared to 2003. Agricultural land increased by 22% whereas plantation decreased by 8%, forest by 12% and scrub vegetation by 42%. Barren/waste land also showed decrease due to conversion to settlement and built-up area.

Anchan et al., 2018, carried out Land use and Land cover change detection through spatial approach: A case study of Mangalore Taluk, Karnataka. Study brought to light that the forest area that occupied 37% of the Taluk's area in 1997 has reduced to 31% in 2017; agricultural land, built up area, water bodies and barren land have also experienced changes. Built-up lands (settlements) have increased from 6 per cent to 23 per cent of the total area. The high land vegetation and forest cover areas are disappearing rapidly; water bodies like lakes are also diminishing.

SCOPE: The study area is erstwhile Udupi Taluk (presently Kapu Taluk) where M/S Udupi Power Corporation limited is located. It includes the assessment of the impact of industrial development in the erstwhile Udupi Taluk (presently Kapu Taluk) and to come out with the calculation of Environmental Carrying capacity of erstwhile Udupi Taluk (Kapu, Karkala and Mangalore Taluks).

GENERAL DESCRIPTION OF THE UDUPI DISTRICT

Udupi district lies in the coastal region and is situated at the foot of Western Ghats running along the West Coast of Karnataka. Udupi is located at the southwest corner of the Karnataka State. It has the greatest extent of 98 km. from north to south and 66 km. from east to west covering a total geographical area of 3,582 sq.km. The most conspicuous areas of very high and very low area of the district are located at 100 and 500 metres of contour lines above the mean sea level respectively.

Udupi District is one of the thirty districts in Karnataka State. It came into existence as a separate district (District Code 569) on August, 24th 1997. The district comprises administrative subdivisions Brahmavara, Byndoor, Hebri, Kapu, Kundapura, Karkala, Udupi, Taluks. Administratively, the district has 233 villages 3653 sub-villages, 158 Grama Panchayat (GPs), one city municipal Council (Udupi City), three Town Municipal council (Kundapura, Kapu and Karkala) and one Town Panchayat (Brahmavara) (**District At A Glance : Udupi District-Statistical Report - FY 2018-19**).

3.1 Physical features:

3.1.1 Location: Located between the foothills of Western Ghats in the East and Arabian Sea in the West, Udupi is one of the three coastal districts in the State. The district lies between 13^{0} 34'North latitude and 74^{0} 75' East longitudes covering an area of 3582 sq. km. It is about 88 km in length and about 100 km in widest part and is bounded by Uttara Kannada district in the North, Shivamogga and Chikamagalur districts in the East and Dakshina Kannada district in the South, while Arabian Sea forms its western boundary. Location of Udupi district and the district map are given in Fig 2.1a and 2.1b (Udupi District-Statistical Report- FY 2018-19).

3.1.2 Physiography: The total geographical area of the district is 3,582 square km, which constitute about 1.86 percent of the total geographical area of the state (Table 1.). Geographically, Kundapura is the largest Taluk with 887 sq.kms (22.29 percent), followed by Karkala, 721 sq.kms (15.32 percent) and Kapu is the smallest, 220 sq.kms (3.96 percent). The district is blessed with diversified endowments of nature. The district has three distinct natural regions; coastal region with a coastal belt of about 98 Kms, rolling midland plain terrain, covering 75 percent of the district and malnad region and the Ghats section with hills and thick forests. Many rivers take birth in the foothills of Western Ghats, flowing westwards and joining the Arabian Sea (Fig 1).
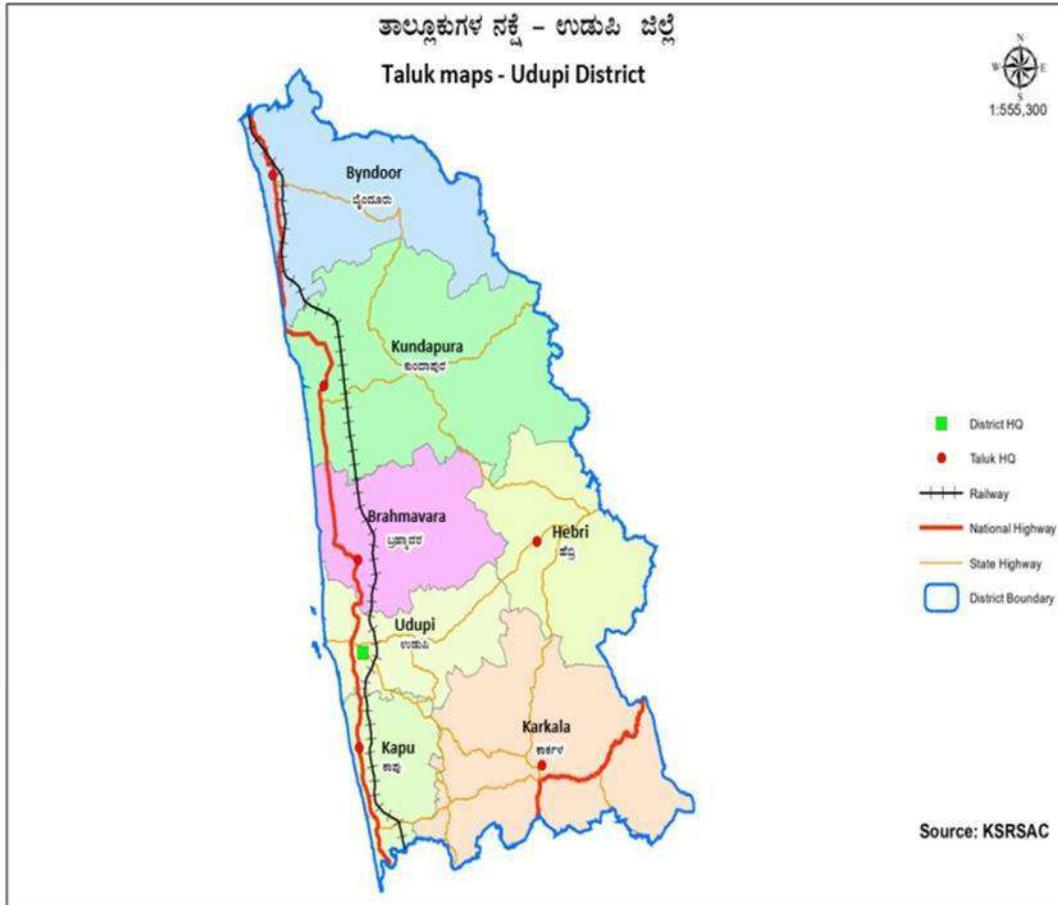
Figure 1: Different Taluks of Udupi Districts

3.1.3 Climate: The district comprises of three distinct physiographic regions: coastal belt, Midland plain terrain and malnad. The midland part between Western Ghats and the coast which constitutes more than 50 percent of geographical area, is upland plain terrain intercepted with forested low hilly topography with valleys. Udupi district has varied climatic zones. It is humid in the coastal region, cool in the Ghat region and warm in eastern region. Humidity is as high as 78 per cent during greater part of the year. The temperature ranges from 220 C in winter to 370 C in summer. Agro-ecology, climate, hydrology and topography are shown in (Table 1.). There are four distinct seasons viz. rainy season from June to September, following withdrawal of monsoon, two months of warm and damp weather during October and November, a pleasant winter season between December and February and a hot and sultry summer season from March to May. The district is blessed with high rainfall from the south-west monsoon. Normal annual rainfall is about 4285mm, which is the highest in the state (Fig 2).

Table 1: Annual Rainfall of Udupi district

Taluks	Year										
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Brahmavara	3252	4638	4411	4680	3974	3968	3205	2962	3742	3994	3682
Byndoor	3677	5126	5242	4994	3736	5136	3775	3469	3428	4974	3354
Hebri	3628	7075	4192	4541	4951	5092	4650	4463	3785	3706	5301
Kapu	2486	3881	4600	4324	4060	3990	3069	3281	3472	2922	3699
Karkala	4465	5791	5196	5469	4464	5145	4600	4381	3710	3938	4810
Kundapura	4013	5749	5176	5075	4283	4864	3909	3573	3529	4231	3382
Udupi	3154	4284	4668	4638	3898	4162	3320	3310	3355	3644	3431

(Source: District At A Glance: Udupi District-Statistical Report - FY 2018-19)
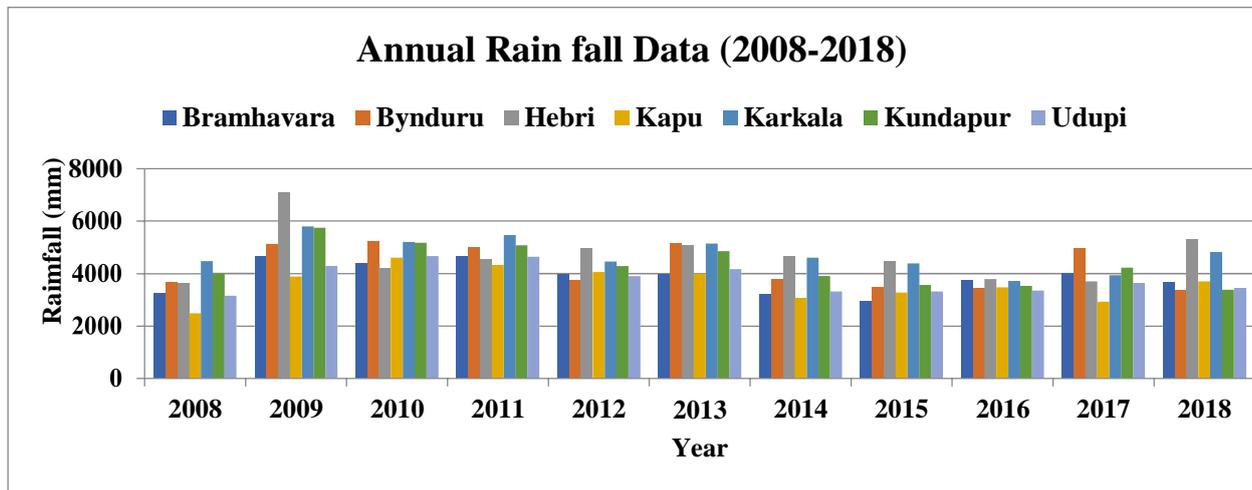
Figure 2: Annual Rainfall of Udupi district

3.1.4 Drainage: The main drainage of the district is westwards. As the Western Ghats are located on the eastern part of the district, the rivers and streams of this district necessarily flow from east to west. Varahi, Gangolli, Sitandi and the Swarna are the important rivers. In the monsoon season all the rivers and streams become swollen due to heavy rains and some of them overflow their banks, inundating the surrounding areas. But they do not last long, for they retrieve to their normal positions within a short period.
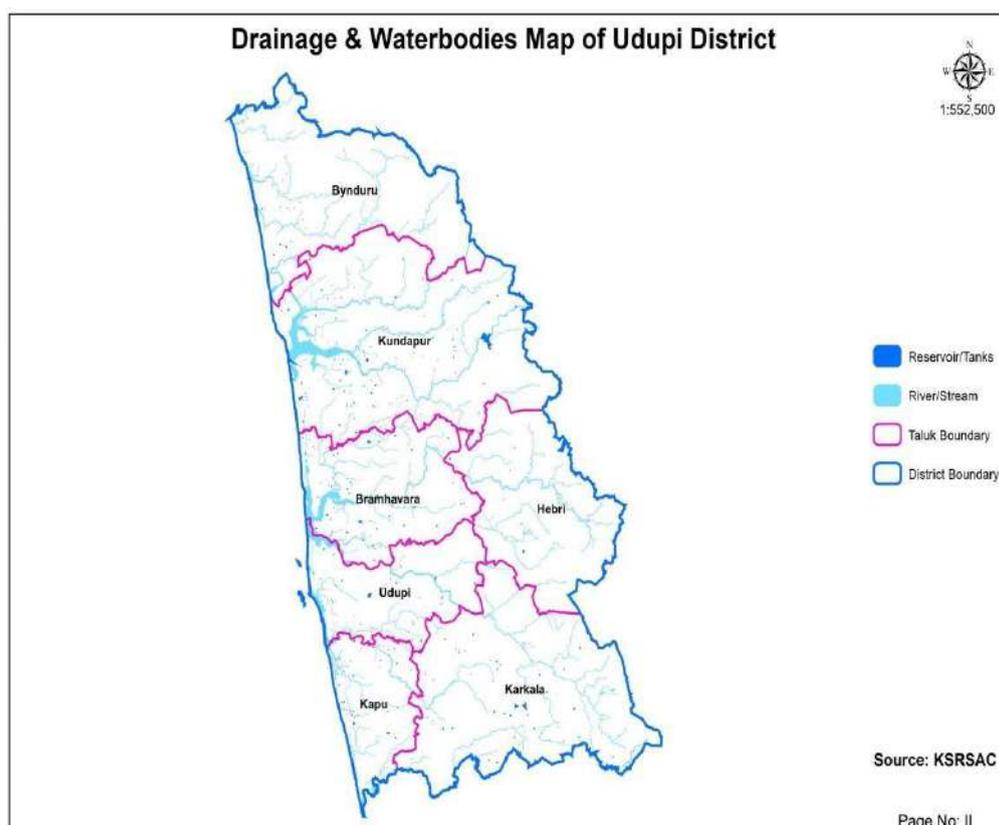
Figure 3. Drainage & Water bodies Map of Udupi District

3.1.5 Land use Pattern: Land utilization pattern in the district reveals that of the total geographical area of 3.56 lakh hectare (ha), the area under forest is one lakh ha (28 percent), area under cultivation, 97827 ha. (27 percent) and fallow land, 13270 ha (3.78 percent). The remaining 41 percent of the land is either not available for cultivation or uncultivable (Table 2.3) (Land Utilization (in Hectares): 2017 – 18 District at Glance).

Table 2. Land Utilization (in Hectares) of Udupi District

Taluks	Geographical Area	Forest	Land not available for Cultivation	Other uncultivated land	Fallow Land	Net cultivated area	Gross cropped area
Brahmavara	39820	2895	8989	9556	-	-	-
Byndoor	58312	28405	7112	7594	-	-	-
Hebri	45691	22917	2863	10230	-	-	-
Kapu	22020	475	4060	7746	-	-	-
Karkala	72081	14973	7690	28513	-	--	-
Kundapura	87563	29121	15203	16244	-	-	-
Udupi	30959	1316	8067	11380	-	-	-

(Source: District At A Glance: Udupi District-Statistical Report - FY 2018-19)

The district has one of lowest percentage of area under cultivation in the state. The net cultivated area in the district is 27 percent of geographical area as compared to state's 55 percent. Talukwise data on land utilization shows that Kundapura has the highest forest area (40 percent) followed by Karkala (30 percent) and Udupi has lowest (5 per cent). As against this, the proportion of net cultivated area is the highest in Udupi Taluk (34 per cent), followed by Kundapura (27 percent) and Karkala has the lowest (22 percent). The gross cropped area in the district is 1.11 lakh ha. The cropping intensity works out to 1.14 as against state average of 1.24 per cent. The low cropping intensity is mainly due to lack of irrigation facilities. There is no much inter-taluk difference in the cropping intensity. With fast urbanization, land use for non-agricultural purposes is increasing and thereby limiting the scope for further increase the net cultivated area. However, there is a good scope to increase the gross cultivated area by increasing the area under irrigation during rabi and summer seasons. There is also considerably a large area (35581 ha) of waste and fallow land which can be brought back under cultivation. The land use map of the district is given in **Fig.2.**

3.1.6 Forestry: Geographically the region is separated from the rest of south interior peninsula by the towering heights of the Western Ghats The slopes of the Western Ghats are clothed with dense forests containing valuable timber species. The heavy rainfall in this area stimulates the growth of the forests, which sometimes, begin with a few kilometres of the seacoast. Generally, dense forest begins about 30 to 40 km. from the coast. Six types of forests are found in the State. Of these, the district is naturally blessed with evergreen, semi-evergreen and moist forests. As per the statistics provided by the Directorate of Economics and Statistics and Annual Season and Crop Report 2017 - 18, out of the 356446 hectares of the total geographical area, 100102 hectares are covered under forest forming about 27.9 per cent of total geographical area. Dense forest areas are more in Kundapura and Karkala Taluks.

3.1.7 Flora: The climatic and soil conditions of the district have promoted the spontaneous growth of plants and trees in almost all parts. The slopes of Western Ghats are clothed with dense vegetation. In the coastal belt however, the tree-growth is somewhat sparse. The chief timber trees are the teak, rosewood, ben teak, kiralbhogi, Matti maravu and Kada halasu. The flora is luxuriant as well as complex and includes species like casuarinas, cashew trees, mango trees, etc. Climbers, reeds and canebrakes are found in abundance on the slopes of Western Ghats in the district. The pineapple was perhaps introduced into the district by the Portuguese and now it grows in considerable quantity all over the district. Turmeric is chiefly found in the Karkala taluk but is grown in small patches all over the district. Ginger, cardamom, plantains, pepper are some of the crops which are grown in the district.

3.1.8 Fauna: A large extent of forestlands in the districts affords a safe home to wild animals of the type generally found in Southern India. Indian Guar, Sambar, Spotted deer, Wild Boars, Monkeys, Rabbits, Foxes, Porcupine, Mongoose, Squirrels, etc. are amongst the important types of animals found in the district. Among the reptiles, Cobras, Python, Rat Snakes and the harmless green whip snakes are found in all parts of the district. The rivers, streams and the sea abound in a variety of fishes. Among the insects, butterflies and moths are found in great variety. The number of leaf insects and the stick insects is also considerable. The only economically valuable insect is the bee, which builds its nest on the higher branches of the lofty trees or in the clefts of rocks. Birds such as Peafowl, Jungle fowl and Spur fowl are seen in the forests. Partridges are not very common but Pigeons of several kinds are found. Domestic animals reared in this district are cattle, goats, buffaloes, sheep, horses and donkeys. Pigs of the common country breed are reared by some people. Fowls are kept by a large number of households. Particular attention is even now paid to the rearing of gamecocks, since cock fighting is a favourite pastime of the people in the rural sector

3.1.9 Geology and Soils: Geographically, the district contains rock formation belonging to the earliest period of the earth's history, namely the Archean epoch; except on the coastal strip. The coastal region contains recent and sub-recent deposits and the lateritic formations. The older metamorphic rocks constitute mainly the Dharwars and these are represented by the banded ferruginous quartzite and by the talc and hornblende schist. The soils of the district are essentially derived from the coastal strip. Soil structure of the district contains three types: sandy alluvium soil, yellow loamy soil and red lateritic soil. The sandy soils are confined to narrow strip of the coastal belt having width ranging from less than 100 meter to about one km. The fine to medium texture sandy soils is characterized by their extremely high rate of infiltration. Yellow loamy soils, which are mostly found along river banks and lower valleys, are fertile and well suited for irrigation and proved to be responsive to irrigation practices. The red lateritic soils are the most dominant soil type in midland area. The texture of the soils varies from fine to coarse.

3.1.10 Demography: As per 2011 census, the total population of Udupi district is 11.77 lakh, of which 5.62 lakh were males and 6.15 lakh females (Table 3). The proportion of male population works out to 47.7 per cent as against the women's share of 52.3 per cent. The sex Ratio works out to 1094 as against state average of 973. The population of Udupi district has increased by 65118 persons during the decade 2001-11 and in terms of percentage; it has registered a decadal growth of 5.8 per cent. The decadal growth rate of population of the district has recorded declining trend from 1981-1991 onwards; it declined from 9.4 per cent to 7.1 per cent during 1991 -2001 and to 5.8 per cent during 2001-11. The decadal growth of population is lower than state average of 15.7 per cent.

Table 3: Population census area & density of Udupi district (2011 census)

Sl No	Taluks	Geographical Area (Sq.kms)	Population Density	Population		
				Male	Female	Total
1	Brahmavara	398	437	83030	91042	174072
2	Byndoor	583	214	58936	66105	125041
3	Hebri	463	101	22604	24059	46663
4	Kapu	220	614	63595	71457	135052
5	Karkala	721	250	86179	94249	180428
6	Kundapura	887	296	123458	138972	262430
7	Udupi	310	818	124329	129346	253675
	Total	3582	330	562131	615230	1177361

(Source: Distract at a Glance 2017-18)

The district has one of the lowest decadal population growth rates in the state. The district has the lowest percentage of schedule caste (SC) population in the state. As against the state percentage of 17.2 per cent SC population, the district has only 6.4 percentage SC population. Even in the case of schedule tribe (ST) population, the district has 4.5 per cent as compared to state's 7 per cent. Taluk-wise, Kundapura Taluk has the highest population (2.62 lakh), followed by Udupi (2.53 lakh), Karkala (18.04 lakh), Bramhavara (1.74) Kapu (1.35 lakh), Bynduru (1.25 lakh) and Hebri (0.46 lakh). The population density of the district works out to 330 per sq.km as against the state population density of 319. Udupi taluk has the highest population density (818 per sq. km) and Hebri the lowest (101 per sq. km) Table 2.7. Out of 11.77 lakh population in the district, the rural population is 8.43 lakh (71.6 percent) and urban population, 3.34 lakh (28.4 percent). The share of rural population has declined from 81.5 percent in 2001 to 71.6 percent in 2011 and the share of urban population increased from 18.5 percent to 28.4 percent. In absolute numbers, the

rural population declined by 62590 and the urban population. Taluk-wise, Kundapura has the highest percentage of rural population (2.21 lakh), followed by Karkala (1.47 lakh). Hebri has the lowest (0.46 lakh) rural population.

The literacy rate in the district is 86.24 per cent as against the state average of 75.6 per cent. It has increased from 81.25 per cent in 2001. Next to Dakshina Kannada, the district has the highest literacy rate in the state. The literacy rate among males is 91.41 percent and among females 81.58 percent. In rural areas, the literacy rate is 83.9 percent and urban areas 92.1 percent. In rural areas 89.8 percent of males and 78.6 percent of females are literates, whereas in urban areas, male and female literacy rates are 95.2 percent and 89.2 percent respectively. During 2001 and 2011, the total workforce of the district has increased from 4.88 lakh to 5.13 lakh. While the male workers constitute 60 percent of total male population, the percentage share of female workforce in total female population is only 29 percent. The occupational pattern shows urban trends in rural employment, more workers are engaged in non-farm employment. The cultivators constitute 12.3 percent of workforce and agricultural labourers 12.4 percent. The number of cultivators in the district declined from 92662 in 1991 to 63143 while agricultural labourers declined from 82314 to 63390 (Table 4).

Table: 4 Literacy Rate of Udupi District (2011 Census)

Sl No	Taluks	Rural			Urban			Total		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
1	Brahmavara	57526	55630	113156	10977	10754	21731	68503	66384	134887
2	Byndoor	47244	45374	92618	-	-	-	47244	45374	92618
3	Hebri	17972	16889	34861	-	-	-	17972	16889	34861
4	Kapu	39027	41834	80861	15415	16084	31499	54442	57918	112360
5	Karkala	57579	58280	115859	13842	13916	27758	71421	72196	143617
6	Kundapura	81876	80399	162275	16775	16425	33200	98651	96824	195475
7	Udupi	23085	22531	45616	84386	82609	166995	107471	105140	212611
	Total	324309	320937	645246	141395	139788	281183	465704	460725	926429

(Source: District At A Glance: Udupi District-Statistical Report - FY 2018-19)

3.1.11 Agriculture:

Agriculture and allied activities are the backbone of the district's rural economy, where the majority of the population lives. In the coastal area, fishing is the main occupation. Agriculture and allied activities contributes 17 percent to district GDP. The district witnessed steady deceleration in gross cropped area since 2001. The gross cropped area declined from 133261ha in 2000-01 to 110929 ha in 2014-15. The cropping intensity which was 1.31 was reduced to 1.14 during this period (Table.5)

Table: 5 Agricultural Land Utilization of Udupi district

| Taluk/Year | Land Utilization (Hectares)- 2018-19 | | | | | | | | |
| | Geo-graphical Area | Land not Available for cultivation | | | | Other Uncultivated Land | | | |
		Forest	Non-agricultural uses	Barren & Uncultivated Land	Total	Cultivable waste	Permanent Pasture	Trees & Groves	Total
Bramhavara	39820	2895	7296	1693	8989	4440	1915	3201	9556
Bynduru	58312	28405	5250	1862	7112	1859	1192	4543	7594
Hebri	45691	22917	1897	966	2863	4333	766	5131	10230
Kapu	22020	475	3593	467	4060	2086	2292	3368	7746
Karkala	72081	14973	4756	2934	7690	14227	1371	12915	28513
Kundapur	87563	29121	12085	3118	15203	2946	2076	11222	16244
Udupi	30959	1316	7511	556	8067	6809	1011	3560	11380
Total	356446	100102	42388	11596	53984	36700	10623	43940	91263

The district has at present no any operational major and medium irrigation projects. Consequently, irrigated area is mainly through wells, tanks and check dams.

3.1.11. I Cropping Patterns: Agriculture is an important livelihood for the people of Udupi besides fishing. The cropping pattern in Udupi is mainly concentrated on paddy. During the crop year 2017-18, total area under paddy was 47095 ha. Paddy crop was mainly raised during Khariff - the rainy season. In Rabi season, mainly pulses and oilseeds are grown. Pulses grown are black gram, horse gram, green gram, cowpeas. The area under pulses was 3195 ha. Groundnut is the main oilseed grown in the district. Groundnut is grown in 1774 ha. Sesamum is grown in 32 ha. and other oilseeds in 29 ha. Paddy accounts for nearly 47 percent of the total gross cropped area, followed by pulses (4.6 percent) and oilseeds (1.8 percent). The area under food grains is steadily declining mainly due to high cost of cultivation and labour scarcity. The area under paddy cultivation has declined from 69892 ha in 1990 to 49555 ha in 2014-15. The area under pulses witnessed a decline from 11759 ha to 3948 ha during this period. Sugarcane, which was grown once in about 2000 ha, is now abandoned with the break-down of Brahmavara sugar factory.

The district has substantial acreage under horticultural crops. In the year 2017-18, the Coconut accounts for 17960 ha, areca nut, 8154 ha, cashew-nut 19373 ha, rubber 4693 ha, banana 992 ha, black pepper 353 ha, and vegetables 1533 ha. The district is also known for growing Mallige in 214 ha. The area under the plantation and horticulture crops also in recent years witnessed stagnation. Small and marginal farmers dominate the agricultural scene. Of the total holdings, 79 per cent are marginal farmers with land-holding less than 1ha. They own 34 per cent of the land area. Small farmers with 1 to 2 ha constitute 13 per cent of farmers and own 23 per cent of land. Marginal and small farmers, together, account for 92 per cent of farming community with less than 2ha holdings. The medium and large farmers with above 2ha, on the other hand, form 8 per cent of farming community and own 42 per cent of the land area cultivated. The average size of land-holding works out to 0.74 ha.

The chief crops grown are cashew nut, mango, banana, sweet potato, sapota, brinjal, papaya, tapioca, lemon, guava, and onion. The other condiments and spices produced in the district are dry chillies, turmeric, dry ginger and black pepper. One special variety of brinjal known locally as "Udupi Gulla" is grown in this district. The district is also known for growing coconut and arecanut in plenty.

3.1.12 Irrigation: There are no major irrigation projects in the district. The district enjoys an average annual rainfall of 4,252 mm and when compared to other districts it ranks first in the state in receiving the highest rainfall. The district is mostly dependent on southwest monsoon, which receives about 86-88 per cent of rainfall. The peculiar formation of the district on account of undulations with deep valleys interspersed with ridges and tablelands makes it difficult for reclamation and cultivation. Moreover, the abundant water available in the rivers and rivulets received from heavy rainfall drains off into the Arabian Sea without being utilized due to lack of facilities for storing the monsoon showers. In the recent past efforts are being made to improve the irrigation facilities and to bring more areas under irrigation. The greatest irony is that even though the district has bountiful rainfall and has many rivers with plenty of waters received through heavy showers during the monsoon; these rivers are emptying into the sea without their waters being properly utilized. In order to prevent the water being discharged into the sea and also to provide irrigation for the agricultural operations, Varahi Irrigation Project was envisaged and was approved by the Government in 1979 as a plan scheme. This project was designed to provide irrigation facility to an extent of 15,702 hectares benefiting Kundapura and Udupi Taluks. The project aims at constructing a pick-up dam across river Varahi at Horiyabbe site near Siddapura village in Kundapura taluk by utilising the daily discharge of tailrace water from Varahi Hydro Electric Project. Initially the height of the dam was proposed at 72 metres but

Table 6; Gross and Net irrigation areas of Udupi District

Sl No	Taluks	Tube Wells			Lift Irrigation			Other sources		Total	
		Nos	Gross Irrigated Area	Net Irrigated Area	Nos	Gross Irrigated Area	Net Irrigated Area	Gross Irrigated Area	Net Irrigated Area	Gross Irrigated Area	Net Irrigated Area
1	Brahmavara	38	59	59	724	370	336	642	642	4201	4156
2	Bynduru	32	58	58	73	152	148	699	697	4160	4110
3	Hebri	40	473	473	213	231	231	482	478	1900	1885
4	Kapu	23	40	40	149	32	26	546	524	3397	3359
5	Karkala	240	900	900	504	577	577	159	143	7258	7228
6	Kundapura	116	133	133	339	221	215	1616	1616	7918	7855
7	Udupi	22	33	33	243	202	173	567	556	3238	3194
	Dist. Total	511	1696	1696	2245	1785	1706	4711	4656	32072	31787

Title row: Gross and Net area Irrigated under different Sources: 2017 - 18 — Net Area Irrigated Under Difference Sources (Hectares)

(Source : ASCR : 2017-18)

subsequently reduced to 49.5 metres in order to reduce the submergence of forest area to the barest minimum of 275 hectares. In order to provide immediate irrigation facility to the farmers, a Varahi Lift Irrigation Scheme was accorded by the Government in 1992. Under this proposal, an extent of 2,723 hectares will be irrigated through this scheme (Table 6).

