CONSERVATION PLAN FOR HASDEO RIVER

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree of

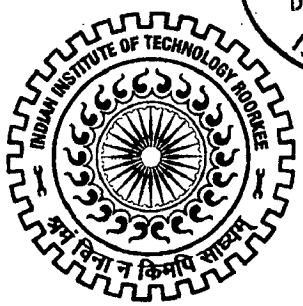
MASTER OF TECHNOLOGY

in

CONSERVATION OF RIVERS AND LAKES

By

SAURABH SONI



ALTERNATE HYDRO ENERGY CENTRE
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ROORKEE - 247 667 (INDIA)

JUNE, 2010

CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in this dissertation, entitled, **"CONSERVATION PLAN FOR HASDEO RIVER"** in partial fulfillment of the requirements for the award of the degree of **Masters of Technology** in **"Conservation of Rivers and Lakes"**, submitted in Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee is an authentic record of my own work carried out during the period from July, 2009 to June, 2010 under the supervision of **Shri M.K. Singhal**, Senior Scientific Officer, Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee.

The matter embodied in this dissertation has not been submitted by me for award of any other degree.

Date: June 30, 2010

Place: Roorkee

(SAURABH SONI)

This is certified that the above statement made by the candidate is correct to the best of my knowledge.

(M. K. Singhal)
Senior Scientific Officer
Alternate Hydro Energy Center
Indian Institute of Technology Roorkee
Roorkee – 247667 (India)

ACKNOWLEDGEMENT

I wish to express my profound sense of gratitude to **Shri M.K. Singhal**, Senior Scientific Officer, Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee for the valuable guidance, encouragement and cooperation and continuous inspiring for completing the dissertation work.

I also express my sincere regards to **Dr.Arun Kumar**, Head, Alternate Hydro Energy Centre, Indian Institute of Technology Roorkee for his immense support, encouragement and inspiration.

I also express my thanks to the staff of Regional Office, Korba, Pollution Control Board, Chhattisgarh for their support and cooperation in the dissertation work.

Dated: June 30 2010 **(SAURABH SONI)**

ABSTRACT

Hasdeo river is a tributory of Mahanadi flows in the stretch of 245 km from Hasdeo mountain North of Sonhat near Mindra village to Barra-Basantpur village, where it meets with the river Mahanadi. Its total catchment area is 9,803 sq. km.

The water of the Hasdeo river has gradually deteriorated due to industrialization and urbanization of catchment area. The river is affected during its course by four urban/industrial centers i.e. Manendragarh, Chirmiri, Korba and Champa. Among the four centers, Korba stands first based on the pollution contribution to the river Hasdeo, where four Thermal Power Plants. Bharat Aluminium Company Ltd. producing Aluminium and Madhya Bharat Paper mill discharge its effluent into Hasdeo river at downstream of champa. Treated partially or untreated wastewater generated from the industries urban centres finds its way into the river or canals through nullahs and drains. The river also receives the sewage water from the colonies of Korba, Urga and Champa city.

. To study the pollution level of Hasdeo river, six numbers of sampling location are selected along the 55 km. stretch of the Hasdeo river. This is currently monitoring by Chhattisgarh Environmental Conservation Board. The secondary water quality data of Hasdeo river collected from regional office Chhattisgarh Environmental Conservation Board, Korba.

Effluents from the different point sources has been analyzed for the physicochemical parameters such as physical, organic, other inorganic,. The water quality has been evaluated on the basis of Water quality index and Temporal and spatial variation of physicochemical parameters and compaired with water quality criteria given by CPCB. The comparison of the water quality of aforesaid classification reflects the extent of pollution at respective sampling stations and different point sources which help us to take necessary measures against the pollution load in the river.

The NSFWQI is used to evaluate the pollution level in river water. The NSFWQI are mostly used in the USA and also applicable in the Indian water environment. Descriptor words and colours are used against the numerical index value as proposed by NSFWQI to evaluate the pollution level in the water bodies. A comparative index analysis for the monsoon, post monsoon, winter, pre monsoon and various years from 2002 - 2009 periods indicates the exact status of pollution level in the Hasdeo river.

The various classifications such as CPCB, NSFWQI reveals that the Now Hasdeo river is polluted if any conservation measure has not been taken so the river quality will become more bad.

Conservation measures are proposed for Hasdeo river so that the water quality of Hasdeo river will become free of pollution. Under this sewage treatment and municipal solid waste management is proposed with estimated cost for most polluted stretch. These conservation measures plan will not successfully work without public participation and public awareness so that PP/PA steps are also proposed.

NOTATIONS AND ABBEREVIATIONS

Symbol/ Abbreviation	Meaning Explanation
UNEP	United Nations Environment Program
BCM	Billion Cubic Meter
lpcd	Liters per capita per day
UFW	Unaccounted for Water
NTPC	National Thermal Power Corporation
SECL	South Eastern Coal Field Limited
MBPL	Madhya Bharat Paper Mill
BALCO	Bharat Aluminium Corporation
CSEB	Chhattisgarh State Electricity Board
SPCB	State Pollution Control Board
NRCP	National River Conservation Plan
CPCB	Central Pollution Control Board
ETP	Effluent Treatment Plant
WQI	Water Quality Indices
NSFWQI	National Sanitation Foundation Water Quality Index
GAP	Ganga Action Plan
NRCA	National River Conservation Authority
CWC	Central Water Commission
MLD	Million Liter per Day
CECB	Chhattisgarh Environment Conservation Board
STP	Sewage Treatment Plant
ASP	Activated Sludge Process
UASB	Upward Flow Anaerobic Sludge Blanket
MSW	Municipal Solid Waste

PP	Public Participation
PA	Public Awareness
NGO	Non Government Organization
Temp.	Temperature
DO	Dissolved Oxygen
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
Ammo. Nitro.	Ammonical Nitrogen
pH	Hydrogen ion Concentration
MPN	Most Probable Number
NTU	Nephelometric Turbidity Unit
NOSLP	No or Slight Pollution
MOP	Moderate Pollution
HOP	High Organic Polution
DW	Descriptor Words
VLOP	Very Light Organic Polution
TDS	Total Dissolved Solids
Q_0	Parameters
W	Weight
I_0	Sub index

CONTENTS

LIST OF TABLES

LIST OF FIGURES, PHOTOS, MAPS AND GRAPHS

CHAPTER-1
INTRODUCTION

1.1 GENERAL

Long Ago, the Coleridge sang: "Water, water, everywhere / Nor any drop to drink." But water is not everywhere now. The globe is going to face a dry water future. The more a country develops, the more water is required. Availability of drinking water and its conservation is always a bigger problem than oil conservation. But severe crisis of water in general is awaiting us all in the world.

Because of the growing economy and rising population, more water is required. Besides making drinking water available, now the greater task is to overcome the water crisis in general for adding to the dimension of human development. The two problems of climate change and reckless construction have dried up the water bank of a number of countries of the world.

The availability of the groundwater sources is now the only aim of the developed countries. Groundwater levels are rapidly falling within the city and brackish water begin to appear even in localities, which earlier had good quality groundwater sources.Irrigation needs and domestic water supplies usually come from groundwater and over extraction of groundwater may aggravate the water crisis. Water economy of many countries depends on this over extraction of groundwater.

In that Case surface water is only the source of water to fulfill the future requirement of water. Over the years rising populations, growing industrialization, and expanding agriculture have pushed up the demand for water. Efforts have been made to collect water by building dams and reservoirs and digging wells; some countries have also tried to recycle and desalinate (remove salts) water. Water conservation has become the need of the day. The idea of ground water recharging by harvesting rainwater is gaining importance in many cities.

In the forests, water seeps gently into the ground as vegetation breaks the fall. This groundwater in turn feeds wells, lakes, and rivers. Protecting forests means protecting water 'catchments'. In ancient India, people believed that forests were the 'mothers' of rivers and worshipped the sources of these water bodies. There is a need of taken suitable steps to conserve our water resources both ground and surface water for fulfill the future requirement.

1.2 INDIAN RIVER SYSTEM

The Indian River Systems can be divided into four categories – the Himalayan, the rivers traversing the, Daeccan Plateau the Coastal and those in the inlands drainage basin (Figure 1). The Himalayan rivers are perennial as they are fed by melting glaciers every summer. During the monsoon, these rivers assume alarming proportions. Swollen with rainwater, they often inundate villages and towns in their path. The Gangetic basin is the largest river system in India, draining almost a quarter of the country.

The rivers of the Indian peninsular plateau are mainly fed by rain. During summer, their flow is greatly reduced, and some of the tributaries even dry up, only to be revived in the monsoon. The Godavari basin in the peninsula is the largest in the country, spanning an area of almost one-tenth of the country. The rivers Narmada (India's holiest river) and Tapti flow almost parallel to each other but empty themselves in opposite directions. The two rivers make the valley rich in alluvial soil and teak forests cover much of the land. While coastal rivers gush down the peaks of the Western Ghats into the Arabian Sea in torrents during the rains, their flow slow down after the monsoon. Streams like the Sambhar in western Rajasthan are mainly seasonal in character, draining into the inland basins and salt lakes. In the Rann of Kutch, the only river that flows through the salt desert is the Luni. The major river system of India is discussed below (**Fig 1.1**) [54].