3.1.13 Animal Husbandry Livestock rearing plays an important role in the rural economy in the district. It supplements family income from agriculture and also provides employment. It is more vital wherever agriculture is predominant in the society. Farmers are dependent on animal husbandry activities to utilize agricultural by-products and crop residues to convert them into animal products with good returns. Particularly in this district, the climatic and topographical features have not been conducive for livestock rearing. Despite abundance of green vegetation, the livestock wealth of the district is not quite impressive. The table below shows the distribution of various types of livestock in the district. According to Livestock Census, 2007 the total livestock population in the district is 4,71,076 which includes cattle, buffaloes, sheep, goats, pigs, rabbits and dogs. The district is the 4th largest in the State in dogs' population. The total poultry stock is 11,01,159 (Table 7).'

Table 7: Livestock census data of Udupi District

	Livestock	Brahmavara	Byndoor	Hebri	Kapu	Karkala	Kundapura	Udupi
Cattle	Indigenous	10975	29299	13474	2322	28665	51673	18901
	Exotic Breed	0	0	0	0	0	0	0
	Cross Breed	12806	6082	5240	8372	12772	21378	30108
	Total	23781	35381	18714	10694	41437	73051	49009
Buffaloes	Buffaloes	416	966	312	90	1242	4143	1677
Sheep	Indigenous	0	15	3	-	-	5	38
	Exotic Breed	-	-	-	-	-	-	0
	Cross Breed	-	-	3	-	3	3	0
	Total	0	15	6	0	3	8	38
Goats	Goats	81	362	109	446	582	961	4059
Pigs	Indigenous	51	0	0	94	170	67	681
	Exotic Breed	0	0	0	0	0	0	0
	Cross Breed	276	285	130	114	66	655	509
	Total	327	285	130	208	236	722	1190
Rabbits		208	283	6	23	185	431	260
Dogs		7869	6807	7413	5342	18948	29525	16941
Others		0	0	0	0	0	7	4
Total Livestock		32682	44099	26690	16803	62633	108848	73178
Total Poultry		152635	212881	35796	166318	126983	257242	241917

(Source: Udupi District - Statistical Report - FY 2018-19)

3.1.14 Fisheries: Udupi district has rich resources for fisheries development. Its coastal line is about 100 kms. Fishing is a major economic activity in the district. Udupi is known for marine fishing and its exports. The marine fish landing of Udupi district constitutes about 98,217 MT for the year 2008-09. During 2008-09 Udupi district accounted for 49.03% of the total marine fish production. Ten Fish Landing Centres (5 in Udupi taluk and 5 in Kundapura taluk) and Malpe Fishing Harbour and Gangolli Harbour with all necessary infrastructures are located in Udupi district. There are 69 Ice plants, 8 Cold Storage, 5 Freezing Plants and 4 Frozen Storage in the district. Though in the recent past mechanized fishing is being practiced, a vast majority of the fishermen are still using the traditional fishing gears. The statistics on fishery for the year 2008-09 reveals that the district has 9,336 mechanized boats and 22,580 non-mechanized boats are being used for fishing purposes. The district has 10,700 various types of fishing nets for the purpose. Out of 1,19,241 Fishermen population, 60,048 are active fishermen. By way of comparison, it is higher than other districts of the state. The Government has introduced various welfare schemes such as Saving-cum-Relief Scheme, Group Accident Insurance for active

fishermen, Fisher Woman Co-operative Societies, Development of Model Fishermen villages under Matsyashraya Scheme, Motorization of Traditional Fishing Craft, Reimbursement of Central Excise duty on diesel used by mechanized boats, subsidy on Sales Tax on diesel used by mechanized fishing boats and Receipt and Payment of Distress Relief Fund to improve the socio-economic conditions of the fishermen in the coastal districts. The following table highlights in brief the fishing activity in the district (Table 8).

Table 8: Status fishing data of Udupi district

Sl No	Taluks	Fish catch (in Tonnes)	Ice Plants		Cold Storage Centres		No. of Fishing Tanks	
			Number	Capacity M. Tonnes / Day	Number	Capacity M. Tonnes / Day	Tanks of Panchayat Raj	Tanks of Minor Irrigation Department
1	Brahmavara	2957	5	200	0	0	6	1
2	Byndoor	9027	4	113	3	1674	8	0
3	Hebri	1	0	0	0	0	3	0
4	Kapu	3939	6	234	0	0	5	1
5	Karkala	3076	0	0	0	0	9	1
6	Kundapura	10500	23	652	9	5031	2	1
7	Udupi	91472	53	1945	5	470	12	1

3.1.15 Industries: Though agriculture is a predominant activity in the district, its growth in industrial sector is fast developing. There are no major industries in the district. However, the district is making all efforts to improve the small-scale industries in the region. The traditional industries around Udupi are tile manufacturing, beedi rolling, and cashew curing. The industrial units comprise of few textiles, chemicals and engineering units in the district. Besides these, there are also other units like automobile, electrical and electronics, chemicals, ferrous and nonferrous, food and intoxicants, glass and ceramics, leather, paper and printing, rubber and plastics and other small-scale industrial units, which have registered their growth. The table below gives the taluk-wise details of major factories for the year 2009-10. There are totally 338 factories in the district providing employment to 29,814 persons.

MATERIALS AND METHODS AND ANALYSIS

4.1 Physiography

The study area is 10 km radius around UPCL (13°9′35″N, 74°48′0″E), situated in Kapu, Karkala and Mangalore Taluks of the Karnataka state. The site is located on the Western coast at a distance of about 6.0 km from the sea front. The site is situated at Yelluru and Santhuru villages, which is about 3 km from Nandikur National Highway, NH 66, which connects Mangalore and Mumbai via Goa running along the western coastline of India. The project site can be approached by state highway connecting SH1 to Karkala town. The site is located adjacent to the new broad gauge line of Konkan Railways connecting Mangalore to Mumbai. The nearest airport is at Mangalore, which is about 35 km from the site. The nearest Sea port is New Mangalore Port Trust (NMPT), which is about 30 km from the site and the nearest Railway Station is Padubidri, which is about 3 km from the site.

M/s. Udupi Power Corporation Limited (UPCL), a subsidiary of Adani Power Limited (APL), has established a 2x600 MW coal-based power plant which is located in notified industrial area at villages Yelluru and Santhuru, Taluk Udupi, Dist. Udupi, in Karnataka state. These existing units of 2x600 MW of UPCL use 100% imported coal and both the units are in operation since November 2010 and August, 2012 respectively. About 2.2 million tons of coal per annum is imported from Indonesia (UPCL website). In August 2014, Lanco Infratech sold this power plant to Adani Power. Its power is distributed to Karnataka (90%) and Punjab (10%).

Memorandum of Understanding (MoU) for expansion of existing power plant has been signed between State Government of Karnataka and the Company, M/s UPCL. Hence the Company has proposed for expansion of existing 1200 MW (2x600 MW– Sub Critical Units in Phase I) coal-based power plant at villages Yelluru and Santhuru to 2800 MW by addition of 1600 MW (2x800 MW – ultra super critical units in Phase II) in the land adjacent to the existing power plant.

4.1.1 Study location
The Buffer area mainly consists of revenue areas of 36 villages that fall in 10.0 km periphery of the project site (Fig 4 &5). Majority of the land of the buffer area is occupied by the agriculture fields.

The broad categories of the land use types in the buffer area include agricultural fields, built-up areas, plantations, sandy beach, sea water and Reserve Forest (Pilarkhan RF).
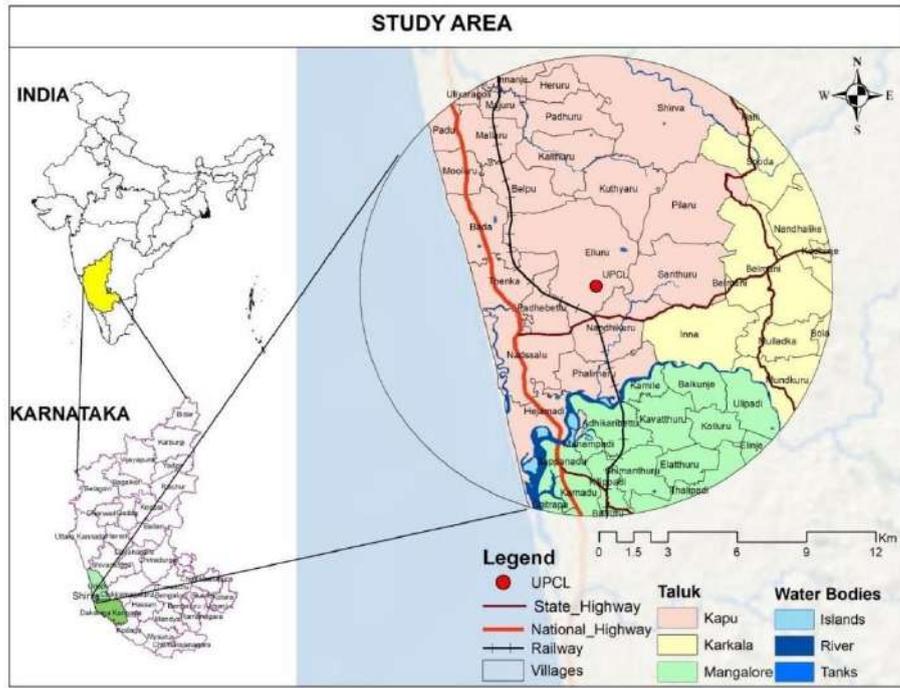
Figure 4: Study area map showing 10.0 km radius of buffer area.

Table 9. List of Villages in the study area

Sl. No	Village Name	Sl. No	Village Name	Sl. No	Village Name
1	Adhikaribettu	13	Yalatthuru	25	Padhebettu
2	Balkunje	14	Bada	26	Padhuru
3	Bappanadu	15	Belpu	27	Phalimaru
4	Mulladka	16	Hejamadi	28	Pilaru
5	Belman	17	Heruru	29	Santhuru
6	Karnire	18	Kalthuru	30	Shirva
7	Kavatthuru	19	Kuthyaru	31	Thenka
8	Kilippadi	20	Majuru	32	Yalluru
9	Kolluru	21	Mallaru	33	Inna
10	Manampadi	22	Mooluru	34	Mundkuru
11	Shimanthuru	23	Nadssalu	35	Nandhalike
12	Ulipadi	24	Nandikur	36	Sooda
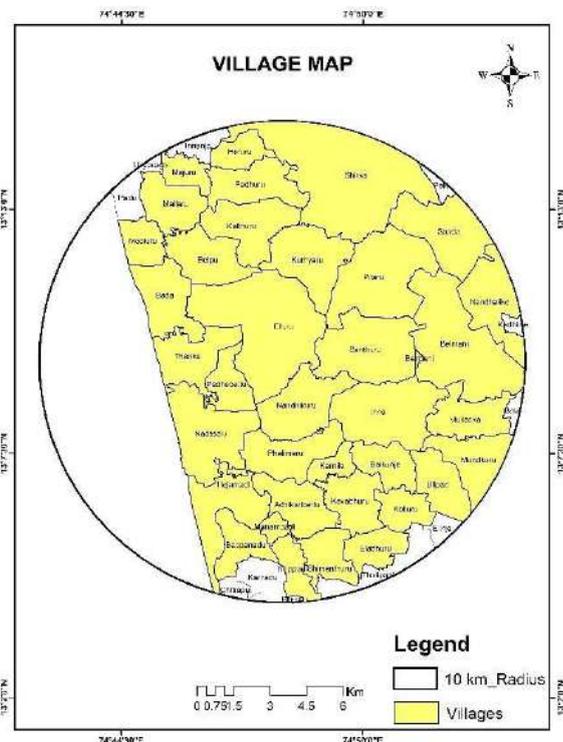
Figure 5: List of Villages in the study area

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In order to achieve the objectives envisaged in the Govt. order an integrated approach involving meteorological, remote sensing, geological, ecological, agricultural, biological and related scientific approaches have been followed. The methodology adopted for achieving the objectives is briefly discussed here.

1. Review of literature published by various government departments and other authentic sources and collection of secondary data from various government departments and organizations.

2. Collection of primary data on environmental parameters like air, water and soil being carried out.

3. Assessment of landuse and landcover status and changes noticed between 2002, 2012 and 2019 in the study area by using satellite imageries is completed.

4. Identification of various ecosystems and bio-diversity hotspots is being carried out.

5. Estimation of Carrying Capacity to develop the industrial siting guidelines in the study area is being carried out.

4.2 Objective-1

To collect the existing baseline data of Environmental Parameters and to assess the current environmental status duly considering the industrial and other land use activities.

4.2.1 Description of the Environment

Baseline Environmental parameters status data have been collected within the 10km radius of the project study site to determine the existing status of various Environmental attributes viz., Air, Water, Soil, Land use pattern, Ecological and Socio- Economical environment, this study would help to undertake corrective mitigation measures for protection of the environment on account of any change deviation of attributes due to activities of the proposed project.

Secondary data was collected from various Departments of State/Central Government Organizations, Semi- Government and Public Sector Organizations. Table 11 gives various environmental attributes considered for formulating environmental baseline and Table gives the frequency and monitoring methodology for various environmental attributes.

Table 10: Various Environmental Attributes

Sl. No	Attribute	Parameter	Source of Data
1	Land Use	Trend of land use change for different categories	Digitised LULC 2019 layers using Satellite imagery from NRSC (2019) thematic layers from KSRSAC (2002 & 2012)
2	Water Quality	Physical, Chemical and Biological parameters	Water samples are collected at different locations during this study period
3	Ambient Air Quality	PM2.5, PM10, NOx & SOx,	Secondary data from Karnataka State Pollution Control Board (KPCB)
4	Noise Levels		Secondary data from Karnataka State Pollution Control Board (KSPCB)
5	Ecology	Existing terrestrial flora and fauna within the 10 Kms radius of the study site.	Field survey and secondary sources from KFD.
6	Geology	Geological history	Secondary sources
7	Soil	Soil types and samples analysed for physical and chemical parameters	Field samples and secondary sources
8	Socio economic Aspects	Socio-economic characteristics of 36 different villages	Based on field survey

4.2.2 LAND USE, LAND COVER CHANGES (LULC)

LULC is one of the basic information required for assessing the status of any region. The inventories of various LULC patterns which were existing before and are existing presently will aid in assertion of changes which has occurred over time. This is primary step for identifying, planning and management of areas.

Details of different themes have been collected from Karnataka State Remote Sensing Application Centre (KSRSAC) which is a state nodal agency for all Remote Sensing and GIS works. Data is shared in form of shape files (.shp) for different layers. The layers shared by KSRSAC are prepared by digitizing on Satellite imagery and are verified on ground as well.

All the maps contain the necessary map elements out of which the legend is as per the classification of KSRSAC, which has class level 1 description (Fig 6).

The collected secondary data from KSRSAC is analysed and integrated for each layer. From the integrated data attribute information is extracted, analysed graphs and statistics are generated. From the analysed secondary data, final GIS maps are prepared with the scale of 1:50,000 (table 12).

Data Used

Table 11: Data sources for the study

Data	Year	Sources
Thematic Layers	2002 and 2012	KSRSAC
Satellite imagery	2019	NRSC
Toposheets(reference)	2010 and 2011	Survey of India
Google Earth (reference)	2019	Google earth
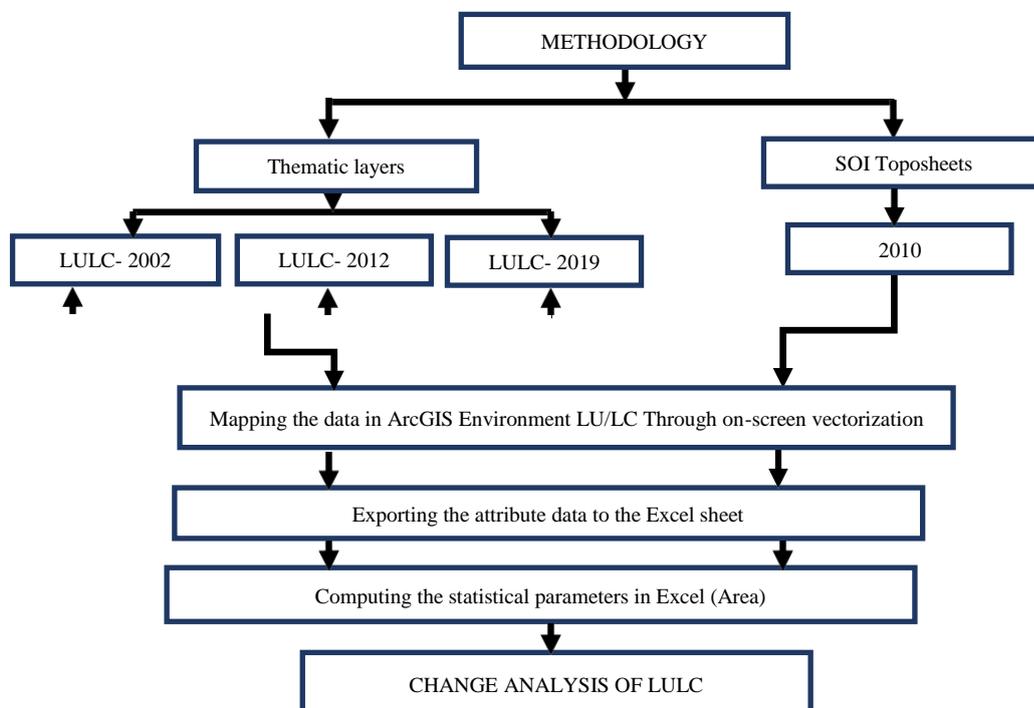
Figure 6: Flow chart for assessing the land use and land cover changes

This is primary step for identifying, planning and management of areas. In order to create LULC layer in GIS compatible manner and to provide an organized structure for future spatial analysis LULC layer data model is prepared.

The secondary data of Land use and Land Cover for the year 2002, 2012 and 2019 have been collected from Karnataka State Remote Sensing Application Centre (KSRSAC) which was shared in the form of shape files (.shp). Change detection analysis was carried out for the year 2002, 2012 and 2019 and quantifying the difference that has occurred.

Classification scheme has been adopted, five broad categories which can be applied to LULC. They are:

> ➢ Agricultural land
> ➢ Built-up areas
> ➢ Forests
> ➢ Wastelands
> ➢ Water bodies

- **Agriculture land:** It was defined as the land primarily used for farming and for production of food fibber or other commercial and horticultural crops. Agricultural area was again divided into Kharif, double crop and agricultural plantation.

- **Built-up areas:** Built up land covers buildings, roads, industries, etc., which was the area habituated by the human. In the present study, only important settlement locations are demarcated and considered for mapping.

- **Forest:** It was defined as an area of trees of species of forestry importance and raised on notified forestlands. It includes Eucalyptus, Casuarina, and Bamboo.

- **Wastelands:** Wasteland is defined as land which can be brought under vegetation cover with reasonable effort, and which is currently underutilized and deteriorating due to lack of appropriate water and soil management on an account of natural causes. Waste land was grouped into different classes as land with or without scrub and barren rocky/stony waste/sheet rock area.

- **Water bodies:** It was an area of impounded water, areal in extent and often with a regulated flow of water. It includes man made reservoirs/lakes/canals, besides natural lakes, rivers, streams.

4.2.2.2. Results of Land Use, Land Cover and its Change:

4.2.2.2. I Land use analysis: the Spatio-temporal land use changes during 2002 to 2012 were observed. The results of land-use and land cover changes depicted that the year 2002 (Table 13 & Fig 7) to 2012 ((Table 14 & Fig 8) the agricultural land area were decreased by 44.47%. It was observed that there was a rapid growth in the build-up area by increasing 50% within the study site. In case of forest land, the results show that there were no changes in the forest land from 2002 to 2012 data. Waste land and water body has decreased by 3.82% and 1.72% area respectively (Table 15).

Table 12: land use/land cover –2002

LULC Classification-2002	Area in Sq km	Area in %
Agricultural land	191.62	75.76
Built up	14.83	5.86
Forest	1.45	0.57
Wastelands	38.26	15.12
Water bodies	6.77	2.68
Grand Total	**252.93**	**100**
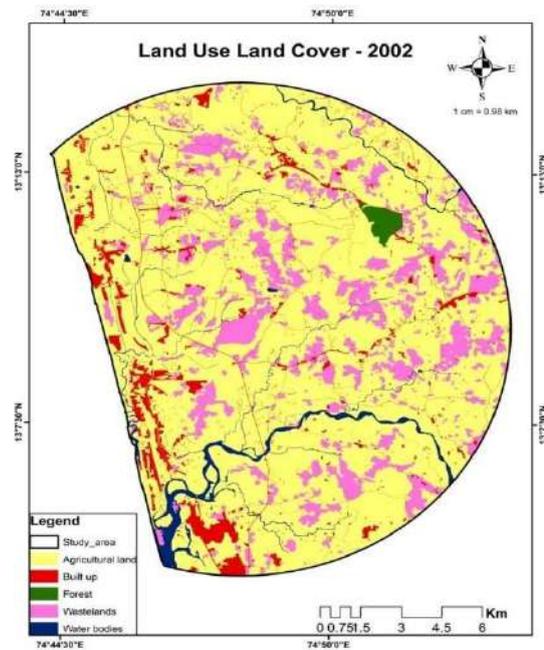
Figure 7: Land use Land Cover map - 2002

Table 13: land use/land cover – 2012

LULC Classification-2002	Area in Sq km	Area in %
Agricultural land	177.88	70.33
Built up	30.28	11.97
Forest	1.45	0.57
Wastelands	37.08	14.66
Water bodies	6.24	2.47
Grand Total	**252.93**	**100**
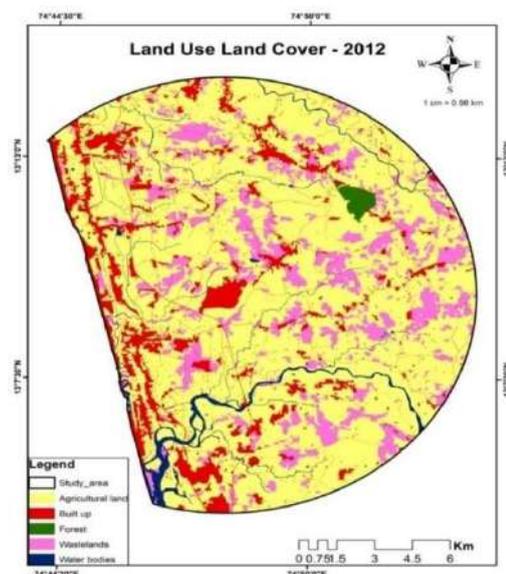
Figure 8. Land use Land Cover map for 2012

Table 14: land use/land cover - 2019

LULC Classification	Area in Sq. km	Area in %
Agricultural land	176.80	69.90
Built up	34.70	13.72
Forest	1.4568	0.57
Wastelands	33.46	13.23
Water bodies	6.53	2.58
Grand Total	252.93	100.00
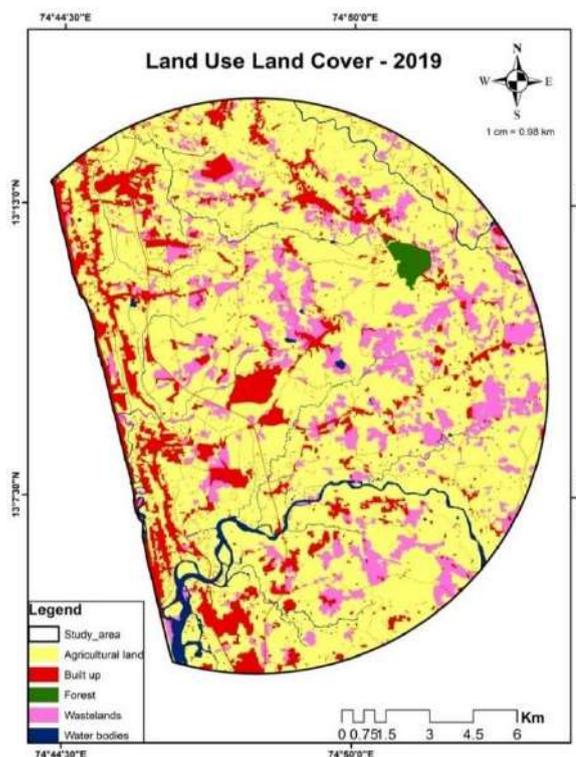
Figure 9: Land use Land Cover map for 2019

Table 15: Land use/land cover changes between the years 2002 and 2012

LULC Classification	Area in Sq. Km		Difference	Difference in %
	2002	2012		
Agricultural land	191.62	177.88	13.74 Decrease ↓	44.47
Built up	14.83	30.28	15.45 Increase ↑	50.00
Forest	1.45	1.45	No changes	-
Wastelands	38.26	37.08	1.18 Decrease ↓	3.82
Water bodies	6.77	6.24	0.53 Decrease ↓	1.72
Grand Total	252.93	252.93		

4.2.2.2. II Land use Land cover changes from 2012 to 2019

The agricultural land was decreased by 11.49% area with the increase in build-up area. The built-up area has increased by 47.02% area (Table 15 & Fig 9). It was observed that there was small decrease in the forest land about 0.02%. Waste lands and water body was decreased by 38.51% and 2.98% respectively (Table 16).

Table 16: Land use/land cover change between 2012 and 2019

LULC Classification	Area in Sq. km		Difference (Sq. Km)	Difference in %
	2012	2019		
Agricultural land	177.88	176.80	1.08 Decrease ↓	11.49
Built up	30.28	34.70	4.42 Increase ↑	47.02
Forest	1.45	1.4468	0.0019 Decrease↓	0.02
Wastelands	37.08	33.46	3.62 Decrease ↓	38.51
Water bodies	6.24	6.53	0.28 Increase ↑	2.98
Grand Total	252.93	252.93		

4.2.2.2. III Land use Land cover changes from 2002 to 2019

The agricultural, Forest, Waste land, and Water bodies shows that about 14.82 (37.31%), 0.0019 (0.005%), 4.80 (12.08%), and 0.28 (0.60%) sq. km area was decreased respectively and there was much conversion of built up area of about 19.86 sq. km area (50.00%).

The land use and land cover change as a temporal change occurs from the above map of 2002 and 2019. Study area in the year 2012 covered with the agricultural land patches but in the year 2019 agricultural land was drastically decreased.

The built-up area was significantly increased from 2002 to 2019 due to construction of houses, road, small scale industries etc (Table 17).

Table 17 : land use/land cover change between 2002 and 2019

LULC Classification	Area in Sq. km		Difference	Difference in %
	2002	2019		
Agricultural land	191.62	176.80	14.82 Decrease ↓	37.31
Built up	14.83	34.70	19.86 Increase ↑	50.00
Forest	1.45	1.4468	0.0019 Decrease↓	0.005
Wastelands	38.26	33.46	4.80 Decrease ↓	12.08
Water bodies	6.77	6.53	0.28 Decrease ↓	0.60
Grand Total	252.93	252.93		

It concludes that this study aims to investigate or focuses on land use land cover change detection from 2002, 2012 and 2019 in 10km radius of Kapu, Karkala and Mangalore taluk. The pattern of land cover has changed drastically over the past decade. The Land use types such as, Agricultural land and settlements have dramatically changed, but in different ways. The present study has added to our insight that the changes in land cover of different Land use types did not take similar pattern since the change in one Land use type is favored at the

expense of the other Land use type (for example, compare agricultural land vs. built up or wasteland vs. Built up). Therefore, land managers and conservationists would give due emphasis on understanding how the changes among different land use types are related and act accordingly on devising land use plan, agricultural production and conservation strategies.

4.3 DESCRIPTION OF THE ENVIRONMENTAL COMPONENTS

4.3.1 Air Quality Analysis

The prime objective of collecting the secondary data is to evaluate the existing air quality of the study area. This section describes the results of ambient air monitoring carried out by Karnataka Pollution Control Board (KSPCB) in the different locations of the study area. Various statistical parameters like average, maximum and minimum values have been computed from the observed raw data collected from KSPCB source. The data collected from 15.12.2020 to 18.12.2020 were analysed and following observations were made (Fig 10).

PM10: An average of maximum and minimum value of 50 and 29 µg/m^3 was noticed at R&R Colony Adamar Village and Inna Village respectively.

PM2.5: An average maximum and minimum value of 40 and 20 µg/m^3 was noticed at Mudurangadi Village and Hejmady Village respectively. **SOX** – An average of maximum and minimum value of 11 µg/m^3 was observed at Inna village of study areas (table 18).

Table 18: Analysis Report of Ambient Air Quality parameters (PM 2.5, 10, SOx, NOx) of the study site

Sl. No	Parameter Analysed	Standard (24hrs. Avg.)	Stations							
			Mudurangadi Village (GPS location Latitude 13.173659 & Longitude 74.821251)		R&R Colony Adamar Village (GPS location Latitude 13.171574 & Longitude 74.786834)		Hejmady Village (GPS location Latitude 13.097808 & Longitude 74.776902)		Inna Village (GPS location Latitude 13.142498 & Longitude 74.841005)	
			15.12.2020-16.12.2020	17.12.2020-18.12.2020	15.12.2020-16.12.2020	17.12.2020-18.12.2020	15.12.2020-16.12.2020	17.12.2020-18.12.2020	15.12.2020-16.12.2020	17.12.2020 18.12.2020
1	Particulate Matter(PM 10) in μ/m^3	100	38	40	35	50	44	45	38	29
2	PM $_{2.5}$ μ/m^3	60	40	29	33	26	31	20	38	23
3	Sulphur Di-Oxide (SO$_2$) μ/m^3	80	8	9	8	8	9	9	11	8
4	Nitrogen Di-Oxide (NO$_2$) μ/m^3	80	10	11	10	11	14	15	13	12

4.3.2 Water Quality Analysis

Selected water quality parameters of ground water and surface water resources within the study area have been considered for assessing the water environment. To assess the water quality of the study area, few groundwater sampling and surface water samples were collected and analyzed at Water laboratory, Environmental Management and Policy Research Institute and the results of the water quality samples were explained below.
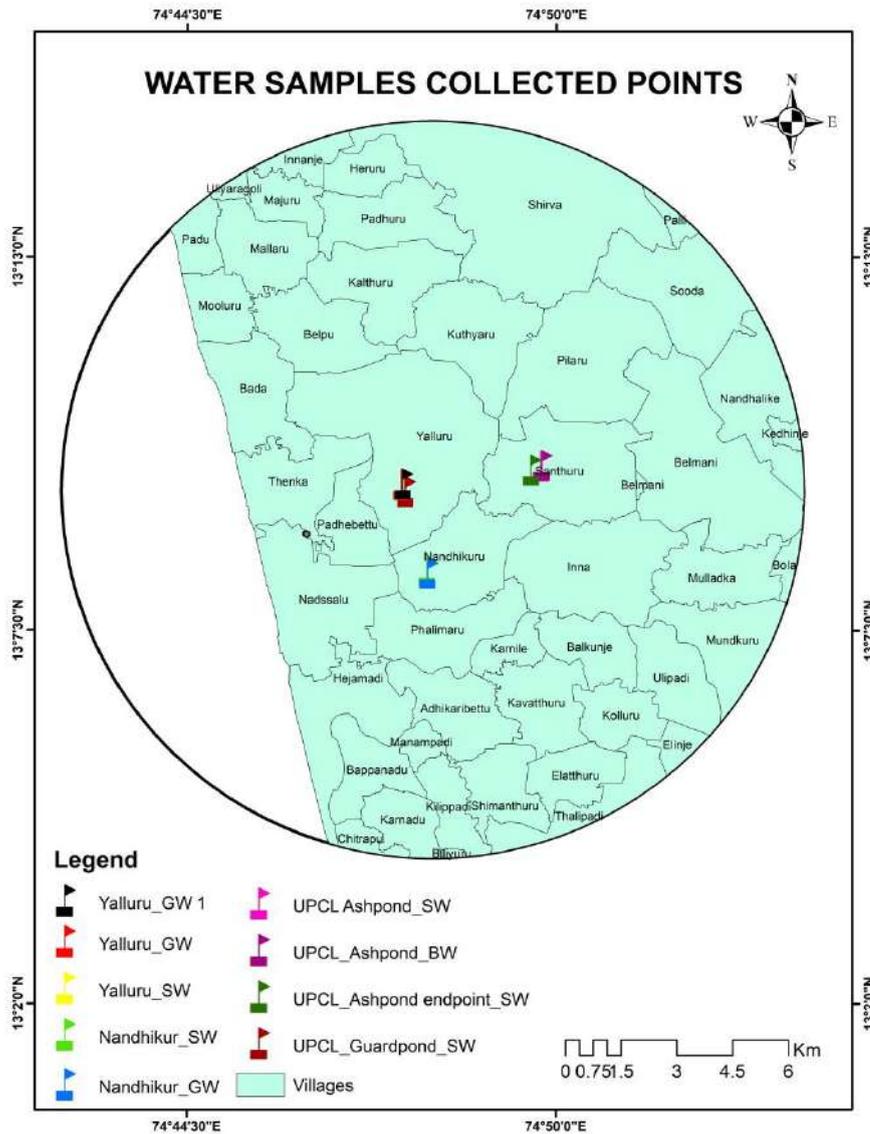
Figure 10: Water samples collected from study site

Fresh water samples were collected to know the quality of both the surface water as well as ground water. Nine water samples that were collected at different places within the study area are as given below.

Sl. No	Location	Type
1	13^0 09 38.20 -$74^0$47 43.63 Yelluru Village.	Ground Water
2	13^0 09 38.37 -$74^0$47 43.35 Yelluru Village.	Surface Water
3	13^0 08 22.28-74^0 48 05.80 Nandikur Village	Surface Water
4	13^0 08 20.85-74^0 48 06.45 Nandikur Village	Ground Water
5	13^0 09 38.02- $74^0$47 43.12 Yelluru Village.	Ground Water
6	UPCL Ash Pond End Point.	Surface Water
7	Inside the UPCL Plant.	Ground Water
8	UPCL Ash Pond Starting Point.	Surface Water
9	UPCL Guard Pond.	Surface Water

Inference: The samples from all the above places were analyzed and compared with Drinking Water Standards - IS 10500, 2012 and the results do not conform to the stipulated standards. The analysis reports are indicated in the result form and are given in the Table 19-27.

Table 19: Analysis of surface water of Nandikur Village (13^0 08 22.28-74^0 48 05.80)

Sl No.	Parameters	Units	Result	As per IS 10500: 2012 Drinking water		Methods followed for analysis
				Acceptable limit	Permissible limit in the absence of alternate source	
1.	pH at 25°C		5.6	6.5 to 8.5	No relaxation	APHA (23rd Ed.,): 2017 4500-H+B,4-95to4-99
2.	EC μS/cm at 25°C	μs/cm	467	NS	NS	APHA (23rd Ed.,): 2017 2510-B, 2-58 to 2-59
3.	Total Suspended Solids at 105°C	mg/L	11.0	NS	NS	APHA (23rd Ed.,): 2017 2540-D, 2-70 to 2-71
4.	Total Dissolved Solids at 180°C	mg/L	324	500	2000	APHA (23rd Ed.,): 2017 2540 C, 2-69 to 2-70
5.	Chloride	mg/L	95.64	250	1000	APHA (23rd Ed.,): 2017 4500-Cl-B, 4-75 to 4-76
6.	Total hardness as CaCO3	mg/L	270	200	600	APHA (23rd Ed.,): 2017 2340-C, 2-48 to 2-50
7.	Calcium as Ca	mg/L	5.05	75	200	APHA (23rd Ed.,): 2017 2340-B, 2-48 to 2-50
8.	Magnesium as Mg	mg/L	62.54	NS	NS	APHA (23rd Ed.,): 2017 2340-C, 2-37
9.	Alkalinity as CaCO3	mg/L	21	200	600	APHA (23rd Ed.,): 2017 2320-B, 2-37 to 2-39
10.	Sulphate as SO_4	mg/L	BDL	200	400	APHA (23rd Ed.,):2017 ,4500-SO4-E,4-199 to 4-200
11.	Fluoride as F	mg/L	0.91	1.0	1.5	APHA (23rd Ed.,): 2017 4500-F, 4-90 to 4-91
12.	Ammonia NH_3-N	mg/L	5.6	0.5	No relaxation	APHA (23rd Ed.,): 2017 4500-NH_3C , 4-116
13.	Phosphate as P	mg/L	12.27	NS	NS	APHA (23rd Ed.,): 2017 4500-P D, 4-163 to 4-164
14.	Nitrate as NO_3	mg/L	8.48	45	No relaxation	APHA (23rd Ed.,): 2017 4500- NO_3, 4-127
15.	Nitrite as NO_2	mg/L	BDL	NS	NS	APHA (23rd Ed.,): 2017 4500 NO_2 - B, 4-124 to 4-125

Table 20: Analysis of Ground water of Nandikur Village (13⁰ 08 20.85-74⁰ 48 06.45)

Sl No.	Parameters	Unit s	Result	As per IS 10500: 2012 Drinking water		Methods followed for analysis
				Acceptable limit	Permissible limit in the absence of alternate source	
1.	pH at 25°C		5.2	6.5 to 8.5	No relaxation	APHA (23rd Ed.,): 2017 4500-H+B,4-95to4-99
2.	EC μS/cm at 25°C	μs/cm	1,080	NS	NS	APHA (23rd Ed.,): 2017 2510-B, 2-58 to 2-59
3.	Total Suspended Solids at 105°C	mg/L	12.8	NS	NS	APHA (23rd Ed.,): 2017 2540-D, 2-70 to 2-71
4.	Total Dissolved Solids at 180°C	mg/L	647	500	2000	APHA (23rd Ed.,): 2017 2540 C, 2-69 to 2-70
5.	Chloride	mg/L	352.3	250	1000	APHA (23rd Ed.,): 2017 4500-Cl-B, 4-75 to 4-76
6.	Total hardness as CaCO3	mg/L	369	200	600	APHA (23rd Ed.,): 2017 2340-C, 2-48 to 2-50
7.	Calcium as Ca	mg/L	5.41	75	200	APHA (23rd Ed.,): 2017 2340-B, 2-48 to 2-50
8.	Magnesium as Mg	mg/L	86.38	NS	NS	APHA (23rd Ed.,): 2017 2340-C, 2-37
9.	Alkalinity as CaCO3	mg/L	21	200	600	APHA (23rd Ed.,): 2017 2320-B, 2-37 to 2-39
10.	Sulphate as SO_4	mg/L	16.88	200	400	APHA (23rd Ed.,):2017 ,4500-SO4-E,4-199 to 4-200
11.	Fluoride as F	mg/L	0.91	1.0	1.5	APHA (23rd Ed.,): 2017 4500-F, 4-90 to 4-91
12.	Ammonia NH_3-N	mg/L	5.6	0.5	No relaxation	APHA (23rd Ed.,): 2017 4500-NH_3 C , 4-116
13.	Phosphate as P	mg/L	BDL	NS	NS	APHA (23rd Ed.,): 2017 4500-P D, 4-163 to 4-164
14.	Nitrate as NO_3	mg/L	8.23	45	No relaxation	APHA (23rd Ed.,): 2017 4500- NO_3, 4-127
15.	Nitrite as NO_2	mg/L	BDL	NS	NS	APHA (23rd Ed.,): 2017 4500 NO_2 - B, 4-124 to 4-125

Table 21: Analysis of surface water of Yelluru Village (13⁰ 09 38.37 -74⁰47 43.35)

Sl No.	Parameters	Units	Result	As per IS 10500: 2012 Drinking water		Methods followed for analysis
				Acceptable limit	Permissible limit in the absence of alternate source	
1.	pH at 25°C		3.3	6.5 to 8.5	No relaxation	APHA (23rd Ed.,): 2017 4500-H+B,4-95to4-99
2.	EC µS/cm at 25°C	µs/cm	-	NS	NS	APHA (23rd Ed.,): 2017 2510-B, 2-58 to 2-59
3.	Total Suspended Solids at 105°C	mg/L	21.8	NS	NS	APHA (23rd Ed.,): 2017 2540-D, 2-70 to 2-71
4.	Total Dissolved Solids at 180°C	mg/L	2,930	500	2000	APHA (23rd Ed.,): 2017 2540 C, 2-69 to 2-70
5.	Chloride	mg/L	2,214	250	1000	APHA (23rd Ed.,): 2017 4500-Cl-B, 4-75 to 4-76
6.	Total hardness as CaCO3	mg/L	180	200	600	APHA (23rd Ed.,): 2017 2340-C, 2-48 to 2-50
7.	Calcium as Ca	mg/L	23.08	75	200	APHA (23rd Ed.,): 2017 2340-B, 2-48 to 2-50
8.	Magnesium as Mg	mg/L	29.74	NS	NS	APHA (23rd Ed.,): 2017 2340-C, 2-37
9.	Alkalinity as CaCO3	mg/L	BDL	200	600	APHA (23rd Ed.,): 2017 2320-B, 2-37 to 2-39
10.	Sulphate as SO_4	mg/L	210.88	200	400	APHA (23rd Ed.,):2017 ,4500-SO4-E,4-199 to 4-200
11.	Fluoride as F	mg/L	0.91	1.0	1.5	APHA (23rd Ed.,): 2017 4500-F, 4-90 to 4-91
12.	Ammonia NH_3-N	mg/L	4.2	0.5	No relaxation	APHA (23rd Ed.,): 2017 4500-NH_3 C , 4-116
13.	Phosphate as P	mg/L	1.54	NS	NS	APHA (23rd Ed.,): 2017 4500-P D, 4-163 to 4-164
14.	Nitrate as NO_3	mg/L	9.51	45	No relaxation	APHA (23rd Ed.,): 2017 4500- NO_3, 4-127
15.	Nitrite as NO_2	mg/L	BDL	NS	NS	APHA (23rd Ed.,): 2017 4500 NO_2 - B, 4-124 to 4-125

Table 22: Analysis of ground water of Yelluru Village (13⁰ 09 38.20 -74⁰47 43.63)

Sl No.	Parameters	Unit s	Result	As per IS 10500: 2012 Drinking water		Methods followed for analysis
				Acceptable limit	Permissible limit in the absence of alternate source	
1.	pH at 25°C		6.6	6.5 to 8.5	No relaxation	APHA (23rd Ed.,): 2017 4500-H+B,4-95to4-99
2.	EC µS/cm at 25°C	µs/cm	1,779	NS	NS	APHA (23rd Ed.,): 2017 2510-B, 2-58 to 2-59
3.	Total Suspended Solids at 105°C	mg/L	83.8	NS	NS	APHA (23rd Ed.,): 2017 2540-D, 2-70 to 2-71
4.	Total Dissolved Solids at 180°C	mg/L	1,559	500	2000	APHA (23rd Ed.,): 2017 2540 C, 2-69 to 2-70
5.	Chloride	mg/L	105.7	250	1000	APHA (23rd Ed.,): 2017 4500-Cl-B, 4-75 to 4-76
6.	Total hardness as CaCO3	mg/L	144	200	600	APHA (23rd Ed.,): 2017 2340-C, 2-48 to 2-50
7.	Calcium as Ca	mg/L	18.03	75	200	APHA (23rd Ed.,): 2017 2340-B, 2-48 to 2-50
8.	Magnesium as Mg	mg/L	24.05	NS	NS	APHA (23rd Ed.,): 2017 2340-C, 2-37
9.	Alkalinity as CaCO3	mg/L	168	200	600	APHA (23rd Ed.,): 2017 2320-B, 2-37 to 2-39
10.	Sulphate as SO_4	mg/L	BDL	200	400	APHA (23rd Ed.,):2017 ,4500-SO4-E,4-199 to 4-200
11.	Fluoride as F	mg/L	0.91	1.0	1.5	APHA (23rd Ed.,): 2017 4500-F, 4-90 to 4-91
12.	Ammonia NH_3-N	mg/L	2.8	0.5	No relaxation	APHA (23rd Ed.,): 2017 4500-NH_3 C , 4-116
13.	Phosphate as P	mg/L	BDL	NS	NS	APHA (23rd Ed.,): 2017 4500-P D, 4-163 to 4-164
14.	Nitrate as NO_3	mg/L	11.69	45	No relaxation	APHA (23rd Ed.,): 2017 4500- NO_3, 4-127
15.	Nitrite as NO_2	mg/L	0.30	NS	NS	APHA (23rd Ed.,): 2017 4500 NO_2 - B, 4-124 to 4-125

Table 23: Analysis of Surface water of UPCL Ash Pond End Point

Sl No.	Parameters	Units	Result	As per IS 10500: 2012 Drinking water		Methods followed for analysis
				Acceptable limit	Permissible limit in the absence of alternate source	
1.	pH at 25°C		7.7	6.5 to 8.5	No relaxation	APHA (23rd Ed.,): 2017 4500-H+B,4-95to4-99
2.	EC µS/cm at 25°C	µs/cm	532	NS	NS	APHA (23rd Ed.,): 2017 2510-B, 2-58 to 2-59
3.	Total Suspended Solids at 105°C	mg/L	1.8	NS	NS	APHA (23rd Ed.,): 2017 2540-D, 2-70 to 2-71
4.	Total Dissolved Solids at 180°C	mg/L	427	500	2000	APHA (23rd Ed.,): 2017 2540 C, 2-69 to 2-70
5.	Chloride	mg/L	201.4	250	1000	APHA (23rd Ed.,): 2017 4500-Cl-B, 4-75 to 4-76
6.	Total hardness as CaCO3	mg/L	59.4	200	600	APHA (23rd Ed.,): 2017 2340-C, 2-48 to 2-50
7.	Calcium as Ca	mg/L	8.65	75	200	APHA (23rd Ed.,): 2017 2340-B, 2-48 to 2-50
8.	Magnesium as Mg	mg/L	9.18	NS	NS	APHA (23rd Ed.,): 2017 2340-C, 2-37
9.	Alkalinity as CaCO3	mg/L	73.5	200	600	APHA (23rd Ed.,): 2017 2320-B, 2-37 to 2-39
10.	Sulphate as SO_4	mg/L	184.0	200	400	APHA (23rd Ed.,):2017 ,4500-SO4-E,4-199 to 4-200
11.	Fluoride as F	mg/L	0.91	1.0	1.5	APHA (23rd Ed.,): 2017 4500-F, 4-90 to 4-91
12.	Ammonia NH_3-N	mg/L	7.0	0.5	No relaxation	APHA (23rd Ed.,): 2017 4500-NH_3 C , 4-116
13.	Phosphate as P	mg/L	0.38	NS	NS	APHA (23rd Ed.,): 2017 4500-P D, 4-163 to 4-164
14.	Nitrate as NO_3	mg/L	11.17	45	No relaxation	APHA (23rd Ed.,): 2017 4500- NO_3, 4-127
15.	Nitrite as NO_2	mg/L	0.21	NS	NS	APHA (23rd Ed.,): 2017 4500 NO_2 - B, 4-124 to 4-125

Table 24: Analysis of ground water of UPCL

Sl No.	Parameters	Units	Result	As per IS 10500: 2012 Drinking water		Methods followed for analysis
				Acceptable limit	Permissible limit in the absence of alternate source	
1.	pH at 25°C		6.4	6.5 to 8.5	No relaxation	APHA (23rd Ed.,): 2017 4500-H+B,4-95to4-99
2.	EC µS/cm at 25°C	µs/cm	151	NS	NS	APHA (23rd Ed.,): 2017 2510-B, 2-58 to 2-59
3.	Total Suspended Solids at 105°C	mg/L	35.0	NS	NS	APHA (23rd Ed.,): 2017 2540-D, 2-70 to 2-71
4.	Total Dissolved Solids at 180°C	mg/L	120.8	500	2000	APHA (23rd Ed.,): 2017 2540 C, 2-69 to 2-70
5.	Chloride	mg/L	50.33	250	1000	APHA (23rd Ed.,): 2017 4500-Cl-B, 4-75 to 4-76
6.	Total hardness as CaCO3	mg/L	36	200	600	APHA (23rd Ed.,): 2017 2340-C, 2-48 to 2-50
7.	Calcium as Ca	mg/L	3.96	75	200	APHA (23rd Ed.,): 2017 2340-B, 2-48 to 2-50
8.	Magnesium as Mg	mg/L	6.34	NS	NS	APHA (23rd Ed.,): 2017 2340-C, 2-37
9.	Alkalinity as CaCO3	mg/L	94.5	200	600	APHA (23rd Ed.,): 2017 2320-B, 2-37 to 2-39
10.	Sulphate as SO_4	mg/L	BDL	200	400	APHA (23rd Ed.,):2017 ,4500-SO4-E,4-199 to 4-200
11.	Fluoride as F	mg/L	0.91	1.0	1.5	APHA (23rd Ed.,): 2017 4500-F, 4-90 to 4-91
12.	Ammonia NH_3-N	mg/L	4.2	0.5	No relaxation	APHA (23rd Ed.,): 2017 4500-NH_3 C , 4-116
13.	Phosphate as P	mg/L	1.94	NS	NS	APHA (23rd Ed.,): 2017 4500-P D, 4-163 to 4-164
14.	Nitrate as NO_3	mg/L	12.46	45	No relaxation	APHA (23rd Ed.,): 2017 4500- NO_3, 4-127
15.	Nitrite as NO_2	mg/L	BDL	NS	NS	APHA (23rd Ed.,): 2017 4500 NO_2 - B, 4-124 to 4-125

Table 25: Analysis of ground water of UPCL

Sl No.	Parameters	Units	Result	As per IS 10500: 2012 Drinking water		Methods followed for analysis
				Acceptable limit	Permissible limit in the absence of alternate source	
1.	pH at 25°C		6.1	6.5 to 8.5	No relaxation	APHA (23rd Ed.,): 2017 4500-H+B,4-95to4-99
2.	EC µS/cm at 25°C	µs/cm	115	NS	NS	APHA (23rd Ed.,): 2017 2510-B, 2-58 to 2-59
3.	Total Suspended Solids at 105°C	mg/L	351.2	NS	NS	APHA (23rd Ed.,): 2017 2540-D, 2-70 to 2-71
4.	Total Dissolved Solids at 180°C	mg/L	85.2	500	2000	APHA (23rd Ed.,): 2017 2540 C, 2-69 to 2-70
5.	Chloride	mg/L	50.34	250	1000	APHA (23rd Ed.,): 2017 4500-Cl-B, 4-75 to 4-76
6.	Total hardness as CaCO3	mg/L	54	200	600	APHA (23rd Ed.,): 2017 2340-C, 2-48 to 2-50
7.	Calcium as Ca	mg/L	3.60	75	200	APHA (23rd Ed.,): 2017 2340-B, 2-48 to 2-50
8.	Magnesium as Mg	mg/L	10.93	NS	NS	APHA (23rd Ed.,): 2017 2340-C, 2-37
9.	Alkalinity as CaCO3	mg/L	52.5	200	600	APHA (23rd Ed.,): 2017 2320-B, 2-37 to 2-39
10.	Sulphate as SO_4	mg/L	BDL	200	400	APHA (23rd Ed.,):2017 ,4500-SO4-E,4-199 to 4-200
11.	Fluoride as F	mg/L	0.91	1.0	1.5	APHA (23rd Ed.,): 2017 4500-F, 4-90 to 4-91
12.	Ammonia NH_3-N	mg/L	8.4	0.5	No relaxation	APHA (23rd Ed.,): 2017 4500-NH_3 C , 4-116
13.	Phosphate as P	mg/L	3.26	NS	NS	APHA (23rd Ed.,): 2017 4500-P D, 4-163 to 4-164
14.	Nitrate as NO_3	mg/L	13.10	45	No relaxation	APHA (23rd Ed.,): 2017 4500- NO_3, 4-127
15.	Nitrite as NO_2	mg/L	BDL	NS	NS	APHA (23rd Ed.,): 2017 4500 NO_2 - B, 4-124 to 4-125

Table 26: Analysis of Surface water of UPCL near Guard Pond

Sl No.	Parameters	Units	Result	As per IS 10500: 2012 Drinking water		Methods followed for analysis
				Acceptable limit	Permissible limit in the absence of alternate source	
1.	pH at 25°C		6.4	6.5 to 8.5	No relaxation	APHA (23rd Ed.,): 2017 4500-H+B,4-95to4-99
2.	EC µS/cm at 25°C	µs/cm	-	NS	NS	APHA (23rd Ed.,): 2017 2510-B, 2-58 to 2-59
3.	Total Suspended Solids at 105°C	mg/L	3.6	NS	NS	APHA (23rd Ed.,): 2017 2540-D, 2-70 to 2-71
4.	Total Dissolved Solids at 180°C	mg/L	12,428	500	2000	APHA (23rd Ed.,): 2017 2540 C, 2-69 to 2-70
5.	Chloride	mg/L	6,040	250	1000	APHA (23rd Ed.,): 2017 4500-Cl-B, 4-75 to 4-76
6.	Total hardness as CaCO3	mg/L	424.8	200	600	APHA (23rd Ed.,): 2017 2340-C, 2-48 to 2-50
7.	Calcium as Ca	mg/L	13.34	75	200	APHA (23rd Ed.,): 2017 2340-B, 2-48 to 2-50
8.	Magnesium as Mg	mg/L	96.10	NS	NS	APHA (23rd Ed.,): 2017 2340-C, 2-37
9.	Alkalinity as CaCO3	mg/L	63	200	600	APHA (23rd Ed.,): 2017 2320-B, 2-37 to 2-39
10.	Sulphate as SO_4	mg/L	522.7	200	400	APHA (23rd Ed.,):2017 ,4500-SO4-E,4-199 to 4-200
11.	Fluoride as F	mg/L	0.74	1.0	1.5	APHA (23rd Ed.,): 2017 4500-F, 4-90 to 4-91
12.	Ammonia NH_3-N	mg/L	8.4	0.5	No relaxation	APHA (23rd Ed.,): 2017 4500-NH_3 C , 4-116
13.	Phosphate as P	mg/L	BDL	NS	NS	APHA (23rd Ed.,): 2017 4500-P D, 4-163 to 4-164
14.	Nitrate as NO_3	mg/L	46.44	45	No relaxation	APHA (23rd Ed.,): 2017 4500- NO_3, 4-127
15.	Nitrite as NO_2	mg/L	8.61	NS	NS	APHA (23rd Ed.,): 2017 4500 NO_2 - B, 4-124 to 4-125

Table 27: Analysis of Ground water Yelluru Village (13^0 09 38.02- 74^{0}47 43.12)**.**

Sl No.	Parameters	Units	Result	As per IS 10500: 2012 Drinking water		Methods followed for analysis
				Acceptable limit	Permissible limit in the absence of alternate source	
1.	pH at 25°C		5.6	6.5 to 8.5	No relaxation	APHA (23rd Ed.,): 2017 4500-H+B,4-95to4-99
2.	EC µS/cm at 25°C	µs/cm	-	NS	NS	APHA (23rd Ed.,): 2017 2510-B, 2-58 to 2-59
3.	Total Suspended Solids at 105°C	mg/L	16.0	NS	NS	APHA (23rd Ed.,): 2017 2540-D, 2-70 to 2-71
4.	Total Dissolved Solids at 180°C	mg/L	2,548	500	2000	APHA (23rd Ed.,): 2017 2540 C, 2-69 to 2-70
5.	Chloride	mg/L	1,761	250	1000	APHA (23rd Ed.,): 2017 4500-Cl-B, 4-75 to 4-76
6.	Total hardness as CaCO3	mg/L	102.6	200	600	APHA (23rd Ed.,): 2017 2340-C, 2-48 to 2-50
7.	Calcium as Ca	mg/L	18.03	75	200	APHA (23rd Ed.,): 2017 2340-B, 2-48 to 2-50
8.	Magnesium as Mg	mg/L	13.99	NS	NS	APHA (23rd Ed.,): 2017 2340-C, 2-37
9.	Alkalinity as CaCO3	mg/L	31.5	200	600	APHA (23rd Ed.,): 2017 2320-B, 2-37 to 2-39
10.	Sulphate as SO$_4$	mg/L	BDL	200	400	APHA (23rd Ed.,):2017 ,4500-SO4-E,4-199 to 4-200
11.	Fluoride as F	mg/L	0.91	1.0	1.5	APHA (23rd Ed.,): 2017 4500-F, 4-90 to 4-91
12.	Ammonia NH$_3$-N	mg/L	22.4	0.5	No relaxation	APHA (23rd Ed.,): 2017 4500-NH$_3$ C , 4-116
13.	Phosphate as P	mg/L	3.16	NS	NS	APHA (23rd Ed.,): 2017 4500-P D, 4-163 to 4-164
14.	Nitrate as NO$_3$	mg/L	10.67	45	No relaxation	APHA (23rd Ed.,): 2017 4500- NO$_3$, 4-127
15.	Nitrite as NO$_2$	mg/L	BDL	NS	NS	APHA (23rd Ed.,): 2017 4500 NO$_2$ - B, 4-124 to 4-125

4.4. PEOPLE'S PERCEPTION SURVEY:

4.4.1 Introduction

A survey was conducted in the 36 villages surrounding the UPCL plant in Udupi district to know the socieo-economic, health, environment and ecological aspects of the respondents. The data was collected from a randomly selected 387 respondents in these villages in a prescribed questionnaire. The main objectives were

1. To know the socio-economic conditions of the residents

2. To elicit the opinion of the residents on the impact of the UPCL plant on their environment and their health conditions

3. To know their opinion on the expansion of UPCL plant and on setting up any new industry in the area

4.4.2 Methodology:

A structured questionnaire in Kannada language was used to collect the information. A random sample of 36 villages within a radius of 10Kms was first selected. In the second stage a random sample of 387 families was selected from the 36 villages selected at the first stage. For determining the sample size for the study the small sample techniques as suggested by Robert V. Krejcie and Daryle W Morgan [1] are adopted. The data collected in the prescribed questionnaire were further processed and tabulated using R software. A preliminary analysis is carried out. The summary tables with actual numbers and percentages are presented and used for interpretation. A graphical summary of the tables is also presented.

4.4.3 Results

The results are presented in different sub-sections as per the objectives listed above.

4.4.3.1 Socio-Economic conditions:

Classification of respondents by gender is given in table 28. From this it is observed that 69% of the respondents were males and the remaining were females. Thus there is adequate representation for both genders and hence there may not be any gender bias in the results. In the next Table 29 the distribution of respondents by the level of education. Only a small percent (1%) were illiterate, rest had at least primary education. Occupational classification of respondents is given in Table 30. Large proportions (69.25%) have Agriculture as their primary occupation. Fisheries are the occupation of 10.6%. Monthly income of 39.8% is found to be lesser than Rs. 10,000/- per month, while 50.6% had more than that and 10.8%

did not disclose their income (Table 31). Joint ownership of the property was observed among 57.1% and 27.1% singly owned their property and 15.87% did not disclose the information. Table 31a shows the size distribution of land holdings in the sample. Many did not disclose the size of their land holdings (72.0%).