- Indus River
- Brahmaputra
- Ganga River
- Yamuna River
- Narmada River
- Tapti River
- Krishna River
- Cauvery River
- Mahanadi River

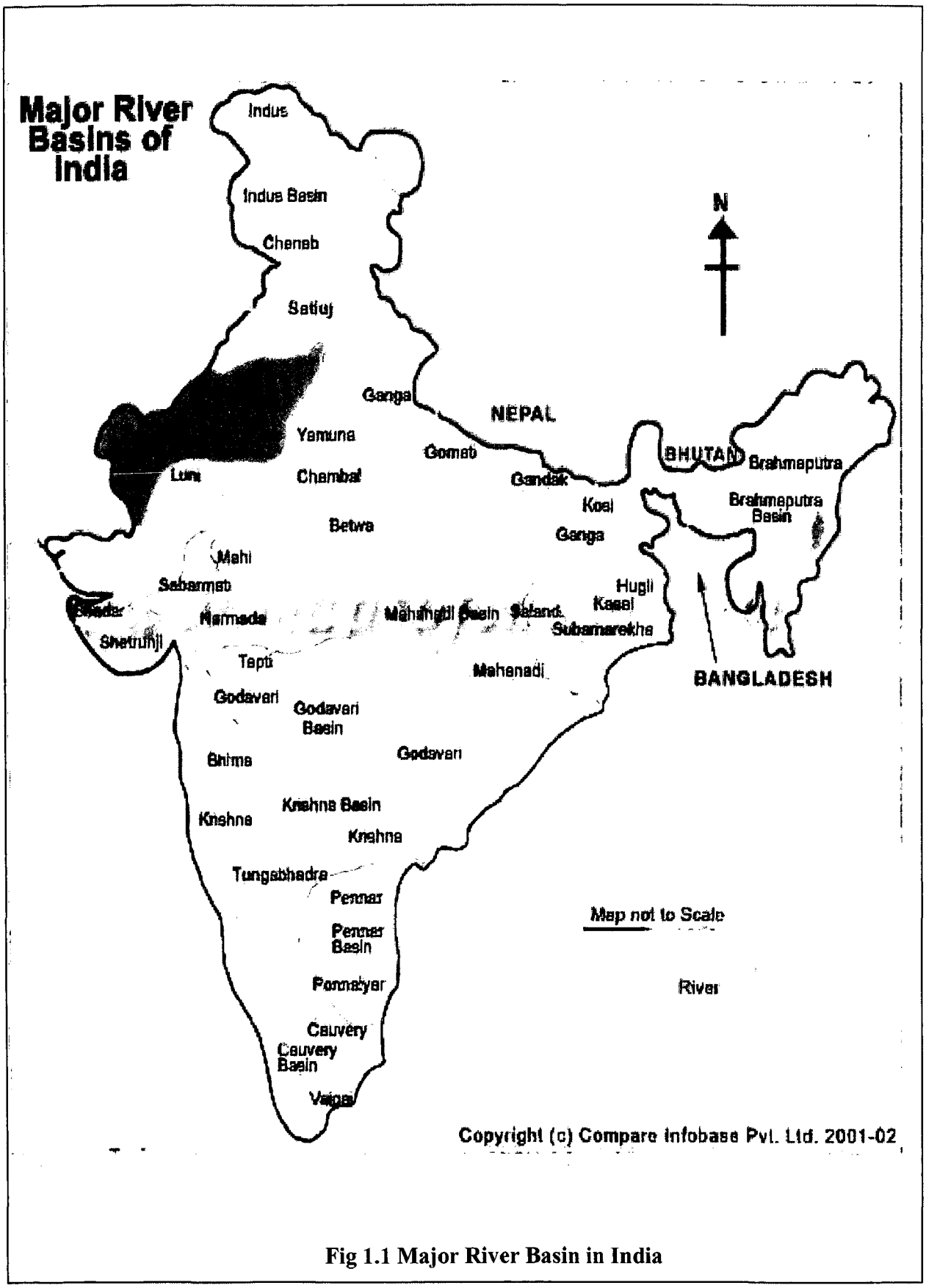


Fig 1.1 Major River Basin in India

Table 1.1 Major River Basins of the Country

S.No.	Name of the River	Origin	Length (km)	Catchment Area (Sq.km)
1	Indus	Mansarovar(Tibet)	1114+	321289+
2	a.) Ganga	Gangotri(Utter Kashi)	2525+	861452+
	b.) Brahmaputra	Kailash Range (Tibet)	916+	194413+
	c.) Barak & other rivers flowing into Meghna Gomti, Muhari, Fenny etc.			41723+
3	Sabarmati	Aravalli Hills(Rajasthan)	371	21674
4	Mahi	Dhar(Madhya Pradesh)	583	34842
5	Narmada	Amarkantak	1312	98796
6	Tapi	Betul (Madhya Pradesh)	724	65145
7	Brahmahi	Ranchi(Bihar)	799	39033
8	Mahanadi	Nazari Town	851	141589
9	Gidavari	Nasik	1465	312812
10	Krishna	Mahabaleshwar	1401	258948
11	Pennar	Kolar(Kolkata)	597	55213
12	Cauvery	Coorg(Karnataka)	800	81155
Total				**2528084**
Source : Central Water Commission, W.M. Directorate (Reassessment of Water Resources Potential of India				

1.2.1 Environmental Factors of River Water Quality

River water quality is highly variable by nature due to environmental conditions such as basin lithology, vegetation and climate. In small watersheds spatial variations extend over orders of magnitude for most major elements and nutrients, while this variability is an order of magnitude lower for major basins. Standard river water for use as reference is therefore not

applicable. As a consequence natural waters can possibly be unfit for various human uses, even including drinking.

There are three major natural sources of dissolved and soluble matter carried by rivers: the atmospheric inputs of material, the degradation of terrestrial organic matter and the weathering of surface rocks. These substances generally transit through soil and porous rocks and finally reach the rivers. On their way, they are affected by numerous processes such as recycling in terrestrial biota, recycling and storage in soils, exchange between dissolved and particulate matter, loss of volatile substances to the atmosphere, production and degradation of aquatic plans within rivers and lakes etc. As a result of these multiple sources and pathways, the concentrations of elements and compounds found in rivers depend on physical factors (climate, relief), chemical factors (solubility of minerals) and biological factors (uptake by vegetation, degradation by bacteria). The most important environmental factors controlling river chemistry are [54]:

- Occurrence of highly soluble (halite, gypsum) or easily weathered(calcite, dolomite, pyrite, olivine) minerals
- Distance to the marine environment which controls the exponential decrease of ocean aerosols input to land (Na^+, Cl^-, SO^- , and Mg^{2+}).
- Aridity (precipitation/runoff ratio) which determines the concentration of dissolved substances resulting from the two previous processes.
- Terrestrial primary productivity which governs the release of nutrients (C,N.Si, K).
- Ambient temperature which controls, together with biological soil activity, the weathering reaction kinetics.
- Uplift rates (tectonisum, relief) Stream quality of unpolluted waters (basins without any direct pollution sources such as dwellings, roads, farming, mining etc.

1.2.2 Impact of River Water Pollution

The pollutants include oils, greases, plastics, plasticizers, metallic wastes, suspended solids, phenols, toxins, acids, salts, dyes, cyanides, pesticides etc. Many of these pollutants are not easily susceptible to degradation and thus cause serious pollution problems. Contamination of ground water and fish-kill episodes are the major effects of the toxic discharges from

industries. Discharge of untreated sewage and industrial effluents leads to number of conspicuous effects on the river environment (**Table 1.2**). The impact involves gross changes in water quality viz. reduction in dissolved oxygen and reduction in light penetration that's tends loss in self purification capability of river water.

On the worldwide scale, the river water pollution leads hazardous impact on aquatic animals and plants. Some studies show alarming condition of river pollution implications. Pratap B and Vandana performed detailed study on pesticide accumulation in Fish species and concluded that, pesticide bioaccumulation was higher in cat- fishes as compared to carps and have species specific in their tissues (liver, brain and ovary) causing metabolic and hormonal imbalance affecting at GnRH and GTH secretion. The reproductive sex steroid hormones were lowered in catfishes and carps of the polluted rivers. They suggested that the bio accumulated insecticide in ovary may cause blocking of the receptor site so that natural hormone cannot bind at the site of estrogen receptor which may cause the dysfunctions of the reproduction in catfish and carps inhabiting the polluted river Gomti and Ganga. They also suggested that the fish bio accumulated insecticide beyond permissible limit must be avoided for the food purpose from such polluted rivers.