Table 28: Distribution of respondents by gender

Gender	Number.	Percent
Male	268.00	69.25
Female	119.00	30.75
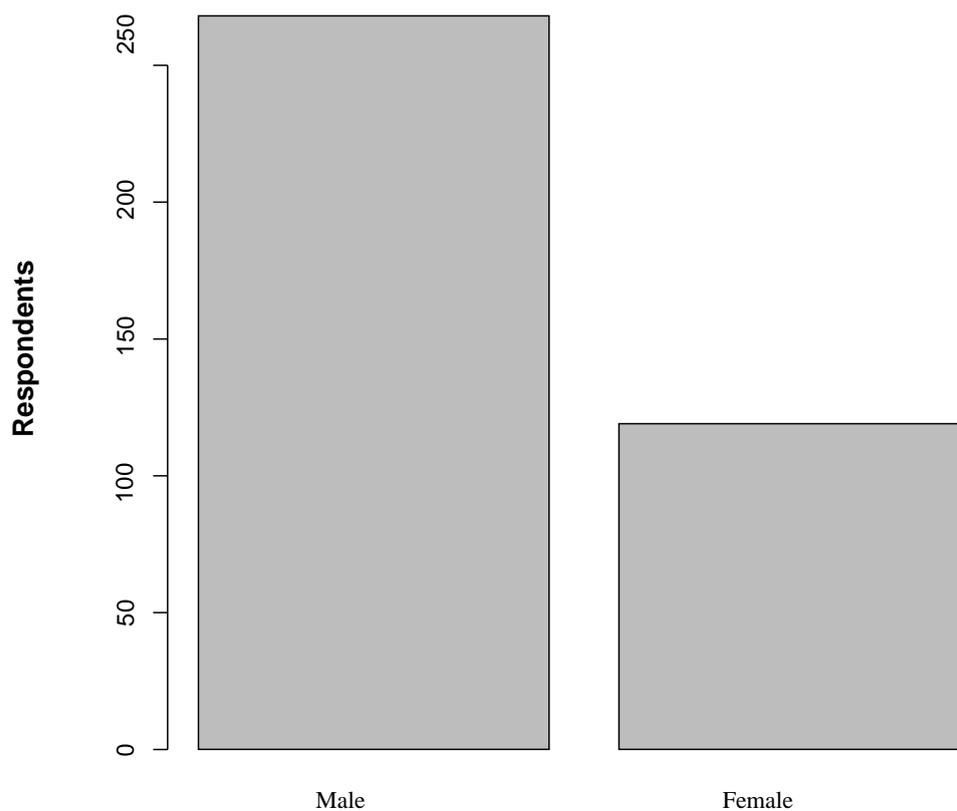
Figure 11: Distribution of respondents by gender

Table 29: Education level of Respondents

Education	Number.	Percent
Primary	104.00	26.87
High school	140.00	36.18
Pre university	56.00	14.47
Degree	64.00	16.54
Illiterate	5.00	1.29
NA	18.00	4.65
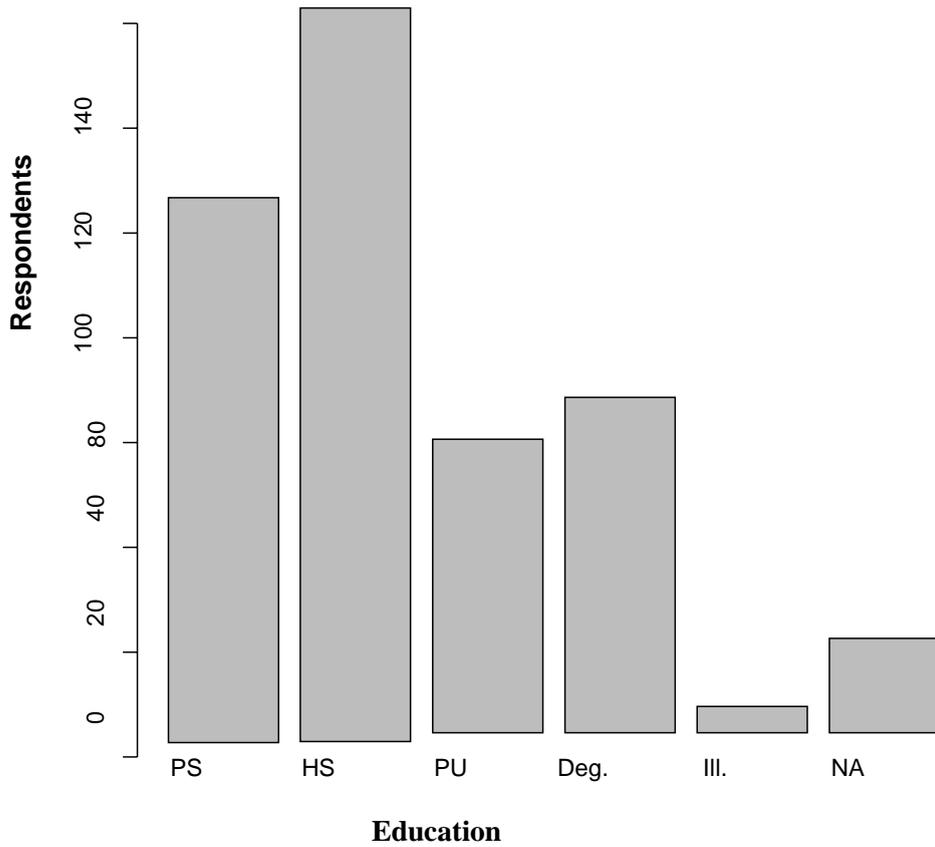
Education
Figure 12: Education level of respondents

Table 30: Occupation of Respondents

Occupation	Number	Percent
Agriculture	268.00	69.25
Agri, Private job	4.00	1.03
Agri,private job,Fishery	1.00	0.26
Agri,Business	14.00	3.62
Agri, Fishery	4.00	1.03
Govt.job	7.00	1.81
Private job	22.00	5.68
Private job,Fishery	2.00	0.52
Business	16.00	4.13
Fishery	41.00	10.59
Other	1.00	0.26
NA	7.00	1.81

Figure 13: Occupation of Respondents

Table 31: Distribution of monthly income

	Income (Rs./month)	Number.	Percent
1	Lesser than 10000	154.00	39.79
2	More than 10000	196.00	50.64
3	NA	37.00	9.56
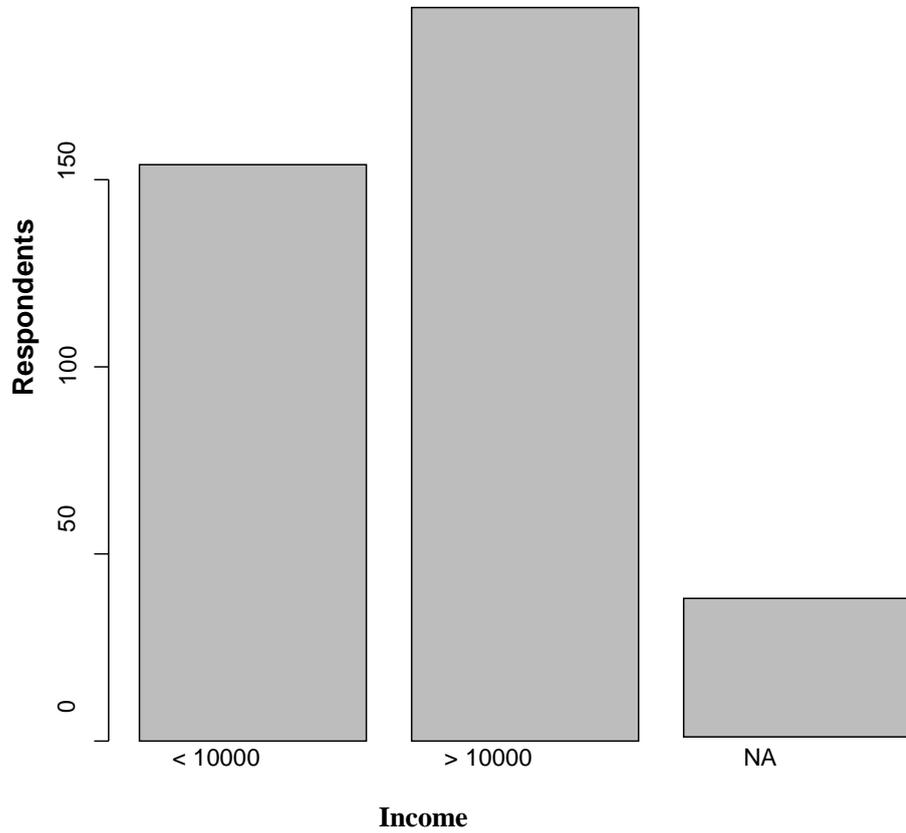
Figure 14: Respondents−Income

Table 32: Size of holdings of respondents

	Size(Acres)	Number.	Percent
1	Less than 1	5.00	1.29
2	1-2	19.00	4.91
3	2-5	50.00	12.92
4	5-10	26.00	6.72
5	10-20	5.00	1.29
6	40	1.00	0.26
7	50	2.00	0.52
8	NA	279.00	72.09
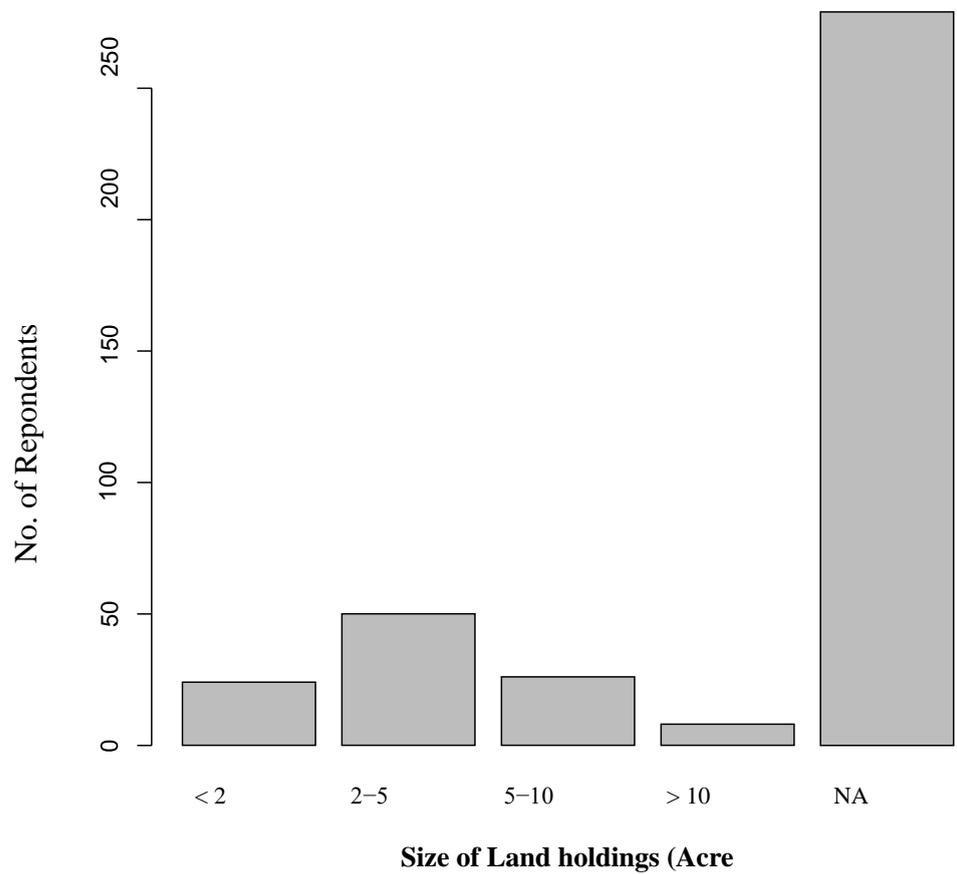
Figure 15: Land holding size in the study area

Table 33: Ownerships of Property by the respondents

	Ownership	Number.	Percent
1	Single	105.00	27.13
2	Joint	221.00	57.11
3	NA	61.00	15.76
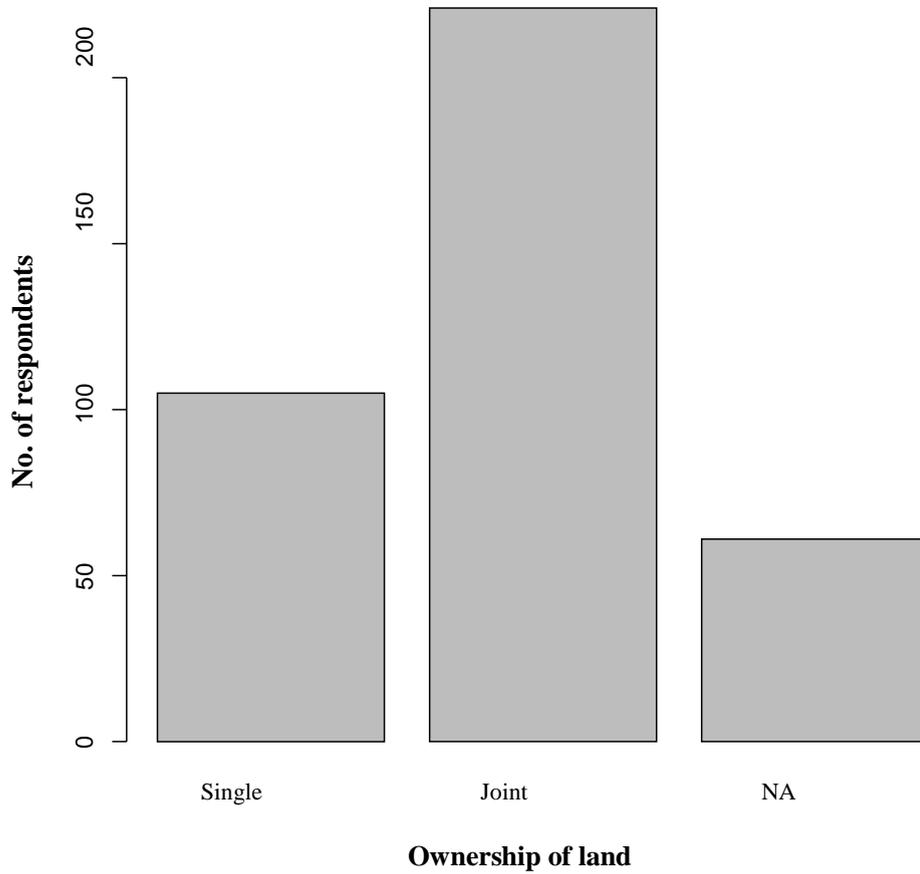
Figure 16: Ownership of lands in the study area

4.4.3.2 Impact of UPCL plant

From Table 35 it is observed that 84.75% suffered loss of their Agricultural land, 9.56% lost their house and land, while 10.85% failed to part with the information. It is observed from Table 34 that 93.5% expressed that there is no benefit from the UPCL plant, only 3.6% expressed on employment and a negligible 0.77% expressed improvement in infrastructure. From Table 36 it is observed that 54.26% had multiple health problems due to UPCL, 39.3%

had respiratory problems and 13.5% suffered from cough fever and head ache. From Table 37, 54.8% expressed their basic needs of air, water and soil was adversely affected by UPCL plant. Some also expressed that their lands and buildings are also adversely affected. Regarding unemployment (Table 38) 68.2% expressed that there is unemployment.

Table 34: Opinion on Benefits due to setting up UPCL

	Benefits	Number	Percent
1	Employment	14.00	3.61
2	Better infra	3.00	0.77
3	No benefits	363.00	93.56
4	Other	4.00	1.03
5	NA	4.00	1.03
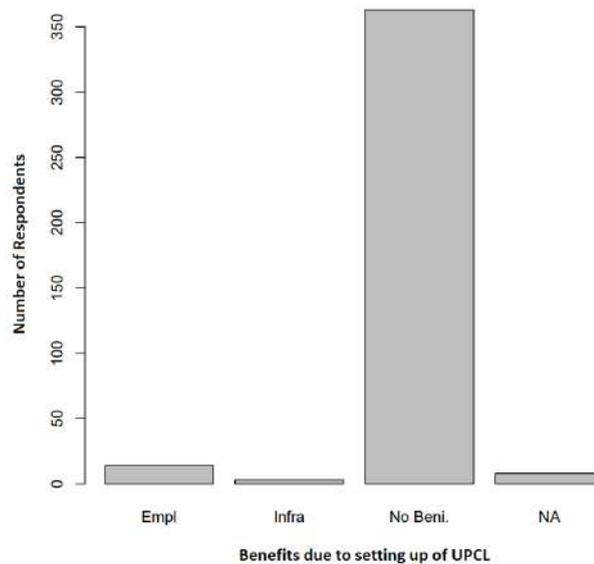
Figure 17: Opinion on Benefits due to setting up UPCL

Table 35: Effect of UPCL-LOSS

	Items	Number.	Percent
1	Agri. land	328.00	84.75
2	House	17.00	4.39
3	Land	20.00	5.17
4	Other	36.00	9.30
5	Fishery	17.00	4.39
6	NA	42.00	10.85
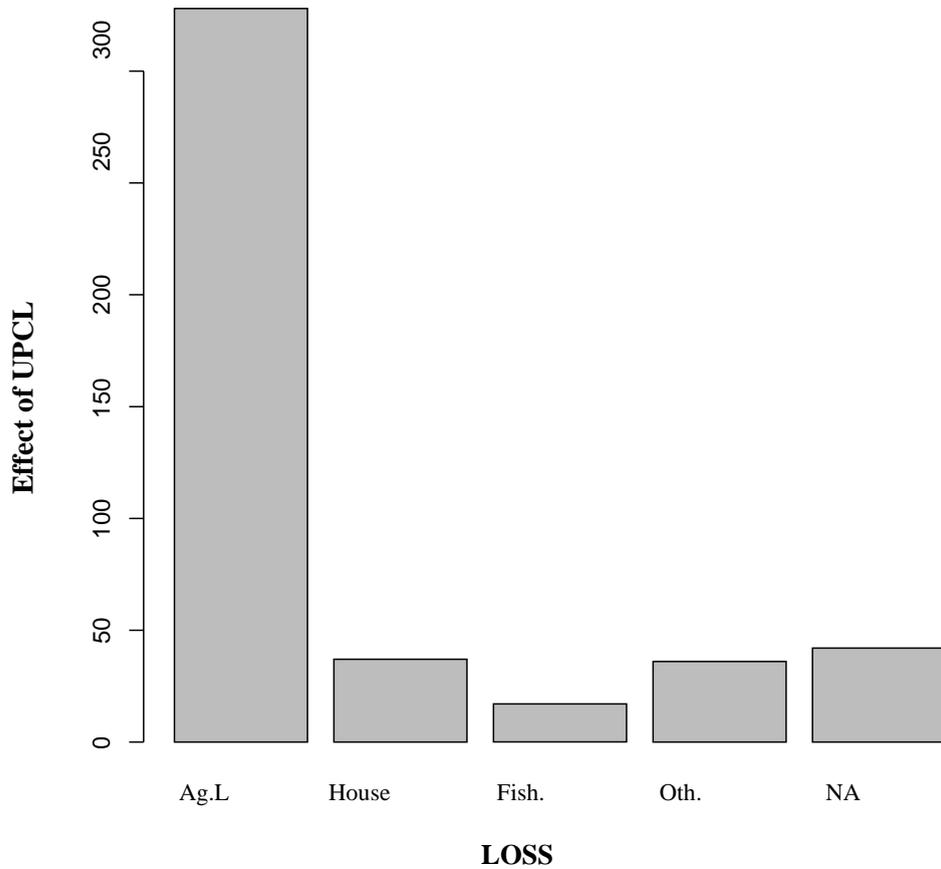
LOSS

Figure18: Represents the effect of Udupi power Corporation limited (UPCL) loss

Table 36: Health problems of the respondents due to UPCL

	Problems	Number	Percent
1	Cough	3.00	0.78
2	Fever	47.00	12.14
3	Headache	3.00	0.78
4	Breathing trouble	152.00	39.28
5	Others	41.00	10.59
6	Multiple problems	210.00	54.26
7	NA	11.00	2.84
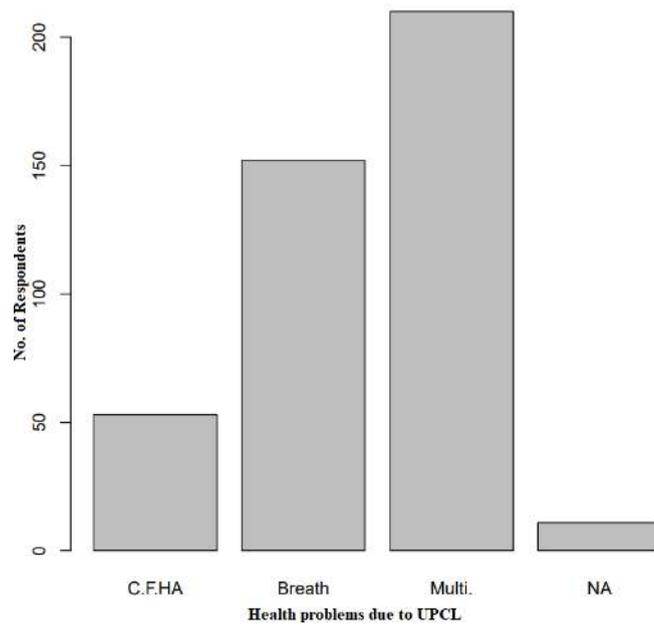
Figure 19: Health problems due to UPCL

Table 37: **Problems of Basic needs of respondents due to UPCL (1: Air, 2: Water, 3: Soil, 4: Land, 5: Building)**

	Problems	Number.	Percent
1	1	17.00	4.13
2	1,2	39.00	10.08
3	1,2,3	212.00	54.78
4	1,2,3,4	49.00	12.66
5	1,2,3,4,5	36.00	9.30
6	1,2,3,5	2.00	0.52
7	1,2,4	5.00	1.29
8	1,3	2.00	0.52
9	1,3,4	1.00	0.26
10	2	5.00	1.29
11	2,3,4	2.00	0.52
12	2,3,4,5	1.00	0.26
13	2,4,5	1.00	0.26
14	4	2.00	0.52
15	NA	13.00	3.36

Figure 20: Problems of Basic needs of respondents due to UPCL

Table 38: **Opinion about Status of Unemployment due to UPCL**

	Status	Number	Percent
1	Yes	264.00	68.22
2	No	1.00	0.26
3	Don't Know	122.00	31.52
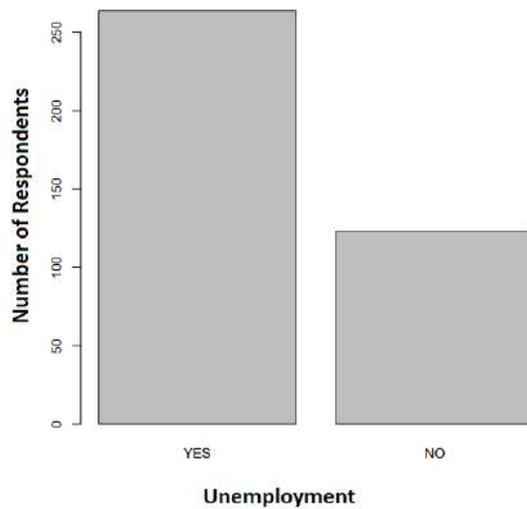
Figure 21: Opinion about Status of Unemployment due to UPCL

Table 39: Source of Cattle feed/fodder (1: Natural grass, 2: Planted grass, 3: Feeds from Market, 4: Crop residues

	Source	Number.	Percent
1	1	72.00	18.60
2	1,2	28.00	7.24
3	1,2,3	41.00	10.59
4	1,2,3,4	74.00	19.12
5	1,2,4	13.00	3.36
6	1,3	45.00	11.63
7	1,3,4	8.00	2.07
8	1,4	10.00	2.58
9	2	7.00	1.81
10	3	3.00	0.78
11	NA	86.00	22.22
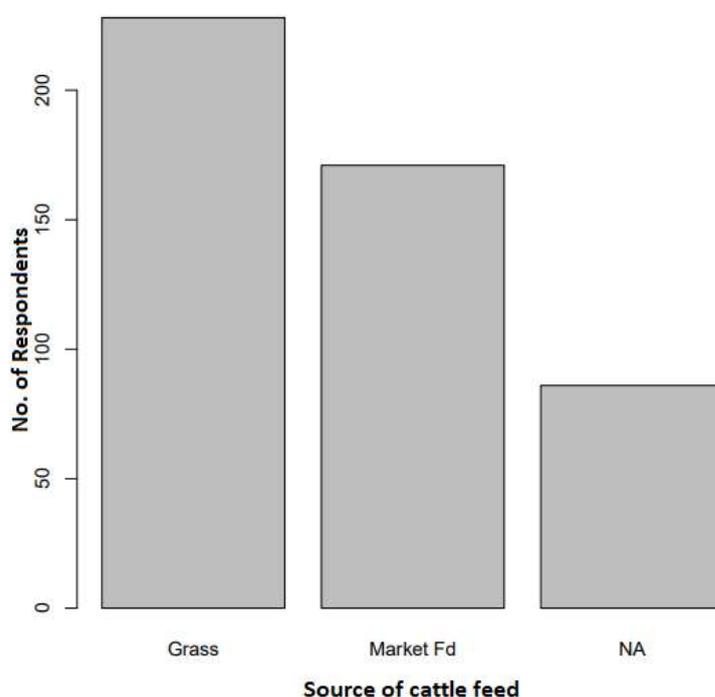
Figure 22: Source of Cattle feed/fodder

4.4.3.3 Other facilities

From Table 41 it is observed that 80.1% resided in "Kachcha" houses while 19.9% in "Pakka" houses. Good quality drinking water is available for 84.75% and remaining 14.25% got polluted and water unfit for drinking (Table 42). Majority (89.7%) got their drinking water from open wells and a small percentage (1.55%) got tap water (Table 43). The area grows crops mainly from rainfall (54%). Some (22.2%) also used bore wells and other

sources for irrigation (Table 44). Cattle are mainly fed with grass, both natural grass and planted grass. Crop residues and cattle feed from markets are also used (Table 39). Among the list of important places include places of worship, lakes, seashore and forest (Table 40).

Table 40: Opinion about Places of importance (1: Places ofworship, 2: Lake, 3: Seashore, 4: Forest, 5: Others)

	Places	Number	Percent
1	1	196.00	50.65
2	1,2	23.00	5.94
3	1,2,3	7.00	1.81
4	1,2,3,4	3.00	0.78
5	1,2,4	21.00	5.43
6	1,2,5	2.00	0.52
7	1,3	30.00	7.75
8	1,4	23.00	5.94
9	1,4,5	2.00	0.52
10	1,5	37.00	9.56
11	2	5.00	1.29
12	3	20.00	5.17
13	4	2.00	0.52
14	5	5.00	1.29
15	NA	11.00	2.84
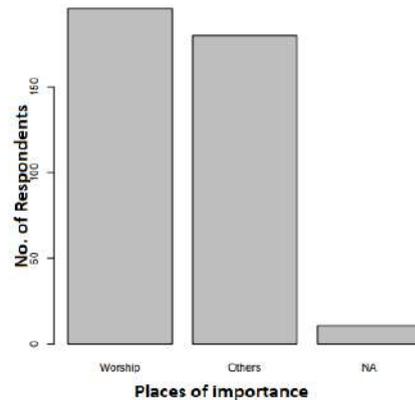
Figure 23: Opinion about Places of importance

Table 41: Condition of residential house of respondents

	Quality	Number	Percent
1	Pakka	77	19.90
2	Kachcha	310	80.10
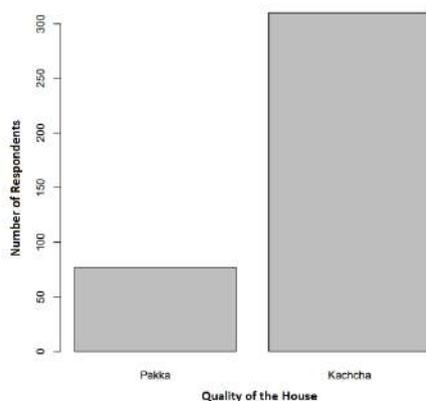
Figure 24: Condition of residential house of respondents

Table 42: Opinion about quality of Drinking water

	Quality	Number	Percent
1	Good	328.00	84.75
2	Polluted	33.00	8.53
3	Polluted, unfit	3.00	0.78
4	Unfit	23.00	5.94
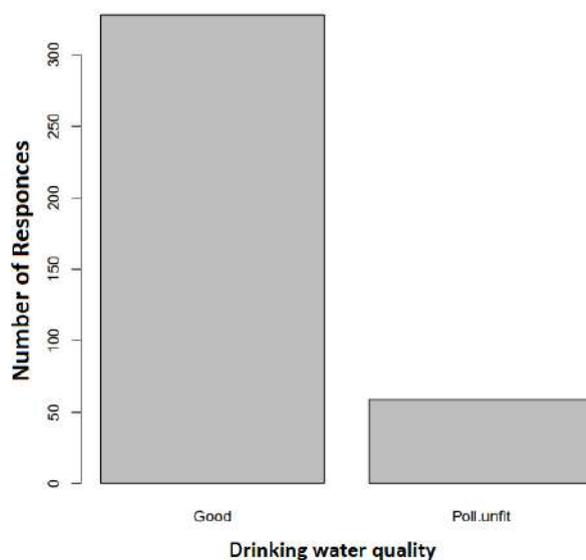
Figure 25: Opinion about quality of Drinking water

Table 43: Source of drinking water

	Source	Number	Percent
1	Bore well	8.00	2.07
2	Open well	347.00	89.66
3	Tap water	6.00	1.55
4	Bore/Open well	19.00	4.91
5	Other	4.00	1.03
6	NA	3.00	0.78
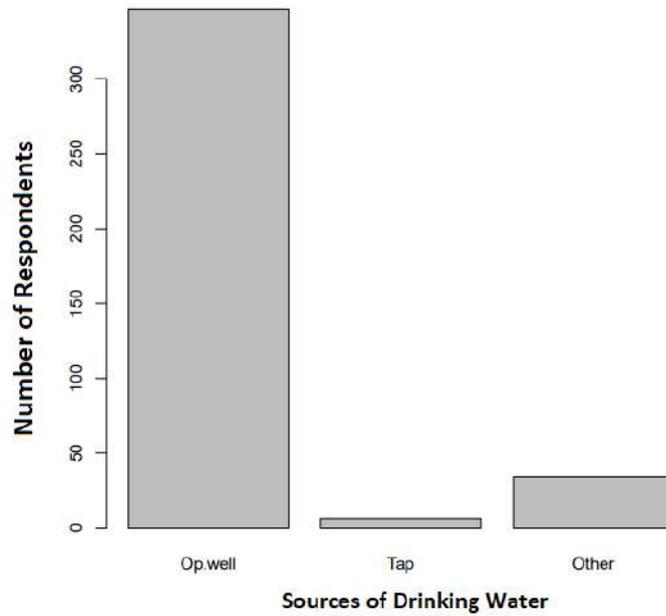
Figure 26: Source of drinking water

Table 44: Source of irrigation water (1:Rain, 2:Ground water, 3:Tanks, 4:Borewell, 5:Other)

	Source	Number.	Percent
1	1	203.00	52.45
2	1,2	4.00	1.03
3	1,2,3	4.00	1.03
4	1,2,5,	1.00	0.26
5	1,3	8.00	2.07
6	1,3,5	2.00	0.52
7	1,4	30.00	7.75
8	1,4,5	5.00	1.29
9	1,5	86.00	22.22
10	2	5.00	1.29
11	3	3.00	0.78
12	4	5.00	1.29
13	5	5.00	1.29
14	NA	26.00	6.72
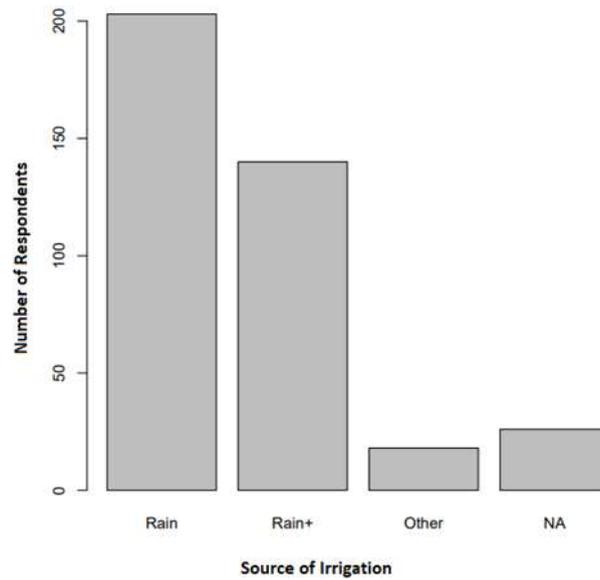
Figure 27: Source of irrigation water

4.4.3.4 Environment condition

The opinion on general environmental condition is given in Table 45. Opinion of 26.36%
was water pollution, air pollution and health problems persisted. Problems of health,
land/saoil erosion loss of trees in addition to air, water pollution was also observed (52.4%).
Local environmental condition (Table 46) was moderate (69.25%) and was healthy
(21.45%). In Table 47, 64.4% felt no health facility and 23.25% felt otherwise. From Table
48 it is observed that 95% of respondents saw a change in the landscape of the district.
Many did not respond (75%) regarding suffering from ill health in the family (Table 49).