Contamination by synthetic organic pollutants is a more recent phenomenon which is even more difficult to demonstrate for lack of appropriate monitoring. The DDT content of the Yamuna river which flows through Delhi is one of the highest ever reported many other problems affect river water quality on a global scale. Very severe pollution by pathogenic microorganisms is still the prime cause of waterborne morbidity and mortality although it is difficult to establish reliable statistical correlation in each case. Many streams and rivers in South America, Africa and paxticulaxly on the Indian sub-continent show high coliform levels together with high BOD and nutrient levels. Eutrophication, which has spread widely to lakes and reservoirs of developing countries now also, affects slow flowing rivers [54].

Table 1.2 : Environmental implications of the discharged of sewage and industrial effluents

S.N.	Factor	Principal environmental effect	Potential ecological Consequences	Remedial action
1	High biochemical oxygen demand (BOD) caused by bacterial breakdown of organic matter	Reduction in dissolved oxygen (DO) concentration	Elimination of sensitive species, increase in some tolerant species; change in the community structure	Pretreatment of effluent, ensure adequate dilution
2	Partia biodegradation of proteins and other nitrogenous material	Elevated ammonia nitrite and nitrate levels concentration; increased	Elimination of intolerant species, reduction in sensitive species	Improved treatment to ensure complete nitrification; nutrient stripping possible but expensive
3	Release of suspended solid matter	Increased turbidity and reduction of light penetration	Reduced photosynthesis of submerge plants; abrasion of gills or interference with normal feeding behavior	Provide improved settlement, insure adequate dilution
4	Deposition of organic sludges in slowe water	Release of Methan and hydrogen as sulphide decomposes anoxically, Modification of substratum by blanket of Sludge	Elimination of normal benthic community loss of interstitia species; increase in the species able to exploit increased food source	Discharge where velocity adequate to prevent deposition
Other Poisons				
1	Presence of poisonous substances	Change in water quality	Water directly and acutely toxic to some organisms, causing change in community composition; consequential effect on pray-predator relation; sub- lethal effects on some species	Increase dilution
Inert Solids				
1	Particles in suspension	Increased turbidity. Possibly increased abrasion	Reduced photosynthesis of submerged plant. Impairing feeding ability through reduced vision or interference with collecting mechanism of filter feeders (e.g. reduction in nutritive value of collected material).Possible abrasion	Improve settlement
2	Deposition of material	Blanketing of substratum, filing of interstices and/or substrate instability	Change in benthic community, reduction in diversity (increased number of a few species)	Discharge where velocity adequate to ensure dispersion

Source : S.C. Santra , The Earth Encyclopedia

1.3 GLOBAL WATER SCENARIO

Water, the most vital element for the survival on earth, has become one of the emerging environmental issues our ecosystems are facing today. Issues of water quantity, quality and availability are the three major concerns and are vital to the quality of the life on earth. The assessment of the global water resources can alarm us for its future consequences. Water crises are the challenges to the global environment communities, as water issues have been included under the agenda 21 of the United Nations Environment Program (UNEP). Freshwater resources are being depleted very fast.

The available freshwater resources are unevenly distributed, with much of the water located far from human population. There are an estimated 263 major international river basins in the world, covering about 45% of the earth's land surface area1. Among the available freshwater, 90% is available through groundwater resources serving the drinking water requirement of about 1.5 billion people. Agriculture sector is the largest consumer of the available water accounting to 75% of the available global water followed by industrial activities to 20% and remaining 5% is for domestic sector. An estimate shows that two third people of world will be forced to live under water stressed conditions by the end of the next two decades. In Africa alone, 25 countries will be water stressed (< 1,000 cubic meters per capita per year) by the year 2025. At present, about 450 million people in 29 countries are facing water scarcity.

Safe drinking water supply and sanitation remain the major problem across the world with about 20% of the global population lacking access to safe water. Water pollution is also another matter of the major concern in the developing countries, which is affecting about 1.2 billion people and costing the lives of nearly 15 million children annually. Besides human life, coastal and marine ecosystems are also facing great threats from a variety of human activities. About 50% of the world's coasts are threatened by haphazard developmental activities. Land based activities amount to 80% marine pollution leading to severe eutrophication in several seas. Increasing marine pollution is resulting in the decrease in yield of marine fisheries, which can be seen as inland and marine aquaculture production contributes 30% of the total global fish yield. Rise in atmospheric pollution is leading to climate change causing the rise in the sea level and the submergence of low-lying coastal areas. This, in turn, will increase human vulnerability in other areas, as they are highly dependent upon marine resources [58].