**Table 45: Opinion about Environmental pollution problems (1:Water
pollution, 2:Airpolltion, 3:Health problem, 4:Land/Soil erosion, 5:Loss of
trees)**

	Opinion	Number	Percent
1	1,2,3	102.00	26.36
2	1,2,3,4	54.00	13.95
3	1,2,3,4,5	203.00	52.45
4	2,3,4,5	24.00	6.20
5	NA	4.00	1.03
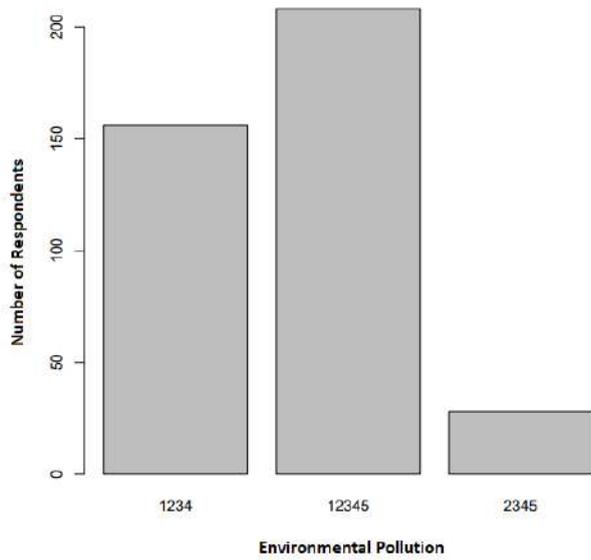
Figure 28: Opinion about Environmental pollution problems

Table 46: Opinion about your local environment (1: Very ugly, 2: Ugly, 3: Moderate, 4: Clean, 5: Healthy

	Opinion	Number	Percent
1	1	5.00	1.29
2	2	15.00	3.88
3	3	268.00	69.25
4	4	6.00	1.55
5	4,5	3.00	0.78
6	5	83.00	21.45
7	NA	7.00	1.81
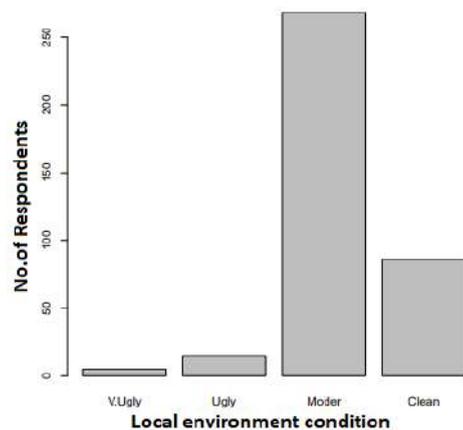
Figure 29: Opinion about your local environment

58

Table 47: Opinion about availability of health facilities

	Opinion	Number	Percent
1	Yes	90	23.25
2	No	257	66.41
3	NA	40	10.33
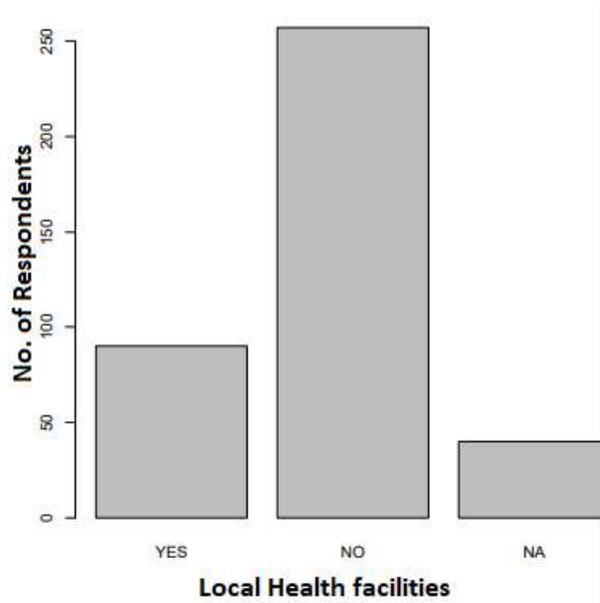
Figure 30: Opinion about availability of health facilities

Table 48: Opinion about change in the landscape of your district

	Opinion	Number	Percent
1	Change	367	94.82
2	No change	6	1.55
3	NA	14	3.62
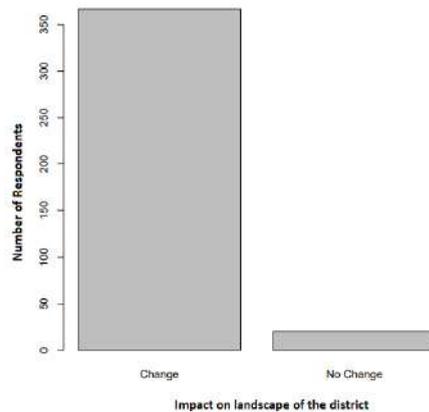
Figure 31: Opinion about change in the landscape of your district

4.4.3.5 Opinion on expansion of UPCL and setting up new industry

The opinion about expansion of UPCL was against (97.4%). For new industry 93.4% expressed against setting up of any new industry in the region (**Tables** 50 & 51).

Table 49: Anyone in the family suffering from ill health

	Opinion	Number	Percent
1	Yes	62	16.20
2	No	36	9.30
3	NA	289	74.67

Table 50: Opinion about the Expansion of UPCL plant

	Opinion	Number.	Percent
1	Yes	9	2.32
2	No	377	97.41
3	NA	1	0.26
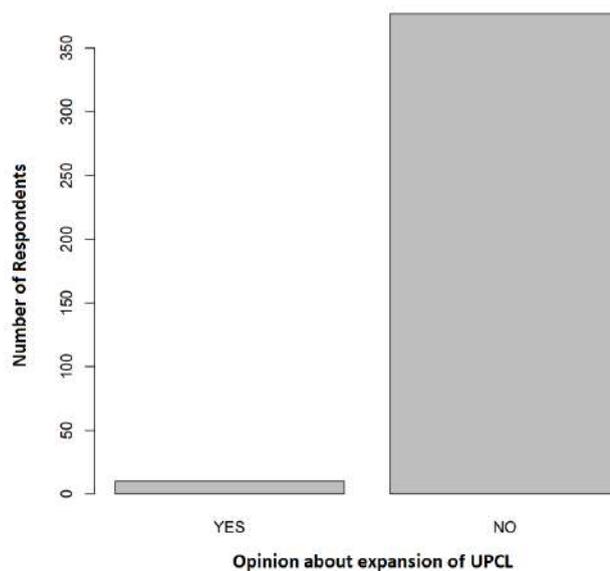
Figure 32: Opinion about the expansion of UPCL

Table 51: Opinion about starting new industries in the area

	Opinion	Number.	Percent
1	Yes	23	5.94
2	No	361	93.28
3	NA	3	0.77
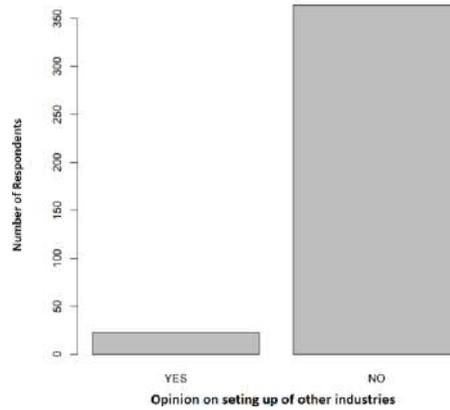
Figure 33: Opinion about starting new industries in the area

4.4.4 Conclusion

Based on the analysis of the survey data following conclusions emerge. This is purely a opinion or perception based socio-economic survey and the opinions on the quality of air, water and soil have to be corroborated on the basis of scientific analysis.

1   A large number of respondents who are primarily agriculturists have lost their agricultural land due to setting up of UPCL plant. People have also lost their houses and land.

2   Majority of the respondents are of the opinion that there are nobenefits from the UPCL plant and there is no improvement in the infrastructure also.

3   Health conditions of the residents of the area were adversely affected by the UPCL plant. Many people (54.25%) are of the opinion that people are suffering from multiple health problems and 39 percent expressed that people suffered from respiratory problems.

4   People were of the opinion that environmental pollution occurred with respect to Air, Water and Soil. According to 69.25 percent of respondents local Environmental conditions were moderate.

5   Most of the respondents (97.4%) expressed their opinion against the expansion of UPCL plant and 93.4% expressed their opinion against setting up of any new industry in the region.

4.5 Objectives 2: To identify the critical ecosystems and biodiversity hotspots in the region.

DESCRIPTION OF THE STUDY SITE

4.5.1 Vegetation:

The characteristic features of secondary evergreen or semi-evergreen forests are the preservation of a dense cover and structure, which are very similar to the initial climax forest but lacking the characteristic species of the initial climax forest (Pascal 1988). These forests, found in regions where anthropogenic pressure was initially very high, were protected after they were designated as reserve forests. In India, one such secondary forest is the Pilarkan Reserve Forest (74° 51' E and 13°12' N), covering an area of 124.32 hectares situated 3 km south- east of Shirva in Udupi District of Karnataka.

Bhat (1993) reported 160 species of angiosperms belonging to 135 genera and 75 families as well as the soil and climatic characteristics of this reserve forest. The soil is lateritic with an underlying rock of peninsular gneiss. The climate is of wet monsoon type with an annual rainfall of about 3500mm. This reserve forest is partly natural and partly the result of massive plan ting of *H. parviflora* and other species after the First World War (Bhat 1993) (Fig 34).
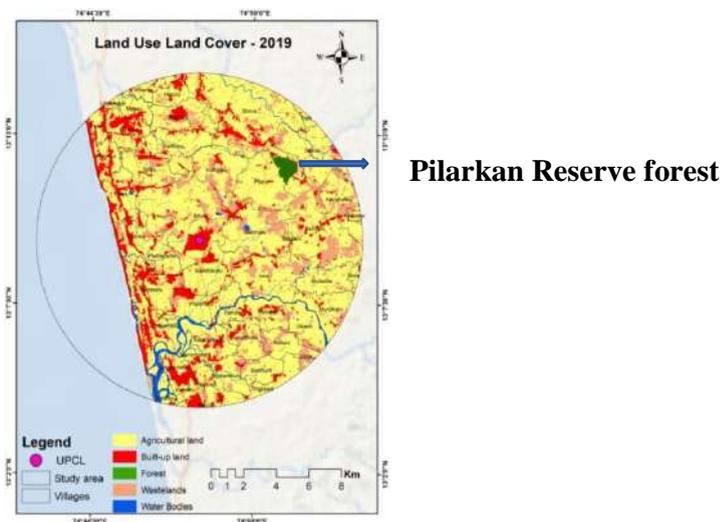
Figure 34: Location map of Pilarkan Reserve Forest at the study area

4.5.1.1 Sampling area

The entire reserve forest comes under a *kan* or *Devara kadu* (sacred grove) containing a small temple in the middle. The people around this forest consider this forest a sacred place and they are against any felling of trees. They strongly believe that any felling inside the forest will result in unforecastable happenings.

There is a small stream in the middle of the forest which dries up during the summer. There are

fewer number of trees towards the exterior, which may be due to the collection of dry leaves and branches, which is permitted to the locals.

4.5.1.2 Sampling design

The study was conducted in Pilarkan Reserve Forest (74° 51' E and 13°12' N), covering an area of 124.32 hectares located in 3 km south-east of Shirva in Udupi District of Karnataka.

The area has an average altitude of 28 meters above sea level, average annual rainfall of about 4285mm and the temperature ranges from 22^0 C in winter to 37^0 C in summer. The area is mainly covered by an irregular topography with depressions, numerous chain mountains, flat lands, gorges scattered trees and dense shrubs of patch natural vegetation.

4.5.1.3 Floristic data collection

Afield visit was carried out in the month of October 2020 to understand and assess the status of flora and fauna and natural habitats.

Reconnaissance survey was made across the natural forest in order to obtain vegetation patterns and determine representative sampling site. The vegetation data were collected using a systematic sampling method. One quadrate was laid in on 0.01sampling percentage such a way so as to include the areas with variation in the density. The woody species specimens were collected by laying quadrates of 38.1×38.1 m (1451.61m^2) and within the plot laid 5X5m for shrubs and 1X1m for regeneration study. The coordinates of the quadrate all corners and centre of the plot were recorded using a GPS and the coordinates are $13^0$1150' 1" 74o5109'09", $13^0$1149'03" $74^0$5108'51", $13^0$1149'24" $74^0$5107'10", $13^0$115'15" $74^0$5107'60" and E mid-point $13^0$1149'55" $74^0$5108'16" (Fig;35).
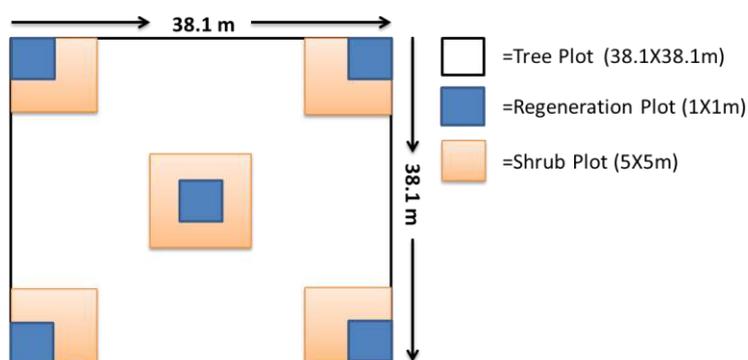
Figure 35: Layout of the quadrants for floristic assessment

All the trees >10 cm at 1.37-meter height (gbh) within the transect were botanically identified to the species level by using field guides (Pascal and Ramesh, 1987) and local floras (Saldanha, 1996; Keshavmurthy and Yoganarasimhan, 1990; Bhat, 2003). The regeneration and shrub growth of tree species was enumerated using measuring tape.

4.5.1.4 Data Analysis

Vegetational analysis was conducted using descriptive statistics to determine the relative dominance, relative frequency, relative density and the importance value of each species in the study site. Trees with the highest importance value will be those that exist in the greatest number or are of the greatest size. Once importance value is determined, a specific community can be described in terms of its most important species. Thus, communities are often described by the species or genera that are determined to be the most dominant in the community (Smith and Smith, 2002).

Various estimates of diversity were calculated using PAST (Hammer et al 2001). A simple estimate of diversity is species richness (number of species).

Basal area was estimated as an area of a circle (πr^2); the sum of the individual basal area was represented as a basal area of the plot and expressed as square meters.

Biomass of each individual was estimated allometrically using equation developed for calculation of biomass for CTFS forest dynamics plots by J. Chave based on Chave et al 2014. This equation estimates biomass based on the diameter of an individual. Half of biomass is considered as carbon content based on IPCC definition.

4.5.1.5 Observations of Floristic analysis

Tree, shrubs and herbs population were enumerated by direct counting method. Different species were identified by referring the key provided and measured the height, girth of each species. Using some basic formulas, estimated the biomass and carbon of tree species of the forest. Total 474 individuals were identified, out of which 40 species of Angiosperms have been documented belonging to 36 genera and 32 families. Two species of Pteridophytes were also seen. Later the individuals were categorised as an Herb, Shrub, Trees, and Climbers etc. The complete list of floral diversity is as follows (Table 52) (Table 53).

Table 52: List of floral species in Pilarkan Reserve Forest and IUCN classification

Sl. No	Species	Family	Category	Threat Status
1	*Adenia hondala* (Gaertn.) W.J. de Wilde	Passifloraceae	Climber	-
2	*Anamirta cocculus* (L.) Wight. & Arn.	Menispermaceae	Climber	-
3	*Artocarpus hirsutus* Lam.	Moraceae	Tree	Endemic & Threatened
4	*Bulbophyllum sterile* (Lam.) Suresh	Orchidaceae	Orchid	-
5	*Canthium coromandellicum* (Burm.f.) Alston	Rubiaceae	Herb	-
6	*Carissa spinarum* L.	Apocynaceae	Shrub	-
7	*Cissus javana* DC.	Haloragaceae	Climber	-
8	*Clerodendrum infortunatum* L.	Verbenaceae	Shrub	-
9	*Combretum latifolium* Blume	Combretaceae	Climber	-
10	*Dichapetalum gelonioides* (Roxb.) Engl.	Dichapetalaceae	Shrub	-
11	*Dillenia pentagyna* Roxb.	Dilleniaceae	Tree	-
12	*Diospyros buxifolia* (Blume.) Hiern.	Ebenaceae	Tree	-
13	*Dracaena terniflora* Roxb.	Asparagaceae	Herb	-
14	*Drynaria quercifolia* (L.) J. Sm.	Polypodiaceae	Fern	-
15	*Flacoutia montana* J. Graham	Flacourtiaceae	Tree	-
16	*Garcinia Morella* (Gaertn.) Desr.	Clusiaceae	Tree	-
17	*Holigarna ferruginea*Marchand	Anacradiaceae	Tree	Endemic
18	*Hopea parviflora* Bedd.	Dipterocarpaceae	Tree	Endemic
19	*Hopea ponga* (Dennst.) Mabb.	Dipterocarpaceae	Tree	Endemic
20	*Ixora brachiata* Roxb.	Rubiaceae	Tree	Endemic
21	*Ixora coccinea* L.	Rubiaceae	Shrub	
22	*Knema attenuata* (Hook.f. & Thoms) Warb.	Myristicaceae	Tree	Endemic & Least Concern
23	*Leea indica* (Burm.f.) Merr.	Leeaceae	Shrub	-
24	*Mammea suriga* (Buch.-Ham.ex Roxb.) Koesterm.	Clusiaceae	Tree	-
25	*Memecylon edule* Roxb.	Melastomataceae	Tree	-
26	*Memecylon randerianum* S.M.Almedia& M.R.Almeida	Melastomataceae	Shrub	-
27	*Myristica malabarica* Lam	Myristicaceae	Tree	Endemic
28	*Naregamia alata* Wight. & Arn.	Meliaceae	Herb	-
29	*Olea dioica* Roxb.	Oleaceae	Tree	-
30	*Piper nigrum* L.	Piperaceae	Climber	-
31	*Pothos scandens* L.	Aeraceae	Shrub	
32	*Psychotria dalzellii* Hook.f	Rubiaceae	Shrub	Endemic
33	*Psychotria flavida* Talbot.	Rubiaceae	Shrub	Endemic
34	*Rhynchostylsis retusa* (L.) Blume	Orchidaceae	Orchid	-
35	*Scleropyrum pentandrum* (Dennst.) Mabb.	Santalaceae	Tree	-
36	*Smilax zeylanica* L.	Smilacaceae	Shrub	-
37	*Strychnos minor* Dennst.	Loganiaceae	Shrub	-
38	*Syzygium caryophyllatum* (L.) Alston.	Myrtaceae	Tree	-
39	*Tectaria polymorpha* (Wall. ex Hook.) Copel.	Tectariaceae	Fern	-
40	*Ventilago maderaspatana* Gaertn.	Rhamnaceae	Shrub	-
41	*Wendlandia notoniana* Wall. ex Wight & Arn	Rubiaceae	Tree	-
42	*Xylia xylocarpa* (Roxb.) Taub.	Fabaceae	Tree	-

4.5.1.5. I Regeneration (1X1M)

Sl.No.	Species Name	No. of Individuals	Family	Status
1	*Psychotria thwaitesii*	7	Rubiaceae	
2	*Piper nigrum*	6	Piperaceae	
3	*Grass spp.*	56	Poaceae	
4	*Epiphyte spp.*	1	Orchidaceae	
5	*Hopea parviflora*	1	Dipterocarpaceae	Endemic
6	*Wild Climber*	3	-	

4.5.1.5. II Shrub Plot (5X5m)

Sl.No.	Scientific name	No. of Individuals	Family	Status
1	*Artocarpus hirsutus*	2	Moraceae	Endemic & Threatened
2	*Diospyros buxifolia*	3	Ebenaceae	
3	*Hopea parviflora*	9	Dipterocarpaceae	Endemic
4	*Myristica malabarica*	4	Myristicaceae	Endemic
5	*Wendlandia notoniana*	8	Rubiaceae	
6	*Psychotria thwaitesii*	145	Rubiaceae	
7	*Leea indica*	27	Leeaceae	
8	*Ixora brachiata*	1	Rubiaceae	Endemic

Table 53. Biomass and carbon estimation at Pilarkan reserve forest

Girth Class	Species Name	No. of Individuals	Basal Area Cm2	Biomass (Kg)	Carbon (Kg)
1 to 10	*Holigarna arnottiana*	3	89.5358	2.72	1.36
	Flacourtia montana	1	71.69	1.67	0.83
	Artocarpus hirsutus	1	15.61	0.65	0.32
	Wendlandia notoniana	8	245.18	7.45	3.72
	Hopea ponga	1	76.55	1.75	0.87
	Hopea parviflora	3	112.55	3.2	1.6
	Mundelu	1	71.69	1.67	0.83
	Mundi	1	13.46	0.6	0.3
	Vitex altissima	3	54.88	2.07	1.04
	Diospyros buxifolia	62	2274.56	64.5	32.25
	Memecylon edule	7	219.62	6.53	3.26
	Myristica malabarica	27	851.86	25.54	12.77
	Mimusops elengi	11	250.206	8.59	4.29
10.1 to 20	*Holigarna arnottiana*	1	127.45	2.62	1.31
	Ficus drupacea	1	109.05	2.31	1.15
	Alstonia scholaris	1	249.808	4.76	2.38
	Artocarpus hirsutus	1	161.307	3.2	1.6
	Dillenia pentagyna	1	97.58	2.11	1.05
	Hopea parviflora	11	1674.256	33.57	16.78
	Diospyros buxifolia	8	978.601	20.28	10.14
	Myristica malabarica	2	201.77	4.33	2.17
	Mimusops elengi	1	92.08	2.02	1.01
20.1 to 40	*Holigarna arnottiana*	1	718.915	14.06	7.03
	Artocarpus hirsutus	2	1453.76	28.63	14.32
	Hopea parviflora	19	13925.05	277.15	138.57
	Mangifera indica	1	630.97	12.18	6.09
	Myristica malabarica	1	718.91	14.06	7.03
40.1 to 60	*Artocarpus hirsutus*	1	1913.78	44.79	22.39
	Hopea parviflora	17	29515.6	680	340
> 60	*Hopea parviflora*	3	9264.25	250.55	125.27

4.5.1.5. III Mangroves

Mangrove vegetation provides nursery ground for a number of commercially important fishes, shrimps, crabs and molluscs (both fresh water and marine) it enhances the fishery production by enriching coastal water by providing nutrients. Mangroves are important in maintaining and building the soil, act as a reservoir in the tertiary assimilation of waste and in the global cycle of carbon dioxide, nitrogen and sulphur. In addition, mangroves support a large number of birds and other biodiversity.

Table: 54. List of mangroves Floral Species

Sl No.	Name	Family
1	*Acanthus ilicifolius*	Acanthaceae
2	*Acrostichum aureum*	Pteridaceae.
3	*Aegiceras corniculatum*	Myrsinaceae
4	*Avicennia alba*	Avicenniaceae
5	*Avicennia officinalis*	Avicenniaceae
6	*Bruguiera gymnorrhiza*	Rhizophoraceae
7	*Excoecaria agallocha*	Euphorbiaceae
8	*Kandelia candel*	Rhizophoraceae
9	*Rhizophora mucronata*	Rhizophoraceae

Table 55: The list of fauna documented in the study site.

55.a: List of Birds				
No	Family	Sl No	Common Name	Scientific Name
1	Accipitridae	1	Black Kite	*Milvus migrans*
		2	Black-winged Kite	*Elanus caeruleus*
		3	Brahminy Kite	*Haliastur indus*
		4	Crested Serpent Eagle	*Spilornis cheela*
		5	Oriental Honey Buzzard	*Pernis ptilorhynchus*
		6	Shikra	*Accipiter badius*
		7	Short-toed Eagle	*Circaetus gallicus*
		8	White-bellied Sea Eagle	*Haliaeetus leucogaster*
		9	White-eyed Buzzard	*Butastur teesa*
2	Acrocephalidae	10	Blyth's Reed Warbler	*Acrocephalus dumetorum*
3	Aegithinidae	11	Common Iora	*Aegithina tiphia*
4	Alaudidae	12	Ashy-crowned Sparrow Lark	*Eremopterix griseus*
5	Alcedinidae	13	Common Kingfisher	*Alcedo atthis*
		14	Pied Kingfisher	*Ceryle rudis*
		15	White-throated Kingfisher	*Halcyon smyrnensis*
6	Anatidae	16	Indian Spot-billed Duck	*Anas poecilorhyncha*
		17	Lesser Whistling Duck	*Dendrocygna javanica*
7	Anhingidae	18	Great Thick-knee	*Esacus recurvirostris*
		19	Oriental Darter	*Anhinga melanogaster*
8	Apodidae	20	Asian Palm Swift	*Cypsiurus balasiensis*
		21	Little Swift	*Apus affinis*
		22	Black-crowned Night Heron	*Nycticorax nycticorax*

9	**Ardeidae**	23	Cattle Egret	*Bubulcus ibis*
		24	Great Egret	*Ardea alba*
		25	Grey Heron	*Ardea cinerea*
		26	Indian Pond Heron	*Ardeola grayii*
		27	Intermediate Egret	*Ardea intermedia*
		28	Little Egret	*Egretta garzetta*
		29	Purple Heron	*Ardea purpurea*
		30	Western Reef Egret	*Egretta gularis*
10	**Artamidae**	31	Ashy Woodswallow	*Artamus fuscus*
11	**Bucerotidae**	32	Great Hornbill	*Buceros bicornis*
		33	Malabar Grey Hornbill	*Ocyceros griseus*
		34	Malabar Pied Hornbill	*Anthracoceros coronatus*
12	**Campephagidae**	35	Large Cuckooshrike	*Coracina javensis*
		36	Scarlet Minivet	*Pericrocotus flammeus*
		37	Small Minivet	*Pericrocotus cinnamomeus*
13	**Caprimulgidae**	38	Indian Nightjar	*Caprimulgus asiaticus*
14	**Charadriidae**	39	Little Ringed Plover	*Charadrius dubius*
		40	Red-wattled Lapwing	*Vanellus indicus*
		41	Yellow-wattled Lapwing	*Vanellus malabaricus*
15	**Chloropseidae**	42	Golden-fronted Leafbird	*Chloropsis aurifrons*
		43	Jerdon's Leafbird	*Chloropsis jerdoni*
16	**Ciconiidae**	44	Asian Openbill	*Anastomus oscitans*
		45	Painted Stork	*Mycteria leucocephala*
		46	Woolly-necked Stork	*Ciconia episcopus*
17	**Cisticolidae**	47	Ashy Prinia	*Prinia socialis*
		48	Common Tailorbird	*Orthotomus sutorius*
		49	Plain Prinia	*Prinia inornata*
18	**Columbidae**	50	Blue Rock Pigeon	*Columba livia*
		51	Emerald Dove	*Chalcophaps indica*
		52	Laughing Dove	*Streptopelia senegalensis*
19	**Coraciidae**	53	Indian Roller	*Coracias benghalensis*
20	**Corvidae**	54	House Crow	*Corvus splendens*
		55	Large-billed Crow	*Corvus macrorhynchos*
		56	Rufous Treepie	*Dendrocitta vagabunda*
		57	White-bellied Treepie	*Dendrocitta leucogastra*
21	**Cuculidae**	58	Blue-faced Malkoha	*Phaenicophaeus viridirostris*
		59	Common Hawk Cuckoo	*Hierococcyx varius*
		60	Common Koel	*Eudynamys scolopaceus*
		61	Greater Coucal	*Centropus sinensis*
22	**Dicaeidae**	62	Pale-billed Flowerpecker	*Dicaeum erythrorhynchos*
		63	Thick-billed Flowerpecker	*Dicaeum agile*
23	**Dicruridae**	64	Ashy Drongo	*Dicrurus leucophaeus*
		65	Black Drongo	*Dicrurus macrocercus*
		66	Greater Racket-tailed Drongo	*Dicrurus paradiseus*
		67	White-bellied Drongo	*Dicrurus caerulescens*
24	**Estrildidae**	68	Black-headed Munia	*Lonchura malacca*
		69	Scaly-breasted Munia	*Lonchura punctulata*
25	**Hirundinidae**	70	Barn Swallow	*Hirundo rustica*
		71	Red-rumped Swallow	*Cecropis daurica*
		72	Wire-tailed Swallow	*Hirundo smithii*
26	**Irenidae**	73	Asian Fairy-bluebird	*Irena puella*
27	**Jacanidae**	74	Bronze-winged Jacana	*Metopidius indicus*
28	**Laniidae**	75	Bay-backed Shrike	*Lanius vittatus*
		76	Long-tailed Shrike	*Lanius schach*
29	**Laridae**	77	River Tern	*Sterna aurantia*
30	**Leiothrichidae**	78	Jungle Babbler	*Turdoides striata*

31	**Megalaimidae**	79	Coppersmith Barbet	*Psilopogon haemacephalus*
		80	Malabar Barbet	*Psilopogon malabaricus*
		81	White-cheeked Barbet	*Psilopogon viridis*
32	**Meropidae**	82	Blue-bearded Bee-eater	*Nyctyornis athertoni*
		83	Blue-tailed Bee-eater	*Merops philippinus*
		84	Chestnut-headed Bee-eater	*Merops leschenaulti*
		85	Green Bee-eater	*Merops orientalis*
33	**Monarchidae**	86	Indian Paradise-flycatcher	*Terpsiphone paradisi*
34	**Motacillidae**	87	Paddyfield Pipit	*Anthus rufulus*
		88	White-browed Wagtail	*Motacilla maderaspatensis*
		89	Yellow Wagtail	*Motacilla flava*
35	**Muscicapidae**	90	Asian Brown Flycatcher	*Muscicapa dauurica*
		91	Asian Verditer Flycatcher	*Eumyias thalassinus*
		92	Blue-capped Rock Thrush	*Monticola cinclorhyncha*
		93	Indian Robin	*Saxicoloides fulicatus*
		94	Malabar Whistling Thrush	*Myophonus horsfieldii*
		95	Oriental Magpie Robin	*Copsychus saularis*
		96	Pied Bush Chat	*Saxicola caprata*
		97	Tickell's Blue Flycatcher	*Cyornis tickelliae*
36	**Nectariniidae**	98	Loten's Sunbird	*Cinnyris lotenius*
		99	Purple Sunbird	*Cinnyris asiaticus*
		100	Purple-rumped Sunbird	*Leptocoma zeylonica*
37	**Oriolidae**	101	Black-hooded Oriole	*Oriolus xanthornus*
		102	Indian Golden Oriole	*Oriolus kundoo*
38	**Paridae**	103	Cinereous Tit	*Parus cinereus*
39	**Passeridae**	104	House Sparrow	*Passer domesticus*
40	**Pellorneidae**	105	Puff-throated Babbler	*Pellorneum ruficeps*
41	**Phalacrocoracidae**	106	Great Cormorant	*Phalacrocorax carbo*
		107	Indian Cormorant	*Phalacrocorax fuscicollis*
		108	Little Cormorant	*Microcarbo niger*
42	**Phasianidae**	109	Grey Francolin	*Francolinus pondicerianus*
		110	Grey Junglefowl	*Gallus sonneratii*
		111	Indian Peafowl	*Pavo cristatus*
43	**Picidae**	112	Common Flame-backed Woodpecker	*Dinopium javanense*
		113	Heart-spotted Woodpecker	*Hemicircus canente*
44	**Ploceidae**	114	Baya Weaver	*Ploceus philippinus*
45	**Podicipedidae**	115	Little Grebe	*Tachybaptus ruficollis*
46	**Psittaculidae**	116	Malabar Parakeet	*Psittacula columboides*
		117	Rose-ringed Parakeet	*Psittacula krameri*
		118	Vernal Hanging Parrot	*Loriculus vernalis*
47	**Pycnonotidae**	119	Red-vented Bulbul	*Pycnonotus cafer*
		120	Red-whiskered Bulbul	*Pycnonotus jocosus*
		121	White-browed Bulbul	*Pycnonotus luteolus*
48	**Rallidae**	122	Common Coot	*Fulica atra*
		123	Common Moorhen	*Gallinula chloropus*
		124	Purple Swamphen	*Porphyrio porphyrio*
		125	White-breasted Waterhen	*Amaurornis phoenicurus*
49	**Recurvirostridae**	126	Black-winged Stilt	*Himantopus himantopus*
50	**Rhipiduridae**	127	White-spotted Fantail	*Rhipidura albogularis*
51	**Scolopacidae**	128	Common Redshank	*Tringa totanus*
		129	Common Sandpiper	*Actitis hypoleucos*
52	**Sittidae**	130	Velvet-fronted Nuthatch	*Sitta frontalis*
53	**Stenostiridae**	131	Grey-headed Canary-flycatcher	*Culicicapa ceylonensis*
54	**Strigidae**	132	Spotted Owlet	*Athene brama*
		133	Common Myna	*Acridotheres tristis*
		134	Hill Myna	*Gracula religiosa*

55	**Threskiornithidae**	135	Jungle Myna	*Acridotheres fuscus*
55	**Threskiornithidae**	136	Black-headed Ibis	*Threskiornis melanocephalus*
56	**Trogonidae**	137	Malabar Trogon	*Harpactes fasciatus*
57	**Turdidae**	138	Orange-headed Thrush	*Geokichla citrina*
58	**Tytonidae**	139	Common Barn Owl	*Tyto alba*
59	**Upupidae**	140	Common Hoopoe	*Upupa epops*
60	**Zosteropidae**	141	Oriental White-eye	*Zosterops palpebrosus*

55.b: *List of Butterflies*

No	Family	Sl No	Common Name	Scientific Name
1	**Blues**	1	Angled Pierrot	*Caleta decidia*
		2	Apefly	*Spalgis epeus*
		3	Blue-bordered Plane	*Bindahara moorei*
		4	Common Cerulean	*Jamides celeno*
		5	Common Guava Blue	*Virachola isocrates*
		6	Common Hedge Blue	*Acytolepis puspa*
		7	Common Imperial	*Cheritra freja*
		8	Common Lineblue	*Prosotas nora*
		9	Common Pierrot	*Castalius rosimon*
		10	Common Silverline	*Spindasis vulcanus*
		11	Dark Grass Blue	*Zizeeria karsandra*
		12	Gram Blue	*Euchrysops cnejus*
		13	Grass Jewel	*Freyeria trochylus*
		14	Grass Jewel	*Freyeria putli*
		15	Indian Sunbeam	*Curetis thetis*
		16	Lesser Grass Blue	*Zizina otis*
		17	Lime Blue	*Chilades lajus*
		18	Metallic Cerulean	*Jamides alecto*
		19	Monkey Puzzle	*Rathinda amor*
		20	Pale Grass Blue	*Pseudozizeeria maha*
		21	Pea Blue	*Lampides boeticus*
		22	Plains Cupid	*Chilades pandava*
		23	Red Pierrot	*Talicada nyseus*
		24	Tailless Lineblue	*Prosotas dubiosa*
		25	Tiny Grass Blue	*Zizula hylax*
		26	Zebra Blue	*Leptotes plinius*
2	**Brushfooted**	27	Angled Castor	*Ariadne ariadne*
		28	Anomalous Nawab	*Charaxes agrarius*
		29	Baron	*Euthalia aconthea*
		30	Baronet	*Symphaedra nais*
		31	Black Rajah	*Charaxes solon*
		32	Blackvein Sergeant	*Athyma ranga*
		33	Blue Tiger	*Tirumala limniace*
		34	Chestnut-streaked Sailer	*Neptis jumbah*
		35	Chocolate Pansy	*Junonia iphita*
		36	Clipper	*Parthenos sylvia*
		37	Commander	*Moduza procris*
		38	Common Bushbrown	*Mycalesis perseus*
		39	Common Castor	*Ariadne merione*
		40	Common Crow	*Euploea core*
		41	Common Evening Brown	*Melanitis leda*
		42	Common Five-ring	*Ypthima baldus*
		43	Common Four-ring	*Ypthima huebneri*
		44	Common Lascar	*Pantoporia hordonia*
		45	Common Leopard	*Phalanta phalantha*
		46	Common Sailer	*Neptis hylas*
		47	Common Treebrown	*Lethe rohria*
		48	Cruiser	*Vindula erota*
		49	Danaid Eggfly	*Hypolimnas misippus*
		50	Dark Blue Tiger	*Tirumala septentrionis*
		51	Double-branded Crow	*Euploea sylvester*
		52	Gaudy Baron	*Euthalia lubentina*

		53	Glad-eye Bushbrown	*Mycalesis junonia*
		54	Glassy Tiger	*Parantica aglea*
		55	Great Eggfly	*Hypolimnas bolina*
		56	Grey Count	*Tanaecia lepidea*
		57	Grey Pansy	*Junonia atlites*
		58	Indian Nawab	*Charaxes bharata*
		59	Lemon Pansy	*Junonia lemonias*
		60	Malabar Tree-Nymph	*Idea malabarica*
		61	Map Butterfly	*Cyrestis thyodamas*
		62	Medus Brown (Nigger)	*Orsotriaena medus*
		63	Painted Lady	*Vanessa cardui*
		64	Peacock Pansy	*Junonia almana*
		65	Plain Tiger	*Danaus chrysippus*
		66	Rustic	*Cupha erymanthis*
		67	Sahyadri (Tamil) Lacewing	*Cethosia mahratta*
		68	Small Leopard	*Phalanta alcippe*
		69	Striped Tiger	*Danaus genutia*
		70	Tamil Yeoman	*Cirrochroa thais*
		71	Tawny Coster	*Acraea terpsicore*
		72	Yellow Pansy	*Junonia hierta*
3	**Skipper**	73	African Marbled Skipper	*Gomalia elma*
		74	Brown Awl	*Badamia exclamationis*
		75	Bush Hopper	*Ampittia dioscorides*
		76	Chestnut Bob	*Iambrix salsala*
		77	Common Banded Awl	*Hasora chromus*
		78	Common Branded Redeye	*Matapa aria*
		79	Common Snow Flat	*Tagiades japetus*
		80	Dark Palm-Dart	*Telicota bambusae*
		81	Giant Redeye	*Gangara thyrsis*
		82	Grass Demon	*Udaspes folus*
		83	Grizzled Skipper	*Spialia galba*
		84	Karwar Swift	*Caltoris canaraica*
		85	Pygmy Scrub Hopper	*Aeromachus pygmaeus*
		86	Suffused Snow Flat	*Tagiades gana*
4	**Swallowtail**	87	Blue Mormon	*Papilio polymnestor*
		88	Common Banded Peacock	*Papilio crino*
		89	Common Jay	*Graphium doson*
		90	Common Mormon	*Papilio polytes*
		91	Common Rose	*Pachliopta aristolochiae*
		92	Crimson Rose	*Pachliopta hector*
		93	Five-bar Swordtail	*Graphium antiphates*
		94	Lime Butterfly	*Papilio demoleus*
		95	Malabar Banded Peacock	*Papilio buddha*
		96	Narrow-banded Bluebottle	*Graphium teredon*
		97	Paris Peacock	*Papilio paris*
		98	Red Helen	*Papilio helenus*
		99	Sahyadri Birdwing / Southern Birdwing	*Troides minos*
		100	Tailed Jay	*Graphium agamemnon*
5	**Whites & Yellows**	101	Common Albatross	*Appias albina*
		102	Common Grass Yellow	*Eurema hecabe*
		103	Great Orange-tip	*Hebomoia glaucippe*
		104	Indian Jezebel	*Delias eucharis*
		105	Indian Wanderer	*Pareronia hippia*
		106	Lemon Emigrant	*Catopsilia pomona*
		107	Mottled Emigrant	*Catopsilia pyranthe*
		108	Painted Sawtooth	*Prioneris sita*
		109	Psyche	*Leptosia nina*
		110	Small Grass Yellow	*Eurema brigitta*
		111	Three-spot Grass Yellow	*Eurema blanda*
		112	Yellow Orange-tip	*Ixias pyrene*

55.c: *List of Odonates*			
Family	**Sl No**	**Scientific Name**	**Common Name**
Calopterygidae	1	*Neurobasis chinensis*	Stream Glory
	2	*Vestalis apicalis*	Black-tipped Forest Glory
	3	*Vestalis gracilis*	Clear-winged Forest Glory
Chlorocyphidae	4	*Heliocypha bisignata*	Stream Ruby
Coenagrionidae	5	*Agriocnemis pygmaea*	Pygmy Dartlet
	6	*Agriocnemis splendidissima*	Splendid Dartlet
	7	*Amphiallagma parvum*	Azure Dartlet
	8	*Ceriagrion cerinorubellum*	Orange-tailed Marsh Dart
	9	*Ceriagrion coromandelianum*	Coromandel Marsh Dart
	10	*Ceriagrion olivaceum*	Rusty Marsh Dart
	11	*Ceriagrion rubiae*	Orange Marsh Dart
	12	*Ischnura rubilio*	Western Golden Dartlet
	13	*Ischnura senegalensis*	Senegal Golden Dartlet
	14	*Pseudagrion rubriceps*	Saffron-faced Blue Dart
Euphaeidae	15	*Euphaea fraseri*	Malabar Torrent Dart
Gomphidae	16	*Ictinogomphus rapax*	Indian Common Clubtail
Lestidae	17	*Lestes elatus*	Emerald Spreadwing
Libellulidae	18	*Acisoma panorpoides*	Trumpet-Tail
	19	*Brachydiplax sobrina*	Little Blue Marsh Hawk
	20	*Brachythemis contaminata*	Ditch Jewel
	21	*Bradinopyga geminata*	Granite Ghost
	22	*Cratilla lineata*	Emerald-Banded Skimmer
	23	*Crocothemis servilia*	Scarlet Skimmer
	24	*Diplacodes lefebvrii*	Black Ground Skimmer
	25	*Diplacodes trivialis*	Blue Ground Skimmer
	26	*Neurothemis fulvia*	Fulvous Forest Skimmer
	27	*Neurothemis tullia*	Pied Paddy Skimmer
	28	*Orthetrum chrysis*	Brown-Backed Marsh Hawk
	29	*Orthetrum glaucum*	Blue Marsh Hawk
	30	*Orthetrum luzonicum*	Tri-coloured Marsh Hawk
	31	*Orthetrum pruinosum*	Crimson-tailed Marsh Hawk
	32	*Orthetrum sabina*	Green Marsh Hawk
	33	*Pantala flavescens*	Wandering Glider
	34	*Rhyothemis variegata*	Common Picturewing
	35	*Tramea basilaris*	Red Marsh Trotter
	36	*Tramea limbata*	Black Marsh Trotter
	37	*Trithemis aurora*	Crimson Marsh Glider
	38	*Trithemis festiva*	Black Stream Glider

4.5.1.5. IV Marine and Coastal Ecosystems

All organisms live on a blue planet, with oceans and seas covering more than 70 per cent of the Earth's surface. Oceans and seas feed us, regulate our climate and generate most of the oxygen we breathe. They also serve as the foundation for much of the world's economy, supporting sectors from tourism, fisheries to international shipping.

But despite their importance, oceans and seas are facing unprecedented threats as a result of human activity. Our oceans and seas are being degraded by human activities that harm marine life, undermine coastal communities and negativity affect human health. **Every year an estimated 8 million tonnes of plastic waste end up in the world's oceans and seas**. At the same time, climate change is damaging coral reefs and other key ecosystems; overfishing is

threatening the stability of fish stocks; nutrient pollution is contributing to the creation of dead zones; and nearly **80 per cent of the world's wastewater is discharged without treatment to the oceans and seas.** Fishes and Molluscs provide nutritious food to mankind and livelihood for fisherman. **They are known as the best bio indicators of water**.

Some of the fishes and molluscs recorded in the ECC study areas are listed below.

SL No.	Species	Common Name

55.d: *List of Marine Fishes*

SL No.	Species	Common Name
1	*Anchoviella commersonii*	Anchovy
2	*Anchoviella spp.*	Anchovy
3	*Stolephorus commersonii*	Anchovy
4	*Epinephelus areolatus*	Areolated reef cod
5	*Sphyraena jello*	Baracuda
6	*Rachycentron canadam*	Black king fish/ Cobia
7	*Parastomateus niger*	Black pomfret
8	*Metapenaeus monoceros*	Brown shrimp
9	*Priacanthus cruentatus*	Bull's eye -blood coloured
10	*Priacanthus hamrur*	Bull's eye -Dusky finned
11	*Arius thalassinus*	Cat fish
12	*Pampus chinensis*	Chinese Pomfret
13	*Leiognathus equalus*	Commen pony fish
14	*Atrabucca nibe*	Croaker
15	*Johnieops voglari*	Croaker
16	*Johnius dussumeriri*	Croaker
17	*Johnius sp.*	Croaker
18	*Sciaena aneus*	Croaker
19	*Charybdis feriatus*	Crucifix crab
20	*Sepia sp*	Cuttel fish
21	*Sardinella brachysoma*	Deep bodied sardinella
22	*Puerulus sewlii*	Deep sea lobster
23	*Solenoero sp.*	Deep sea shrimp
24	*Coryphaena hippurus*	Dolphin fish
25	*Conger cinereus*	Eel
26	*Ablennes hians*	Flat needle fish
27	*Penaeus semisulcatus*	Flower prawn
28	*Protonibea diacanthus*	Ghol
29	*Sphyraena baracuda*	Great Baracuda
30	*Rhinobatos djiddensis*	Guitar fish
31	*Tenulosa ilisha*	Hilsa
32	*Megalaspis cardyla*	Horse mackeral
33	*Psettodes erumei*	Indian Halibut
34	*Rastelliger kanagurta*	Indian mackerel
35	*Sardinella longiceps*	Indian Oil sardine
36	*Polynemus tetradactylus*	Indian salmon
37	*Decapterus russelli*	Indian scad
38	*Alectis indicus*	Indian thread fish
39	*Nemipterus japonicus*	Japanese thread fin bream
40	*Acetes indicus*	Jawala
41	*Metapenaeus affinis*	King prawn
42	*Aluterus monoceros*	Leather jacket
43	*Scomberoides iysan*	Leather skin Queen fish
44	*Euthynus affinis*	Little tunny
45	*Saurida tumbil*	Lizard fish
46	*Thryssa malabarica*	malabar anchovy
47	*Parapenaeopsis stylifera*	Marine shrimp Karkadi
48	*Makaira indica*	Marlin black
49	*Mixed fishes*	Mixture
50	*Mene Maculata*	Moon fish
51	*Scylla serata*	Mud crab
52	*Mugil cephalus*	Mullet
53	*Hemiraphus fara*	Needle fish
54	*Canthidermis maculata*	Ocean trigger fish
55	*Octopus sp*	Octopus
56	*Leiognathus berbis*	Orange fin pony fish

57	*Sarda orientalis*	Oriental bonito
58	*Pinctada sp.*	Pearl oyster
59	*Etroplus surantensis*	Peral spot
60	*Metapenaeus affinis*	Pink shrimp
61	*Odonus niger*	Red toothed file fish
62	*Epinephelus diacanthus*	Reef cod
63	*Epinephelus malabaricus*	Reef Cod
64	*Epinephelus sp*	Reef cod
65	*Lepturacanthus savala*	Ribbon fish
66	*Trichirus lepturus*	Ribbon Fish
67	*Istiophorus platypterus*	Sail fish
68	*Alepes mate*	Scad
69	*Charybdis cruciata*	Sea crab
70	*Portunus pelagicus*	Sea crab
71	*Portunus sanguinolentus*	Sea crab
72	*Scomberomorus commersoni*	Seer fish
73	*Scomberomorus guttatus*	Seer fish
74	*Scomberomorus lineolatus*	Seer fish
75	*Metapenaeus dobsoni*	Shrimp Poovalan
76	*Pampus argenteus*	Silver pomfret
77	*Lutjanus sanguineus*	Snapper
78	*Lutjanus sp.*	Snapper
79	*Cynoglosus macrostomus*	Sole Fish
80	*Cynoglosus arel*	Sole Fish
81	*Cynoglosus dubius*	Sole fish
82	*Cynoglosus macrolepidotus*	Sole fish
83	*Paraplagusia Bilineata*	Sole Fish
84	*Doryteuthis sibogae*	Squid
85	*Loligo duvacelii*	Squid
86	*Abalistes stellatus*	Starry trigger fish
87	*Dasyatis bleekeri*	Sting ray
88	*Scomberoides commersonnianus*	Talang queen fish
89	*Opisthopterus tardoore*	Tardore
90	*Thryssadussumieri*	Thryssa
91	*Terapon jarbua*	Tiger perch
92	*Penaeus monodon*	Tiger prawn
93	*Trash landings*	Trash fish
94	*Carangoides malabaricus*	Travelly
95	*Lactarius lacterius*	Travelly
96	*Seriolina nigrofasciata*	Travelly
97	*Auxis thazard*	Tuna
98	*Katsuwonus pelamis*	Tuna
99	*Thunnus albacores*	Tuna
100	*Himanture bleekeri*	Whip tail sting ray
101	*Penaeus indicus*	White prawn
102	*Esculosa thorucata*	White sardine
103	*Chirocentrus dorab*	Wolf herring
104	*Atule mate*	Yellow tail scad

55.e. List of Other Marine Fauna:

	Rhopilema Spp.	*Jelly Fish*
	Crambionella Spp.	*Jelly Fish*
	Lepidochelys olivacea	*Olive ridley*
	Sousa Spp.	*Dolphin*

55.f. List of Molluscs:

Sl. No.	Species
1	*Purpura bufo*
2	*Tibia sp*
3	*Mactra cheminitzii*
4	*Mactrinula striatula*
5	*Mytilopsis sp*

6	*Anandara granosa*
7	*Anandara pilula*
8	*Donax scrotum*
9	*Sunetta scripta*
10	*Turitella sp*
11	*Natica picta*
12	*Anandara indica*
13	*Sunetta meroe*
14	*Natica vitellus*
15	*Cyprea sp*
16	*Indothias lacera*
17	*Tellina virgata*
18	*Agaronia gibbosa*
19	*Marcia opima*
20	*Hiatula diphos*
21	*Sunetta sp*
22	*Donax incarnatus*
23	*Meretrix casta*

4.6. Objectives- 3: To determine the carrying capacity of Udupi Taluk for the industrial growth and development.

4.6.1 Industries

4.6.1.1 Distribution of industries Profile of Udupi District:

Udupi is located within the state of Karnataka in India, lying amidst the Arabian Sea and the Western Ghats, was formed in August 1997. Udupi which is well known for its religious & cultural heritage has the highest density of banking branch offices in the state (Scheduled Commercial Banks). It is the birthplace of the Syndicate Bank, Corporation Bank and Harsha Retail, the leading retailer of coastal Karnataka Udupi's economy also consists of agriculture and fishing. It is home to over more than 6 Large Scale Industries, 6 Medium Scale industries and 11,283 small-scale industries (Table 9. Presently there are four major industrial areas viz Manipal, Nandikoor, Belapu and Miyar industrial areas. Two more industrial areas (Bola) and (Mulladka) are proposed to set up and they are under progress.

4.6.1.2. Industrial Profile of Dakshina Kannada District:

Is a district located in the southern and coastal part of Karnataka, which is spread across in 5 Taluks - Mangalore, Puttur, Belthangady, Bantwal and Sullia is sheltered by the soaring Western Ghats on the east and bordered by the blue waters of the Arabian Sea. It is the only city in Karnataka to have all modes of transport — air, road, rail and sea. The fastest growing non-metro (Indian city of population less than 1 million) in South India is Mangalore. Mangalore is one among the 5 cities in the country to have both a Major Port and an International Airport. Mangalore has some of the tallest buildings in South India; with many more under construction. Mangalore is the 2nd largest business centre in Karnataka. Around 75% of India's coffee, timber and cashew nuts exports are handled by the New Mangalore Port. Currently there are 24,072 operating MSMEs operating in the district with 6 industrial areas, 5 industrial estates and two more proposed industrial areas (Niddodi and Badag mijar) and the list of industries is enclosed at annexure.

Table 13; list of Industries

Industries within Study Area			
Taluk	**Large**	**Medium**	**Small**
Karkala	4	1	188
Udupi	10	4	147
Mangalore	7	4	136

(Source: District at a Glance 2016).

Chapter -5

Scope of further work

The scope of carrying capacity study includes Source Emission Dispersion Modelling, AAQM and Water & Wastewater Elemental Analysis and Soil Analysis. The Source dispersion and apportionment study includes arriving at ground level concentration as well as dispersion concentration at 2km, 5km and 10km radius at Udupi Power Corporation using AERMOD 5.2 as per the EPA/CPCB guidelines and using the sampling and analysis as per international standard methods like USEPA, IS, ASTM. In addition to the above the work documenting and analysis of the critical biodiversity and critical ecosystems in the study area would be continued.

In order to carry out the carrying capacity modelling estimation of the atmospheric assimilation capacity, documentation of biodiversity and critical ecosystems is very much needed. The detailed data collection from the field is absolutely essential for which six months of extension time is required.

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ANNEXURE-I: Proceedings of the Govt. of Karnataka

Proceedings of the Government of Karnataka.

Sub: Undertaking environmental carrying capacity study of Udupi Taluk in terms of the orders of the Hon'ble National Green Tribunal, Southern Bench, Chennai dated 14th March 2019 and 14th October 2019 in relation to expansion of existing 2x600 MW Udupi power plant -reg.

Read:
1. The orders of the Hon'ble National Green Tribunal, Southern Bench, Chennai in Original Application No. 578/2018 and connected matters dated 14th March 2019 and 14th October 2019.
2. Letter No. CCC/CR-2/NSCC-EMPRI//2019-2020/02, dated 17.04.2020 of Environment Management and Policy Research Institute (EMPRI).
3. Government Notification No. ಆಇ 267 ಪಚ್ಛ-12/2020, dated 04.05.2020.

* * * *

Preamble:

The Ministry of Environment and Forest and Climate Change, Government of India had accorded Environmental Clearance for expansion of Udupi Power project by Udupi Power Corporation Limited by 2X 800 MW capacity vide the letter dated 1.8.2017. A corrigendum has been issued vide letter dated 26.02.2018 for incorporating the CRZ recommendations for laying the pipeline facilities. The Hon'ble National Green Tribunal vide order dated 14.3.2019 in O.A. No. 578 of 2018 in the matters of Janajagrithi Samithi Versus Union of India & Others have suspended the above said Environmental Clearance. The Hon'ble National Green Tribunal have also directed the State Government to get a carrying capacity study of the area carried out.

A decision has been taken to entrust the task of undertaking carrying capacity study in terms of the orders of the Hon'ble National Green Tribunal, Southern Bench, Chennai dated 14th March 2019 and 14th October 2019 in relation to expansion of existing 2x600 MW Udupi power plant to the Environment Management and Policy Research Institute (EMPRI), Bengaluru. The EMPRI vide their letter dated 17.04.2020 have submitted a proposal with regard to conducting "the study of environmental carrying capacity of Udupi Taluk". The said institute have indicated a total budget requirement Rs. 17.00 Lakhs for the study envisaged.

The Government in the Finance Department have accorded exemption under section 4(g) of Karnataka Transparency in Public Procurement Act, 1999 vide Notification No. ಆಇ 267 ಪಚ್ಛ-12/2020, dated 04.05.2020 for availing the services of EMPRI, Bengaluru to get the aforementioned study conducted.

In view of the above facts and circumstances a decision has been taken by the Government to entrust the task of conducting "environmental carrying capacity study" in terms of the orders of the Hon'ble National Green Tribunal dated 14th March 2019

and 14th October 2019 in relation to expansion of existing 2x600 MW Udupi power plant to the EMPRI, Bengaluru.

Hence this order.

Government Order No. FEE 08 EAA 2019 , Bangalore, Dated: 12.05.2020.

Pursuant to the facts and circumstances explained in the preamble, the Government are pleased to entrust the task of conducting "environmental carrying capacity study" to Environment Management and Policy Research Institute (EMPRI), Bengaluru in terms of the orders of the Hon'ble National Green Tribunal, dated 14th March 2019 and 14th October 2019 in relation to expansion of existing 2x600 MW Udupi power plant at an estimated cost of Rs.17.00 Lakhs (Rupees Seventeen Lakhs only) subject to the following terms and conditions:

1. The EMPRI shall conduct the environmental carrying capacity study in terms of the orders of the Hon'ble National Green Tribunal, dated 14th March 2019 and 14th October 2019 and submit the report within the period of six months.

2. The EMRPI shall be abide to undertake any additional studies that would be suggested by the State Government/ the Hon'ble NGT upon submission of the final report and provide the required clarification /information with regard to the study.

3. The EMPRI shall submit 10 copies of the final study report and a soft copy of the same to the Government along with all the reports, material evidences, satellite imageries, photographs , videographs, etc collected as part of the carrying capacity study to the Government.

4. The expenditure towards the study of carrying capacity shall be borne by the EMPRI.

This order is issued in concurrence with the Finance Department vide Note No. ಆಇ 134 ವೆಚ್ಚ-5/2020, dated 06.05.2020.

By order and in the name of
Governor of Karnataka

(Muralidhar S. Tallikeri) 12|05|2020
Under Secretary to Government,
(Ecology and Environment),
Forest, Ecology and Environment Dept.

To:
1. The Accountant General (Accounts & Audit), Karnataka, Bengaluru.

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2. The Secretary, Ministry of Environment, Forest and Climate Change, Indira Paryavaran Bhavan, Jor Bagh Road, Aliganj, New Delhi- 110003.
3. The Registrar, National Green Tribunal, Faridkot House, Copernicus Marg, New Delhi – 110001.
4. The Registrar, National Green Tribunal, Southern Zone, Kalas Mahal. Chennai.
5. The Director General, Environment Management & Policy Research Institute, Hasiru Bhavan, Dorsanipalya Forest Campus, Vinayaka Nagara, JP Nagara 5th Phase, Bengaluru – 78.
6. The Director – IA 1, Ministry of Environment, Forest and Climate Change, Indira Paryavaran Bhavan, Jor Bagh Road, Aliganj, New Delhi- 110003.
7. M/s Udupi Power corporation, Lotus Tower, 1st Floor, 34 , Devraj Urs Road, Race Cource, Bengaluru- 560001.
8. SG.file/Spare copies

Copy to:

1. PS to the Chief Secretary to Government, Government of Karnataka, Vidhana Soudha, Bengaluru.
2. PS to the Additional Chief Secretary to Government, Forest, Ecology and Environment Department, M.S. Building, Bengaluru.
3. PS to the Principal Secretary to Government, Forest, Ecology and Environment Department (Ecology and Environment), M.S. Building, Bengaluru.
4. PS to the Special Director (Technical Cell), Forest, Ecology and Environment Department, M.S. Building, Bengaluru.
5. Under Secretary to Government, Finance Department (Expenditure-5), Vidhana Soudha, Bengaluru.

3

ANNEXURE-II: CPCB methodology used for Environmental Modelling

Methodology and Framework for Calculating Environmental Carrying Capacity:

There are different methods available to estimate the carrying capacity of an area. The following steps have been adopted to assess the Environmental carrying capacity of the study area.

Carrying capacity is the maximum number of activities like domestic, agriculture, transport, Industries- that can be done continuously over a period of time without affecting:

a) The existing quality of life (from the point of view of existing traditional practices, access to resources, health and pollution levels.

b) The overall balancing of resources (Renew ability/regeneration).

c) The fact that activities can be done on a sustainable manner.

d) Neighbouring systems.

e) Existing ecological systems like agriculture, horticulture, forest etc.

Water Resource Carrying Capacity: Amount of available water resources (AWR), and the amount of surface water withdrawal (SWW). These can be estimated by the following equations:

$$AWR = AGWR + ASWR + OAWR$$

- AGWR is the available ground water resource,
- ASWR is the available surface water resource,
- OAWR is other available water resources, mainly wastewater reuse and collection of rainwater.

$SWW = TWS - GWS - OSWS$

- TWS is total water supply,
- GWS is ground water supply,
- OSWS is other sources of water.

*Water demand Carrying Capacity***:** Gross water amount consumed by all types of water users. The gross amount of water demand includes the conveyance loss of water, domestic water demand, industrial water demand, agricultural water demand, and "other" water demand (Water Resources Bulletin of Tieling 2011).

- *Domestic water* demand includes urban domestic water demand, made up of the residential use of water and the public use of water (including the water use by tertiary industry and the construction industry),

- *Industrial water demand* consists of the demand for fresh water, excluding water recycling within enterprises.

- *Agricultural water demand* is made up of irrigation water demand water recharge.

- *Other water demand* consists mainly of the demand for sanitation water in the urban area and the water restoration requirements of rivers, lakes and wetlands.

Water resource carrying capacity (WRCC) depends on the water availability and water demand, and is given as, $\quad$ WRCC = WA/WD

Where, WA = water availability

WD = water demand

Widodo et al., 2015 stated that for WRCC < 1 capacity is overshoot, WRCC 1 - 3 capacities is conditionally safe and WRCC > 3 capacity is safe.

Rivers *Carrying Capacity***:** The water environmental capacity is the maximum pollutant loading that the water body can hold under a certain water environment quality target. The dominant water pollutant is BOD. The length and width of the computed river is relatively large, so we can ignore the horizontal changes of pollutant concentration, and only take into account changes of pollutant concentration along the river, so we select one-dimensional water quality model to calculate the Surface water environmental capacity. The water environment capacity can be calculated with following equation as per Qingchun Yang et al; 2019

Assuming stream and waste water discharge are at steady state and instantaneous full mixing of all flows.

$$W_R = [C_s - C_o \exp(-KL/u) \times Q]$$

- W_R represents the river's pollutant carrying capacity, g/s;
- C_s represents the water quality target concentration at the downstream cross-section of the river, mg/L;
- Co represents the actual water quality concentration at the upstream cross-section of the river, mg/L:

- K represents the pollutant degradation coefficient, d^{-1};
- L represents the length of river, m; u represents the average flow velocity at the river's cross section, m/s;
- Q represents the designed flow at the river's cross section, m3/s

Note: As per Yingrong Wen et al; 2017, the reported range for laboratory-measured k values is from 0.3 to 0.5 day at a temperature of 20 °C, which is considered representative of field conditions

Lakes Carrying capacity

Pollutant carrying capacity of the lake:

Considering, Lake is of small size with equilibrium of multi-year average in flowing water and outflowing water, it is desirable to adopt the uniform mixture model to calculate the pollutant carrying capacity.

Based on the material balance equation, the pollutant carrying capacity

$$W_L = (C_s - C_o)\ V + KC_S V + C_s q_{out}$$

In this equation,

- W_L represents the pollutant carrying capacity of the lake, t/a;
- C_s represents the water quality target concentration, mg/l;
- C_o represents the actual water quality concentration, mg/l;
- V represents the average storage capacity of the lake in dry seasons, m';
- q_{out} represents multi-year outflowing water of the lake in dry seasons, m' /a;
- K represents the pollutant degradation coefficient, d^{-1} 'mainly BOD parameters under consideration

Ground Water Carrying capacity

For estimating the level of groundwater pollution with low-hazard pollutants the following formula can be used as per Anna Belousova, 2006

$$C_1/MPC_1 + C_2/MPC_2 \pm \text{----------------------} \pm C_n/MPC_n = 1$$

Where C_1, C_n are concentration of separate pollutants, and MPC_1, MPC_n represent maximum permissible concentration.

If the sum of the concentration ratios is more than 1, then the groundwater is polluted. For all cases, pH must not be outside the limit 6.5-8.5.

Atmospheric Assimilation Capacity:

Various approaches are described in the literature for estimating the atmospheric assimilative capacity of a region. (Goyal et al. (2006) propose two approaches, one based on a ventilation coefficient, the other through pollution potential. SEPA (2003) recommend an A-P value method and multi-source simulation model to estimate atmospheric assimilative capacity in China.

Here we are discussing the atmospheric assimilative capacity using simple Box Model: A simple box model based on mass balance and assuming that all pollutants in the box are uniformly mixed (Figure 2) is used for preliminary estimates for step (ii) in Fig 1(a). It is a simple model and has several limitations; however, for the purpose of demonstrating the framework and preliminary analysis, the model may provide broad estimates of carrying capacity. Mathematically, the model can be described as below:

Figure 4: Schematic of box model (De Nevers, 1995)

Mathematically

$$V \, dc/dt = qC_{in} - qC_{out} + S - K_{dd} \, CLW - K_{cr} \, C_{out}V \qquad (1)$$

Where, q = volumetric flow rate (m^3/sec)

C_{in} = influent concentration of a pollutant (g/m^3)

C_{out} = effluent concentration of a pollutant (g/m^3)

K_{dd} = dry deposition velocity (m /sec)

K_{cr} = First order chemical reaction constant (1/sec)

S = source emission rate(g/sec)

K_{dd} C.L.W = the amount of pollutants removed by dry deposition (g/sec)

Kcr C.V = the amount of pollutants converted by chemical reaction (g/sec)

u = wind speed (m/sec)

In equation, V=L*W*H volume of City m^3 (L: length (m), W: Width (m). H; height (m))

The model is further simplified with the following assumptions:

- Steady state condition (i.e. concentration is time invariant); dc/dt = 0
- Pollutant does not have any deposition in the box; Kdd = 0
- Pollutant does not undergo any chemical transformation: Kcr = 0

One can estimate the carrying capacity, Qcc as per the following equation:

Qcc =   (C-Co) x u.W.H   **(2)**

In this calculation,

Area (A) of system boundary, Width (W) of the System boundary, mixing height (H) (average for winter and summer) within the system boundary, Wind Speed (s) within the system boundary is required.

Background concentration (Co) into the system boundary: Alternatively, the multi-source simulation model may be used to estimate atmospheric assimilative capacity based on air quality modelling which takes into consideration region-specific meteorological conditions, terrain characteristics, and emission loads from different sources.

Following Goyal and Chalapati Rao (2007), the discharged emission load at which the maximum allowable concentration is reached under predefined critical conditions is taken to be the assimilative capacity of the region. Prediction of ground-level concentrations of pollutants is carried out using the US EPA approved ISCST-3 simulation model (EPA, 1995a, 1995b). It should be noted that the atmospheric assimilative capacity has a range of values, depending on the variation of emission characteristics with given meteorological and topographical conditions.

ANNEXURE- III: List of Industries at Udupi district

SI. No	Name of the Industry	Taluk	District	Products	Size (L/M/S)
1	Lamina Foundries Limited., Kuntadi Road, Nitte, Karkala	Karkala	Udupi	Foundry	Large
2	Kudluteer tha Mini Hydel Scheme,	Karkala	Udupi	hydel power	Large
3	Upper Sitanadi Mini Hydel Scheme,	Karkala	Udupi	hydel power	Large
4	Bola Surendra Kamath & Sons,	Karkala	Udupi	Cashew Kernels	Large
5	Mookamb ika Industries,	Karkala	Udupi	stone crusher	Medium
6	Markala Mini Hydel Scheme,	Karkala	Udupi	hydel power	Small
7	Carla cashew chemi India ltd,	Karkala	Udupi	CNS oil	Small
8	Raithasev a Gramodyo ga, ,	Karkala	Udupi	boiled rice	Small
9	Gajanana Rice Mill,	Karkala	Udupi	boiled rice	Small
10	Sri Ramanjan eya Industries,	Karkala	Udupi	boiled rice	Small
11	Tsubosak a Aiv India (P) Ltd., Tq Udupi Dt	Karkala	Udupi	tomb stone	Small
12	Vikram Industries,	Karkala	Udupi	boiled rice	Small
13	Sri Vinayaka Cashew Exports,	Karkala	Udupi	Cashew Kernels	Small
14	Sri Durgambi ka Industries, Tq udupi	Karkala	Udupi	CNS oil	Small
15	A.S stone crusher,	Karkala	Udupi	stone crusher	Small
16	Adarsh Industrial Chemical s, Tq,	Karkala	Udupi	CNS oil	Small
17	Akshaya Chemicals,	Karkala	Udupi	turpentine & varnishes	Small
18	Anugraha Stone Cruser Industry, Tq,	Karkala	Udupi	stone crusher	Small
19	Avinash Enterprise s,	Karkala	Udupi	stone crusher	Small
20	B.Surendr a Kamath & Company,	Karkala	Udupi	CNS oil	Small
21	Chamund eshwari Stone Crusher,	Karkala	Udupi	stone crusher	Small
22	Delta Industries,	Karkala	Udupi	stone crusher	Small
23	Durgapara meshwari crushers,	Karkala	Udupi	stone crusher	Small
24	Earth Line Trading Company, Tq, Udupi Dt.	Karkala	Udupi	stone crusher	Small
25	D Govardan Babu Stone Crusher, Tq, Udupi.	Karkala	Udupi	stone crusher	Small
26	J&P Enterprise s,	Karkala	Udupi	stone crusher	Small
27	Kandan Stone Crusher,	Karkala	Udupi	stone crusher	Small
28	Karla Constructi ons,	Karkala	Udupi	Hot mix plant	Small
29	Kiran Stone Crusher,	Karkala	Udupi	stone crusher	Small
30	Krishna Industries,	Karkala	Udupi	stone crusher	Small
31	Leslee Crusher (J.L),	Karkala	Udupi	stone crusher	Small
32	Lime Kiln : Louis D'Douza, Tq,	Karkala	Udupi	lime kiln	Small
33	Lewis Stone Crushers,	Karkala	Udupi	stone crusher	Small
34	Mahavee r Metal Works, Tq, Udupi Dt	Karkala	Udupi	lead recycling	Small
35	Maruthi Industry,	Karkala	Udupi	CNS oil	Small
36	Mookamb ika Crushers,	Karkala	Udupi	stone crusher	Small
37	Mount Mary Industries,	Karkala	Udupi	stone crusher	Small

38	Damodar Infra (Navanidh i Enterprise s),	Karkala	Udupi	stone crusher	Small
39	Oriental Granites & Crusher, Tq, Udupi Dt.	Karkala	Udupi	stone crusher	Small
40	P.R. Ibrahim - Hot Mix Plant,	Karkala	Udupi	Hot mix plant	Small
41	Sanoor Cashew,	Karkala	Udupi	CNS oil	Small
42	Santhosh Industries, Tq, Udupi Dt.	Karkala	Udupi	CNS oil	Small
43	Sanur Stone Crushers,	Karkala	Udupi	stone crusher	Small
44	Sathyashr ee Industries,	Karkala	Udupi	CNS oil	Small
45	Chandram angal Associate s,	Karkala	Udupi	stone crusher	Small
46	Shell Lime Industries,	Karkala	Udupi	lime kiln	Small
47	Shiney Industries,	Karkala	Udupi	stone crusher	Small
48	St. Joseph Industries,	Karkala	Udupi	stone crusher	Small
49	Stone Crusher: B.M. Zakariaq,	Karkala	Udupi	stone crusher	Small
50	Tar Mixing Plant: M.G.Huss ain, .	Karkala	Udupi	Hot mix plant	Small
51	Venkatesh wara Industries, , Tq,	Karkala	Udupi	stone crusher	Small
52	Vishal Industires,	Karkala	Udupi	stone crusher	Small
53	Vks Crusher	Karkala	Udupi	stone crusher	Small
54	Adishakth i Rice Industries,	Karkala	Udupi	boiled rice	Small
55	Ananthap adnabha Rice Mills,	Karkala	Udupi	boiled rice	Small
56	B. Pundalika Sarvotha m Kini	Karkala	Udupi	boiled rice	Small
57	Bhagyoda ya Agro Inds,	Karkala	Udupi	boiled rice	Small
58	Canara Feeds,	Karkala	Udupi	Cattle Feed	Small
59	Chethana Rice Mill,	Karkala	Udupi	boiled rice	Small
60	Girishri Rice Mill, Dt.	Karkala	Udupi	boiled rice	Small
61	Green Vision Industries, Tq, Udupi Dt.	Karkala	Udupi	bitter guard	Small
62	Hegde Rice Mills,	Karkala	Udupi	boiled rice	Small
63	Kamat Phova & Rice Mills,	Karkala	Udupi	boiled rice	Small
64	Kamath Industrial Enterprise s,	Karkala	Udupi	boiled rice	Small
65	Komal Feeds, Tq, Udupi Dt.	Karkala	Udupi	Cattle Feed	Small
66	New Canara Feeds,	Karkala	Udupi	Cattle Feed	Small
67	Raithasev a Dryers, Tq,	Karkala	Udupi	boiled rice	Small
68	Rajashree Rice Mill,	Karkala	Udupi	boiled rice	Small
69	Sanoor Phova & Rice Mills,	Karkala	Udupi	boiled rice	Small
70	Shetty Traders & Rice Mills,	Karkala	Udupi	boiled rice	Small
71	Sri Ganesh Industries.	Karkala	Udupi	boiled rice	Small
72	Sri Vidya Industries, Udupi	Karkala	Udupi	boiled rice	Small
73	Veeravitta la Rice Inds,	Karkala	Udupi	boiled rice	Small
74	Vijaya Aharodya ma (Jaishree Driers),	Karkala	Udupi	boiled rice	Small
75	Allen inds,	Karkala	Udupi	Cashew Kernels	Small
76	Amithi Cashew Inds,	Karkala	Udupi	Cashew Kernels	Small
77	Anantha Padmanab ha Tyre Retreader s, Tq, Udupi Dt.	Karkala	Udupi	tyre retrading	Small
78	Anitha Cashew,	Karkala	Udupi	Cashew Kernels	Small

79	Bahubali Exports,	Karkala	Udupi	Cashew Kernels	Small
80	Balaji Exports, Dt.	Karkala	Udupi	Cashew Kernels	Small
81	Benaka Industries,	Karkala	Udupi	plastic cups & printing on it	Small
82	Bharti Mobile Ltd.,	Karkala	Udupi	telephone tower	Small
83	Bola Raghaven dra Kamath &Sons., .	Karkala	Udupi	CNS oil	Small
84	Bolkar Industries,	Karkala	Udupi	Cashew Kernels	Small
85	Ganapath y Cashew,	Karkala	Udupi	Cashew Kernels	Small
86	Greenland Industries.	Karkala	Udupi	roofing tiles	Small
87	H. Sudheend ra Oil Products,	Karkala	Udupi	coconut oil & gingili oil	Small
88	Hutchison Essar South Ltd.,	Karkala	Udupi	telephone tower	Small
89	Kamakshi Cashew Industries	Karkala	Udupi	Cashew Kernels	Small
90	Kamakshi Exports	Karkala	Udupi	Cashew Kernels	Small
91	Kamakshi Gramodyo ga Sangha	Karkala	Udupi	Cashew Kernels	Small
92	Kamath Cashew Ind,	Karkala	Udupi	CNS oil	Small
93	Laxmi Kripa Kalyanam antapa,	Karkala	Udupi	DG Set kalynama ntapa	Small
94	Laxmi Ravalnath a Cashews,	Karkala	Udupi	Cashew Kernels	Small
95	Madhavpr akash Enterprise s	Karkala	Udupi	Cashew Kernels	Small
96	Mahalax mi Cashew Inds.	Karkala	Udupi	Cashew Kernels	Small
97	Mahamay a Exports	Karkala	Udupi	Cashew Kernels	Small
98	Mangala Gowri Exports	Karkala	Udupi	Cashew Kernels	Small
99	Manjunat ha Enterprice s	Karkala	Udupi	General engg	Small
100	Muddu Krishna Inds,	Karkala	Udupi	Cashew Kernels	Small
101	Nagaraj Cashew Inds	Karkala	Udupi	Cashew Kernels	Small
102	Navadurg a Oil & Flour Mills	Karkala	Udupi	coconut oil & flour mill	Small
103	New Damodar Cashew	Karkala	Udupi	Cashew Kernels	Small
104	New Ramanath Cahsew Industries	Karkala	Udupi	Cashew Kernels	Small
105	New Sridevi Cashew Ind	Karkala	Udupi	Cashew Kernels	Small
106	New Varadaraj Cashew Inds	Karkala	Udupi	Cashew Kernels	Small
107	Palashree Industries	Karkala	Udupi	hollow bricks	Small
108	Palashree Industries	Karkala	Udupi	hollow bricks	Small
109	Panchami Cashew	Karkala	Udupi	Cashew Kernels	Small
110	Paradise Bottling	Karkala	Udupi	soft drinks	Small
111	Prabhu Oil Mills	Karkala	Udupi	oil expellers	Small
112	Prakash Cashew Inds.	Karkala	Udupi	Cashew Kernels	Small
113	Reliance Infocomm Ltd,	Karkala	Udupi	telephone tower	Small
114	Reliance Infocomm Ltd,	Karkala	Udupi	telephone tower	Small
115	Sanoor Umesh Kamath & Co.	Karkala	Udupi	Cashew Kernels	Small
116	Santhosh Cashews,	Karkala	Udupi	Cashew Kernels	Small
117	Sapthagiri Gramodyo ga Sangha,	Karkala	Udupi	Cashew Kernels	Small
118	Sarala Saw Mill, Nandalike , Karkal Tq.	Karkala	Udupi	saw mill	Small
119	Shah Steels,	Karkala	Udupi	processin g waste sand	Small
120	Shah Steels,	Karkala	Udupi	processin g waste sand	Small
121	Sree Durga Cashew Industries.	Karkala	Udupi	Cashew Kernels	Small

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122	Sri Devi Cashew Industries,	Karkala	Udupi	Cashew Kernels	Small
123	Sri Ganesh Cashew Ind,	Karkala	Udupi	Cashew Kernels	Small
124	Sri Gururaj Industries, Main Road,	Karkala	Udupi	Cashew Kernels	Small
125	Sri Jagadeesh wara Rice Mill,	Karkala	Udupi	rice milling	Small
126	Sri Krishikar mikara Seva Gramodyo ga,	Karkala	Udupi	Cashew Kernels	Small
127	Sri Krishna Exports,	Karkala	Udupi	Cashew Kernels	Small
128	Sri Thirumal Cashew (Unit-2)	Karkala	Udupi	Cashew Kernels	Small
129	Sri Shanthara m Cashew Industries. ,	Karkala	Udupi	Cashew Kernels	Small
130	Sri Vinayaka Hollow Bricks, Main Road,	Karkala	Udupi	hollow bricks	Small
131	Sri Vinayaka Agro Products,	Karkala	Udupi	gingelly oil	Small
132	Sri Vinayaka Stores,	Karkala	Udupi	oil expellers	Small
133	St. Lawrence Industries,	Karkala	Udupi	coconut oil	Small
134	Tara Cashews,	Karkala	Udupi	Cashew Kernels	Small
135	Tata Tele Service Ltd,	Karkala	Udupi	telephone tower	Small
136	Tata Teleservic es Ltd.,	Karkala	Udupi	telephone tower	Small
137	Thirumala Cashew Industries,	Karkala	Udupi	Cashew Kernels	Small
138	Veekay Pvc Profiles, Sy.no.522 /1, Hirgana village, Karkala Tq, Udupi.	Karkala	Udupi	Cashew Kernels	Small
139	Veera Vittala Exports,	Karkala	Udupi	Cashew Kernels	Small
140	Vijaya Cashews,	Karkala	Udupi	Cashew Kernels	Small
141	Vinayaka Cashew,	Karkala	Udupi	Cashew Kernels	Small
142	R&G Enterprise s	Karkala	Udupi	stone crusher	Small
143	Sulochana Exports,	Karkala	Udupi	Cashew Kernels	Small
144	St. Joseph Inds,	Karkala	Udupi	stone crusher	Small
145	Shah Steels,	Karkala	Udupi	processin g waste sand	Small
146	HLN nayak &sons,	Karkala	Udupi	Cashew Kernels	Small
147	Komal pellets,	Karkala	Udupi	Cattle Feed	Small
148	Sri Durga crusher, t	Karkala	Udupi	stone crusher	Small
149	Xcell telecom pvt ltd,	Karkala	Udupi	telephone tower	Small
150	Xcel telecom private ltd,	Karkala	Udupi	telephone tower	Small
151	Vintel Industries (Celina Industries),	Karkala	Udupi	coconut oil	Small
152	Rocksand minerals,	Karkala	Udupi	stone crusher	Small
153	Sapthagiri Industries,	Karkala	Udupi	CNS oil	Small
154	Shri Mahisham ardhini stone crusher,	Karkala	Udupi	stone crusher	Small
155	paduthiru pathi biofuels,	Karkala	Udupi	Agro based fuel briquette	Small
156	Shri panchavat i Inds,	Karkala	Udupi	Boiled rice	Small
157	Nithyanan da wood Inds & furnitures, t	Karkala	Udupi	saw mill& wooden furniture	Small
158	Wireless TT info services ltd,	Karkala	Udupi	telephone tower	Small
159	Adishakth i Exports,	Karkala	Udupi	Cashew Kernels	Small
160	Indus Towers,	Karkala	Udupi	telephone tower	Small
161	Indus Towers,	Karkala	Udupi	telephone tower	Small
162	Viom Networks ltd,	Karkala	Udupi	telephone tower	Small
163	Sri Ganesh Cashews	Karkala	Udupi	Cashew Kernels	Small
164	Rose Agro Tech,	Karkala	Udupi	Desiccate d coconut	Small

				powder	
165	Sri Vishnumu rthy Designers,	Karkala	Udupi	wooden furniture	Small
166	Kamakshi Industries,	Karkala	Udupi	Soft Drinks	Small
167	Suprem Stone Crusher,	Karkala	Udupi	Stone crusher	Small
168	N-lite food Industry,	Karkala	Udupi	Bakery Products	Small
169	Sri Devi Shilpakal a,	Karkala	Udupi	Granite cutting & polishing	Small
170	Megha Industries,	Karkala	Udupi	Drinking Water	Small
171	Billava Interlock Industries,	Karkala	Udupi	Hollow Blocks & Interlocks	Small
172	Global Hollow Blocks,	Karkala	Udupi	ollow Bloc	Small
173	New Megha Industries,	Karkala	Udupi	Drinks &	Small
174	Kiran Stone Crusher,	Karkala	Udupi	Stone crusher	Small
175	Sai Stone Crusher,	Karkala	Udupi	Stone crusher	Small
176	Boiler Poultry Farm,	Karkala	Udupi	Poultry	Small
177	Kiran Stone Crushers,	Karkala	Udupi	Stone Crusher	Small
178	Raychel Industries,	Karkala	Udupi	Hollow Bocks	Small
179	Rishal Cashw Industry,	Karkala	Udupi	Cashew Kernals	Small
180	OM Enterprise s, t	Karkala	Udupi	Stone Crusher	Small
181	Sri Ramacha ndra Wood Works,	Karkala	Udupi	Wooden furniture	Small
182	Deepthi Cashew Co,	Karkala	Udupi	Cashew Kernals	Small
183	Durgapara meshwari Stone Crusher,	Karkala	Udupi	Stone Crusher	Small
184	Primary Health Center-	Karkala	Udupi	Clinic	Small
185	Primary Health Center-	Karkala	Udupi	Clinic	Small
186	Primary Health Unit-	Karkala	Udupi	Clinic	Small
187	Primary Veterinar y Clinic-	Karkala	Udupi	Clinic	Small
188	Primary Veterinar y Clinic-	Karkala	Udupi	Clinic	Small
189	Veterinar y Dispensar y,	Karkala	Udupi	Clinic	Small
190	Sri Sai Dental Clinic,	Karkala	Udupi	Clinic	Small
191	Aithal Clinic,	Karkala	Udupi	Clinic	Small
192	Sri Sai Dental Clinic,	Karkala	Udupi	Clinic	Small
193	Aithal Clinic,	Karkala	Udupi	Clinic	Small
194	Mangalor e power company,	Udupi	Udupi	Thermal power	Large
195	Udupi Power Corporati on,	Udupi	Udupi	Thermal power	Large
196	Suzlon wind Internatio nal,	Udupi	Udupi	Wind energy product	Large
197	SE Composit es,	Udupi	Udupi	Wind energy product	Large
198	TA Pai managem ent Institute,	Udupi	Udupi	organisati on	Large
199	Maharaj Infra,	Udupi	Udupi	Apartmen t	Large
200	SKE & C KCT Joint Ventur Stratargic Ltd,	Udupi	Udupi	Crude oil storage & handling facility	Large
201	Mandavi Real Estate Devolpers ,	Udupi	Udupi	STPs Establish ed at Residenti al apartmen ts, with wastewat er generatio n more than 100KLD	Large
202	Sarvada Distillerie s,	Udupi	Udupi	IML Bottling	Large

203	Sri Chakra Container s Pvt Ltd,	Udupi	Udupi	Woven fabrics and sacks(PP/ HDPE) labur accomada tion with 20 kld STP	Large
204	Towm Municipal Council, Kaup, Udupi tq & District	Udupi	Udupi	LB	LB
205	Supreme Feeds, Post Tq & District	Udupi	Udupi	Cattle Feed	Medium
206	SKE & C KCT Joint Ventur Stratargic Ltd,	Udupi	Udupi	stone crusher	Medium
207	Bremels Rubber Industries Pvt Ltd,	Udupi	Udupi	Solid Tyre Plants	Medium
208	Grand Riviera ,	Udupi	Udupi	residential apartment (builtup area - 2438.92 sq.m with 44 flats) & 30 KLD STP	Medium
209	Sri Vinayaka Industries. , Tq & Dist.	Udupi	Udupi	boiled rice	Small
210	Akai Industries Dt	Udupi	Udupi	imitation jewellary	Small
211	Algitech Chemical s,	Udupi	Udupi	Algi proofing compunds	Small
212	Anantha Padmanab ha Stone Crusher,	Udupi	Udupi	stone crusher	Small
213	Anish Stone Crushing Industries,	Udupi	Udupi	stone crusher	Small
214	Annappa foods (Annapp a) Indtries, Tq & Dist	Udupi	Udupi	Prawn shell cleaning	Small
215	Anup Inds, Putthige,	Udupi	Udupi	CNS oil	Small
216	B.M.T. Fish Peelig Shed, Tq & Dt.	Udupi	Udupi	fish peeling	Small
217	Brahma Baidarkal a Industries, Tq, Udupi Dt.	Udupi	Udupi	stone crusher	Small
218	MG Constructi on, Sy No. 382/1, 383/1 & 385/1,	Udupi	Udupi	stone crusher	Small
219	Ennar Enterprise s, Nandikoo r Village,	Udupi	Udupi	stone crusher	Small
220	Magnum Granites,	Udupi	Udupi	stone crusher	Small
221	Oxford Industries,	Udupi	Udupi	stone crusher	Small
222	Saritha Enterprise s,	Udupi	Udupi	stone crusher	Small
223	Seethalax mi Stone Crushing Industry,	Udupi	Udupi	stone crusher	Small
224	Shree Durga Distillery,	Udupi	Udupi	Fenny & IMFL bottling	Small
225	Sri Madanthe shwara Stone Crusher,	Udupi	Udupi	stone crusher	Small
226	Sri Padma Crusher,	Udupi	Udupi	stone crusher	Small
227	Abharan Motors	Udupi	Udupi	service staion	Small
228	Kinara Food Products,	Udupi	Udupi	fruit processin g	Small
229	L.M. Motors, Dt.	Udupi	Udupi	service staion	Small
230	Prathvi Motors,	Udupi	Udupi	service staion	Small
231	Sri Maruthi Mills,	Udupi	Udupi	boiled rice	Small
232	Sri Sai Durgi Auto Service,	Udupi	Udupi	service staion	Small

233	Madhura Food Products,	Udupi	Udupi	fruit processin g	Small
234	Vinayaka Rice Inds,	Udupi	Udupi	boiled rice	Small
235	Alsafa Fabricatio ns, Udupi.	Udupi	Udupi	fabricatio n	Small
236	Bharath Tile Co. ,	Udupi	Udupi	roofing tiles	Small
237	Bharathi Airtel ltd, Udupi.	Udupi	Udupi	telephone tower	Small
238	Canara Cashew Industires,	Udupi	Udupi	Cashew Kernels	Small
239	Canara Ice Plant,	Udupi	Udupi	Ice Block manufact uring	Small
240	Gurugane sh Industries,	Udupi	Udupi	Cashew Kernels	Small
241	Hangyo Ice creams Pvt ltd, (Sri krishna frozen Desserts pvt ltd),	Udupi	Udupi	Ice Cream	Small
242	Kiran Tyre Resoling Works,	Udupi	Udupi	tyre retrading	Small
243	Laxmi Farms,	Udupi	Udupi	poultry farm	Small
244	Medline Transcript ions	Udupi	Udupi	oil expellers	Small
245	Natural Ice Cream	Udupi	Udupi	ice cream	Small
246	Navaneet h Cashews	Udupi	Udupi	Cashew Kernels	Small
247	Navyug Cashew Industries	Udupi	Udupi	Cashew Kernels	Small
248	Prabhath Inds	Udupi	Udupi	coconut oil & flour mill	Small
249	Prakash Saw Mills Ltd,	Udupi	Udupi	saw mill	Small
250	Robosoft Technolo gies,	Udupi	Udupi	software unit	Small
251	Sealine Products.,	Udupi	Udupi	Ice Block manufact uring	Small
252	Shanthala Cashew Ind,	Udupi	Udupi	Cashew Kernels	Small
253	Shetty Ice & Cold Storage,	Udupi	Udupi	Ice Block manufact uring	Small
254	Shivapras ad Bottling Company,	Udupi	Udupi	soft drinks	Small
255	Sri Durga food and bewarages ,	Udupi	Udupi	mineral water	Small
256	Sri Durga Oil Mills,	Udupi	Udupi	coconut oil	Small
257	Sri Ganesh Auto Works,	Udupi	Udupi	automobil e repair	Small
258	Sri Hariprasa d mills,	Udupi	Udupi	coconut oil	Small
259	Sri Laxmi Cahsew Industries,	Udupi	Udupi	Cashew Kernels	Small
260	Sri Mookamb ika Poly Products,	Udupi	Udupi	fiber glass molding	Small
261	Sri Vinayaka Cashew Ind,	Udupi	Udupi	Cashew Kernels	Small
262	Sri Vruddhi Industries,	Udupi	Udupi	plastic carry bag unit	Small
263	Srilatha Softdrinks ,	Udupi	Udupi	mineral water &soft drinks	Small
264	Veerabha draswamy Wood Ind,	Udupi	Udupi	wooden furniture	Small
265	Shalet Rice mill,	Udupi	Udupi	boiled rice	Small
266	Mathaes poultry farm	Udupi	Udupi	poultry farm	Small
267	Diamond concrete bricks,	Udupi	Udupi	concrete bricks	Small
268	Noorani Cashew Inds,Vada rse panchayat h, Kavadi Udupi Tq & Dist.	Udupi	Udupi	Cashew Kernels	Small
269	Sri Ramprasa d Inds,	Udupi	Udupi	coconut oil	Small
270	Sri Shantheri oil and floor mill,	Udupi	Udupi	coconut oil	Small
271	Agro Manipal foods,	Udupi	Udupi	fruit processin g	Small
272	Sri Vinayaka cashew Industries, Sy.No:220 /1P11,	Udupi	Udupi	Cashew Kernels	Small

	Nalkur, Udupi Tq & Dist				
273	Sharada Enterprise s	Udupi	Udupi	paint formulati on	Small
274	Consolida ted Constructi on consortiu m limited,	Udupi	Udupi	concrete batch mixing	Small
275	Concure concrete blocks,	Udupi	Udupi	Hollow Blocks	Small
276	Tata teleservic es ltd,	Udupi	Udupi	telephone tower	Small
277	SP Bricks,	Udupi	Udupi	Wire cut bricks	Small
278	Unity rock Industry,	Udupi	Udupi	stone crusher	Small
279	GTL Infrastruct ure ltd,	Udupi	Udupi	telephone tower	Small
280	Wireless TT info services ltd,	Udupi	Udupi	telephone tower	Small
281	Wireless TT info services ltd	Udupi	Udupi	telephone tower	Small
282	Wireless TT info services ltd,	Udupi	Udupi	telephone tower	Small
283	Wireless TT info services ltd, Syno: 129/20/A, perdoor, brahmava ra, hebri, udupi	Udupi	Udupi	telephone tower	Small
284	Aircel ltd,	Udupi	Udupi	telephone tower	Small
285	Aircel ltd,	Udupi	Udupi	telephone tower	Small
286	Indus towers ltd,	Udupi	Udupi	telephone tower	Small
287	ATC India Tower corporatio n pvt ltd, ltd,	Udupi	Udupi	telephone tower	Small
288	Viom Networks,	Udupi	Udupi	telephone tower	Small
289	Siddhi vinayaka cashew industries,	Udupi	Udupi	Cashew Kernels	Small
290	Century Hollow Blocks,	Udupi	Udupi	Cement Hollow Clocks	Small
291	Navyuga Engneerin g Complny Ltd,	Udupi	Udupi	Hot Mix Plant	Small
292	Navyuga Engneerin g Complny Ltd,	Udupi	Udupi	wet mix plant	Small
293	Akshya cashew Industries,	Udupi	Udupi	Cashew Kernels	Small
294	Coelho Constructi on Pvt Ltd,	Udupi	Udupi	Interlocks & Pavers	Small
295	Udupi Royal Soda & Soft Drinks,	Udupi	Udupi	Soft drinks	Small
296	D P Enterprise s	Udupi	Udupi	Hollow Blocks	Small
297	Arya Industries	Udupi	Udupi	Interlock & Hollow Blocks	Small
298	Hindustha n Durgs	Udupi	Udupi	Ayurvedic Medicine	Small
299	Sarweshw ara Minerals,	Udupi	Udupi	Resine coated sand	Small
300	Vintech India corporatio n,	Udupi	Udupi	fly ash baging	Small
301	Vansh Blocks,	Udupi	Udupi	Hollow Blocks	Small
302	Ayush Enviroot ech Pvt Ltd,	Udupi	Udupi	Common Bio-Medical Waste Treatment	Small
303	Deva Rice Industries,	Udupi	Udupi	Boiled rice without Boiler	Small
304	Sri Nidhi Blocks,	Udupi	Udupi	Hollow Blocks	Small
305	Sri Damodar Constructi on,	Udupi	Udupi	Solid Blocks	Small
306	ATC Telecom tower,	Udupi	Udupi	15KVA DG Set	Small
307	Sri Ram Bricks Industris,	Udupi	Udupi	Fly ash bricks	Small
308	Adith Packers,	Udupi	Udupi	cotton & non wowen plastic bags	Small
309	Chamundi Stone Crusher,	Udupi	Udupi	Stone Crusher	Small
310	Keerthi Resine & Paints,	Udupi	Udupi	Resine	Small

311	Zenith Die Makers Pvt Ltd,	Udupi	Udupi	Die Making	Small
312	Hangyo Ice Cream Pvt Ltd (Unit-II)	Udupi	Udupi	Ice Block manufact uring	Small
313	Royal Industries,	Udupi	Udupi	cashew Nut Shell Oil	Small
314	Abhiman Ice and cold storage,	Udupi	Udupi	Ice Block manufact uring	Small
315	Star Cement Pipes Co,	Udupi	Udupi	Cement Pipes	Small
316	SLG Stone Crusher,	Udupi	Udupi	Stone crusher	Small
317	Alupa Foods Private Limited, C/o Dhanyala xmi Rice Mills,	Udupi	Udupi	Boiled Rice	Small
318	Intaglio Engraving Systems,	Udupi	Udupi	printing rollers	Small
319	Sri Brahmalin geshwara Interlocks & Blocks,	Udupi	Udupi	Interlocks & Solid Blocks	Small
320	Sri Chakra Container s Pvt Ltd,	Udupi	Udupi	Woven fabrics	Small
321	Nandikur Polymers,	Udupi	Udupi	PVC Pipes	Small
322	Padur Enterprise s,	Udupi	Udupi	Paper cup	Small
323	S.L.G Stone Crusher,	Udupi	Udupi	Stone Crusher	Small
324	Aradhya Cashew Industries,	Udupi	Udupi	Cashew Kernals	Small
325	Udaya Aqua Products,	Udupi	Udupi	Mineral water	Small
326	Sristi Ventures,	Udupi	Udupi	Eco Wall (prefabric ated structural panel)	Small
327	Color Park,	Udupi	Udupi	Formulati on and blending of all types of textile dyestuffs and textile chemicals	Small
328	Anchan Ayurvedic Industries,	Udupi	Udupi	urveda Khas	Small
329	Vishal Sand,	Udupi	Udupi	slica sand wash	Small
330	Anjana Packaging ,	Udupi	Udupi	Househol d Plastic Articles & Blow Moulded	Small
331	Hotel Amar,	Udupi	Udupi	Hotel	Small
332	Karavali Hospital,	Udupi	Udupi	Clinic	Small
333	Nayaks Hospital,	Udupi	Udupi	Hospital	Small
334	Padubidri Hospital,	Udupi	Udupi	Hospital	Small
335	Primary Health Centre,	Udupi	Udupi	Clinic	Small
336	Primary Health Centre,	Udupi	Udupi	Clinic	Small
337	Primary Health Unit-	Udupi	Udupi	Clinic	Small
338	Primary Health Unit-	Udupi	Udupi	Clinic	Small
339	Primary Veterinar y Clinic-	Udupi	Udupi	Clinic	Small
340	Primary Veterinar y Clinic-	Udupi	Udupi	Clinic	Small
341	Primary Veterinar y Clinic-	Udupi	Udupi	Clinic	Small
342	Shantheri Pallavi Maternity Hospital,	Udupi	Udupi	Clinic	Small
343	Shree Ravalnath , Medical, Surgical & Maternity	Udupi	Udupi	Clinic	Small

	Centre,				
344	Sri Siddhi Vinayak Hospital,	Udupi	Udupi	Clinic	Small
345	Veterinar y Hospital,	Udupi	Udupi	Clinic	Small
346	Govt. Ayurvedic Dispensar y,	Udupi	Udupi	Clinic	Small
347	Rural Maternity & Child Welfare Home,	Udupi	Udupi	Clinic	Small
348	Medi- Tech Dignostic s,	Udupi	Udupi	Clinic	Small
349	Astanga Clinic,	Udupi	Udupi	Clinic	Small
350	Veterinar y Hospital,	Udupi	Udupi	Clinic	Small
351	Govt. Ayurvedic Dispensar y,	Udupi	Udupi	Clinic	Small
352	Rural Maternity & Child Welfare Home,	Udupi	Udupi	Clinic	Small
353	Medi- Tech Dignostic s,	Udupi	Udupi	Clinic	Small
354	Astanga Clinic,	Udupi	Udupi	Clinic	Small
355	Prabha Clinic Kuthyar	Udupi	Udupi	Clinic	Small

SOCIO-ECONOMIC SURVEY ON PEOPLE'S PERSPECTIVE REGARDING INDUSTRIAL GROWTH AND DEVELOPMENT OF UDUPI

ಸಾಮಾಜಿಕ-ಆರ್ಥಿಕ ಸಮೀಕ್ಷೆಯ ಪ್ರಶ್ನೆಗಳು

I.   ಸಾಮಾನ್ಯ ಮಾಹಿತಿ

ವ್ಯಕ್ತಿಯ ಹೆಸರು :

_____

ಗ್ರಾಮದ ಹೆಸರು:

_____

ಅಂಚೆವಿಲಾಸ: _____

ಹೋಬಳಿ/ತಾಲ್ಲೂಕು ಮತ್ತು ಜಿಲ್ಲೆ

_____

1. **ಮಾತೃ ಭಾಷೆ:**   ☐ ಕನ್ನಡ   ☐ ತುಳು ☐ ಬ್ಯಾರಿ /ಉರ್ದು ☐ ಕೊಂಕಣಿ   ☐ ಇತರೆ

2. **ಕುಟುಂಬ ಸದಸ್ಯರ ಸಂಖ್ಯೆ:** _____

3. **ಶಿಕ್ಷಣದ ಮಟ್ಟ:**   ☐ ಪ್ರಾಥಮಿಕ ☐ ಪ್ರೌಢಶಾಲೆ ☐ ಪೂರ್ವಪದವಿ ☐ ಪದವಿ ☐ಅನಕ್ಷರಸ್ಥ

4. **ಕುಟುಂಬದ ಮುಖ್ಯಸ್ಥನ ಉದ್ಯೋಗ:**

    ☐ ರೈತ   ☐ ಸರಕಾರಿ ನೌಕರ   ☐ ಖಾಸಗಿ ಉದ್ಯೋಗಿ   ☐ ಸ್ವಂತ ವ್ಯಾಪಾರ   ☐ ಇತರೆ

5. **ಕುಟುಂಬದ ಮುಖ್ಯಸ್ಥನ ಪ್ರತಿ ತಿಂಗಳ ಕುಟುಂಬದ ಆದಾಯ:**

    ☐ < 10,000   ☐ > 10,000   ☐ 10,000- 20,000   ☐ 20,000 - ಇದಕ್ಕಿಂತ ಹೆಚ್ಚು

6. **ಯು.ಪಿ.ಸಿ.ಎಲ್ ಯೋಜನೆಯಿಂದಾದ ಪರಿಣಾಮಗಳು:**

    a) ಕೃಷಿ ಭೂಮಿ   ☐ಲಾಭ ☐ ನಷ್ಟ b) ☐ ಮನೆ   ☐ ಜಾಗ   ☐ ಇತರೆ

7. **ಮಾಲೀಕತ್ವದ ಆಸ್ತಿ:**   ☐ ವೈಯಕ್ತಿಕ ☐ ಜಂಟಿ ☐ ಖಾತಾ ನಂ:   ☐ ವಿಸ್ತಾರ (ಎಕರೆಗಳಲ್ಲಿ):

8. **ಯು.ಪಿ.ಸಿ.ಎಲ್ ಸ್ಥಾವರ ವಿಸ್ತರಣೆಯ ಕಡೆಗೆ ನಿಮ್ಮ ಅಭಿಪ್ರಾಯ:** ☐ ಧನಾತ್ಮಕ   ☐ ಋಣಾತ್ಮಕ

9. **ಬೇರೆ ಯಾವುದೇ ಯೋಜನೆಗಳ ಬಗ್ಗೆ ನಿಮ್ಮ ಅಭಿಪ್ರಾಯ:**   ☐ ಬೇಕು   ☐ ಬೇಡ

10. **ಯು.ಪಿ.ಸಿ.ಎಲ್ ಯೋಜನೆಯ ಸಮಯದಲ್ಲಿ ಎದುರಾದ ಪ್ರಯೋಜನಗಳು ಮತ್ತು ತೊಂದರೆಗಳು:**

ಪ್ರಯೋಜನಗಳು: ☐ ಉದ್ಯೋಗಾವಕಾಶ ☐ ಮೂಲಸೌಕರ್ಯಗಳ ಸುಧಾರಣೆ ☐ ಯಾವುದೂ ಇಲ್ಲ   ☐ ಇತರೆ

ತೊಂದರೆಗಳು:

    a) ☐ ಆರೋಗ್ಯದ ಸಮಸ್ಯೆಗಳು – ☐ಕೆಮ್ಮು ☐ಜ್ವರ ☐ತಲೆನೋವು ☐ಉಸಿರಾಟದ ತೊಂದರೆಗಳು ☐ ಇತರೆ

    b). ☐ ಮೂಲ ಸೌಕರ್ಯಗಳ ಕೊರತೆ – ☐ಗಾಳಿ ☐ನೀರು ☐ ಮಣ್ಣು   ☐ನೆಲ ☐ಜಾಗ ☐ಕಟ್ಟಡ

    c). ☐ ನಿರುದ್ಯೋಗ

11. **ಸಾರಿಗೆ ಸೌಲಭ್ಯಗಳು:**   (a) ಖಾಸಗಿ   ☐ ಇದೆ ☐ ಇಲ್ಲ (b) ಸರ್ಕಾರಿ ☐ ಇದೆ ☐ ಇಲ್ಲ

II.   ಆರ್ಥಿಕ ಸ್ಥಿತಿ;

    12. **ಮನೆ:**   ☐ ಪಕ್ಕಾ   ☐ ಕಚ್ಚಾ

13. ವಿದ್ಯುತ್ ಸಂಪರ್ಕ: ☐ ಇದೆ ☐ ಇಲ್ಲ

14. ಕುಡಿಯುವ ನೀರಿನ ಗುಣಮಟ್ಟ ? ☐ಶುದ್ಧ ☐ಕಲುಷಿತ ☐ಸೂಕ್ತವಲ್ಲ

15. ಕುಡಿಯುವ ನೀರಿನ ಮೂಲ: ☐ಕೈಪಂಪು ☐ಮೇಲ್ಮೈನೀರು ☐ತೆರೆದಬಾವಿ ☐ ನೀರು ಸರಬರಾಜು

16. ಕೃಷಿಗೆ ನೀರಿನ ಮೂಲ:- ☐ಮಳೆ ನೀರು ☐ಅಂತರ್ಜಲ ☐ಕೆರೆ ☐ಬೋರ್ವೆಲ್ ☐ಇತರೆ

17. ಜಾನುವಾರುಗಳ ಆಹಾರ; ☐ ನೈಸರ್ಗೀಕ ಹುಲ್ಲು ☐ ನೆಟ್ಟ ಹುಲ್ಲು ☐ ಖರೀದಿಸಿದ ಆಹಾರ ☐ ಬೆಳೆ ಉಳಿಕೆಗಳು

18. ಸ್ವಂತ ವಾಹನಗಳು: ☐ ದ್ವಿಚಕ್ರ ☐ ನಾಲ್ಕು ಚಕ್ರ ☐ ಇತರೆ

19. ಅಡುಗೆ ಮಾಡಲು ಬಳಸುವ ಇಂಧನ ಪ್ರಕಾರ:

☐ ಎಲ್ಪಿಜಿ ಸಿಲಿಂಡರ್ ☐ ಕಟ್ಟಿಗೆ ☐ ಜೈವಿಕ ಅನಿಲ ☐ ಸೀಮೆಎಣ್ಣೆ ☐ ಇತರೆ

20. ಯಾವುದಾದರೂ ಕೃಷಿ ಉಪಕರಣ ಹೊಂದಿದ್ದಾರೆಯೇ?:

1. ಟ್ರಾಕ್ಟರ್ , ಟಿಲ್ಲರ್
2. ಎತ್ತಿನ ಬಂಡಿ
3. ಇತರೆ

III. ಇತರ ಮಾಹಿತಿ;

21. ವಿಶಿಷ್ಟ ಸ್ಥಳಗಳು: ☐ ಧಾರ್ಮಿಕ ಸ್ಥಳ ☐ ಕೆರೆ ☐ ಕಡಲತೀರ ☐ ಅರಣ್ಯ ☐ ಇತರೆ

22. ಪರಿಸರ ಸಮಸ್ಯೆಗಳ ಬಗ್ಗೆ ನಿಮ್ಮ ಅಭಿಪ್ರಾಯ:

☐ ಜಲ ಮಾಲಿನ್ಯ ☐ ವಾಯು ಮಾಲಿನ್ಯ ☐ ಆರೋಗ್ಯದ ಪರಿಣಾಮ ☐ ಭೂ ನಾಶ ☐ ಮರಗಳ ನಷ್ಟ ☐ ತೆರೆದ ಜಾಗ

23. ನಿಮ್ಮ ಸ್ಥಳದ ಪರಿಸರದ ಸ್ಥಿತಿಯ ಬಗ್ಗೆ ನಿಮ್ಮ ಅಭಿಪ್ರಾಯವೇನು?

☐ಚೊಕ್ಕಟ ☐ಕೊಳಕು☐ ☐ಬಹಳ ಕೊಳಕು ☐ಆರೋಗ್ಯಕರ ☐ಸಾಧಾರಣ ಪರಿಸರ

24. ನಿಮಗೆ ಆರೋಗ್ಯ ಸೌಲಭ್ಯಗಳ ಲಭ್ಯತೆಯನ್ನು ಹೊಂದಿದ್ದೀರಾ? ☐ ಇದೆ ☐ ಇಲ್ಲ

25. ನಿಮ್ಮ ಜಿಲ್ಲೆಯ ಭೂದೃಶ್ಯ ಕಾಲಾನಂತರದಲ್ಲಿ ಬದಲಾಗಿದೆ ಎಂದು ನೀವು ಭಾವಿಸುತ್ತೀರಾ?

☐ ಹೌದು ☐ ಇಲ್ಲ

☐ ಹೌದಾದರೆ ಆವು ಯಾವುವು:-

1.
2.
3.
4.

26. ಕುಟುಂಬದಲ್ಲಿ ಯಾವುದೇ ಸದಸ್ಯರು ಯಾವುದಾದರು ಕಾಯಿಲೆಗಳಿಂದ ಬಳಲುತ್ತಿದ್ದಾರೆಯೇ?

ವೈಯಕ್ತಿಕಅಭಿಪ್ರಾಯ:

-
-
-

ಸಂದರ್ಶನದ ದಿನಾಂಕ: ಎಂಪ್ರಿ ಮಾಹಿತಿ ಸಂಗ್ರಹಣೆ

ಬೆಂಗಳೂರು

ANNEXURE- V – Floral Species encountered outside the quadrat

Sl. No	Species	Family	Status
1.	*Alangium salvifolium* (L.F) Wangerin sub sp. *hexapetalum* (Lamk.) Wangerin	Cornaceae	-
2.	*Alstonia scholaris* (L.) R.Br.	Apocynaceae	-
3.	*Caryota urens* L.	Aeracaceae	-
4.	*Cinnamomum verum* J.Presl	Lauraceae	-
5.	*Dalbergia horrida* (Dennst.) Mabb.	Fabaceae	-
6.	*Diospyros malabarica* (Desr.) Kostel.	Ebenaceae	-
7.	*Garcinia xanthochymus* Hook.f.ex.T.Anderson	Clusiaceae	-
8.	*Getonia flouribunda* Roxb.	Combretaceae	-
9.	*Gnetum ula* Brongn	Gnetaceae	Least Concern
10.	*Ixora polyantha* Wight	Rubiaceae	-
11.	*Madhuca nerifolia* (Moon) H.J.Lam.	Sapotaceae	-
12.	*Mangifera indica* L.	Anacradiaceae	-
13.	*Mimusops elengi* L.	Sapotaceae	
14.	*Naringi crenulata* (Roxb.) Nicolson	Rutaceae	-
15.	*Uvaria narum* (Dunal) Blume	Annonaceae	-

Annexure - 4

Assessment of Carrying Capacity of Land

To evaluate the Carrying Capacity, Indicator Benchmark Comparison method was used; this method is the conventional procedure for many Urban Land Carrying Capacity (UCC) assessment models, (Clarke, 1996; Graymore et al., 2010; Liu, 2012; Oh et al., 2005; Shi et al., 2013; Yu & Mao, 2002). In practice, carrying capacities values are compared with the threshold, acceptable, minimum, or recommended standards of UCC (Joardar, 1998; Liu & Borthwick, 2011). Initially, a set of indicators are established. Then, each determining factor is evaluated for carrying capacity assessment, by comparing human activity impacts to thresholds or targets (Graymore et al., 2010). Carrying capacity of the region was evaluated for the urban land, water resources, atmospheric assimilation and waste carrying capacity of the region.

Land Carrying Capacity of the study area

In the present study,

Land Carrying Capacity (LCC) was evaluated based on methodology presented in Urban Carrying Capacity reported by IIT Guwahati (IIT Guwahati, 2012) and adopted the same formula for the study area.

$$AR = [A - (AND + AIF)] * FAR/S$$

Where AR = area for any developmental requirements

      A = total area

      AND = non developable area

      AIF = area for infrastructure development

      FAR = Floor Area Ratio

      S = Floor area requirement per head

In the present study the carrying capacity is to be calculated in relation to the expansion of existing plant capacity of Udupi Power Corporation Limited (UPCL). In this study the values from the LU/LC analysis are considered for calculation of the carrying capacity of land.

Non developable area (AND) consists of forests, agriculture, waste lands and nallahs, accordingly from the LU/LC calculations, the forest, agricultural land and nallahs added and the value is considered. Area for infrastructure development (AIF) consists of area required for commercial, industrial, public, governmental and transportation activities and organized open spaces. Here waste land area was considered.

As per IIT Guwahati 2012 report,

FAR was determined considering various aspects like, provision of intended free space, safe bearing capacity of soil, economy of people for affording earthquake resilient structures, drainage and transportation requirement and so on. While the proposed "SAFE" method itself will determine an acceptable FAR, one need to provide an initial value of FAR. This value was from guidelines provided by different organization including Urban Local Body (ULB). In absence of any such guidelines, a value of 1.5 was used as initial trial value. This value was suggested based on the general trend observed so far in Indian condition and the same value is being used in the present calculation also.

The total study area which is 25292.94 Hectares is considered as the total area (A).

AR = [A – (AND + AIF)] *FAR/S

AR = [25292.94- (17918.99+3181.58)]1.5/20.98

AR =257.58 Ha.

257.58 Ha is available land in study area.

The nature of the available area whether it is Government land or the private land has to be ascertained through Revenue records and also this area should not fall within the ecologically sensitive zone, human habitation, water bodies, CRZ area etc.

The total land requirement for the proposed project is about 730 acres (295.4 ha) that includes 180 acres for main plant, 278 acres for Ash dyke and 272 acres for railway yard/MGR facilities inside the plant.

(Source: Environmental clearance dated 01.08.2017 MoEF&CC)

From the obtained results the land required for UPCL to expand their existing plant is 295.4 hectares, the present land which is available for any development is 257.58 Ha. This shows that the available land is less than the demand; hence it exceeds the carrying capacity of the area.

Land carrying capacity for Udupi district

As per the 'Udupi-Land Use Land Cover-2017-18 Area Statistics' (KSRSAC), the waste land available in the entire Udupi district is 30182.01 Ha from the latest report that is available; the wasteland may not be used for any purposes other than developmental activities. The below Table no.1 shows the LULC for entire district.

Table.1: Udupi-Land Use Land Cover-2017-18 Area Statistics

Sl No.	Level-1	Area Sq. km	Area Ha	Area %
1	Agricultural land	977.94	97793.53	27.39
2	Built-up	458.65	45865.29	12.84
3	Forest	1390.66	139065.87	38.94
4	Grass land and Grazing land	10.12	1012.26	0.28
5	Others	0.85	85.47	0.02
6	Tree clade area	321.00	32100.09	8.99
7	Wastelands	301.82	30182.01	8.45
8	Water bodies	103.04	10304.49	2.89
9	Wetlands	6.92	691.78	0.19
Total		**3571.01**	**357100.79**	**100.00**

(Source: KSRSAC)

Hence, only the land from the available wasteland of 30182.01 Ha can be utilized for any developmental activities perhaps, without disturbing the land that has already been used for agriculture, built-up, grassland, grazing land, waterbodies and tree clad area with these the eco-sensitive zone areas like Western Ghats, reserve forests, sanctuaries, national parks and sensitive coastal regulation zone areas remain undisturbed.

From the above information, the land required for UPCL to expand their existing plant is 295.4 hectares. The land available as wasteland is 30182.01 Ha in the district, this shows that the available land is more than the demand; hence it comes within the carrying capacity for entire district. The conclusion drawn for the area is beyond our study area.
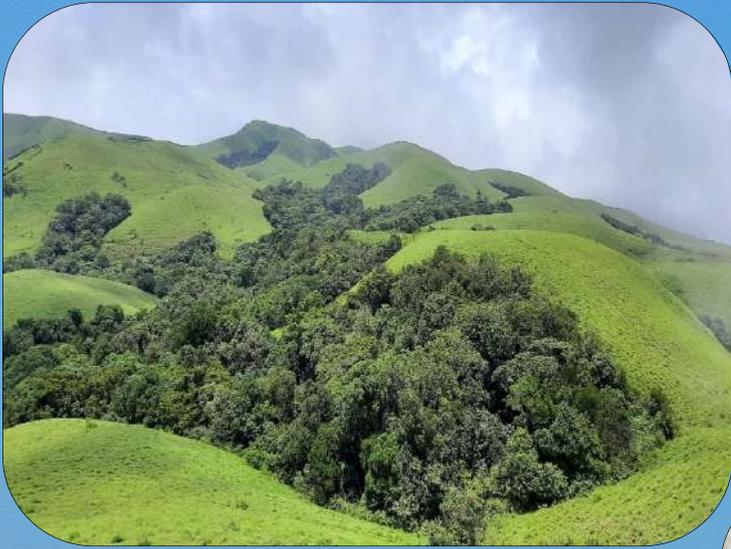
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