1.3.1 Water Scenario in India

India has 1869 cubic km of total natural runoff. Out of which only 690 cubic km. of surface water resources and 432 cubic km. of ground water resources are in the form of utilizable resources. Around 16% of the world population residing in India possesses only 4 % of world water resources. Therefore the pressure on water resources in India is very high.

Population growth along with improved level of living standards has increased the demand of fresh water availability. It is projected that the demand would be huge by 2025. According to Standing Sub-committee, Ministry of Water Resources, a total annual demand for water will increase to 1093 BCM in 2025 from 634 BCM in 2000. Demand of Drinking water, which has been given the first priority in National water policy, will also go high from 42 BCM to 52 BCM.

On the other side resources of water supply are limited. Ground water, being an important source of drinking water and food security for India, supplies around 80 per cent of water for domestic use in rural areas. India has developed almost all the ground water resources. It has also been realized now that ground water quantity and quality are declining and deteriorating rapidly. This has implications on per capita availability of fresh water. The available water per capita per year is 2384 cubic metre in the year of 2000 as against 6008 cubic metre in 1947. This shows a drastic decline in per capita availability of water. It has been projected that per capita per year water availability would be only 1389 cubic metre by the year of 2025.

According to **Water stress Index** given by Falkenmark and Widstrand in 1992, a region whose renewable fresh water availability is below 1700 cubic meters/capita/annum is a 'water stress' region, and the one where availability falls below 1000 cubic meters/capita/annum experiences chronic 'water scarcity'. Several parts of India are classified as water stressed, for example, regions in the Indus, Krishna, Mahi, and Ganga sub-basins. A few parts of India are water scarce, namely, the regions under east flowing rivers between Pennara and Kanyakumari, between Mahanadi and Pennar, Cauvery, etc. As per this index, India as a whole may face severe water stress by 2025 with a per capita availability of only 1389 cubic meters. (IUCN, 2004)

In short, it is seen that water demand has increased but supply has remained limited, which has resulted into shortages and scarcity of water resources in India [54].

1.4 WATER QUALITY AND ITS CONSUMPTION

1.4.1 Water and its Quality

Water is colorless, tasteless, and odorless. It is an excellent solvent that can dissolve most minerals that come in contact with it. Therefore, in nature, water always contains chemicals and biological impurities i.e. suspended and dissolved inorganic and organic compounds and micro organisms. These compounds may come from natural sources and leaching of waste deposits. However, Municipal and Industrial wastes also contribute to a wide spectrum of both organic and inorganic impurities. Inorganic compounds, in general, originate from weathering and leaching of rocks, soils, and sediments, which principally are calcium, magnesium, sodium and potassium salts of bicarbonate, chloride, sulfate, nitrate, and phosphate. Besides, lead, copper, arsenic, iron and manganese may also be present in trace amounts. Organic compounds originate from decaying plants and animal matters and from agricultural runoffs, which constitute natural humic material to synthetic organics used as detergents, pesticides, herbicides, and solvents. These constituents and their concentrations influence the quality and use of the natural water resource [49].

Primary water quality criteria for designated best classes (for drinking water, outdoor bathing, propagation of wildlife & fisheries, irrigation, industrial cooling) have been developed by the Central Pollution Control Board. The limits for criteria pollutants are given at **Table 1.3** and Industrial effluent standard is given in **Table 1.4**

Table 1.3: Primary Water Quality Criteria for Designated Best Use Classes

S. No.	Designated Best Use	Class of Water	Criteria
1.	Drinking water source without conventional treatment	A	Total Coli forms MPN/100 ml shall be 50 or less pH between 6.5 and 8.5 Dissolved oxygen 6 mg/l or more Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
2.	Outdoor bathing (Organised)	B	Total Coli forms Organism MPN/100ml shall be 500 or less, pH between 6.5 and 8.5 Dissolved Oxygen 5 mg/l or more, Biochemical Oxygen Demand 5 days 20°C 3 mg/l or less
3.	Drinking water source after conventional treatment and disinfection	C	Total Coli forms Organism MPN/100ml shall be 5000 or less, pH between 6 to 9, Dissolved Oxygen 4 mg/l or more; Biochemical Oxygen Demand 5 days 20°C 3 mg/l or less
4.	Propagation of wild life and Fisheries	D	pH between 6.5 and 8.5, Dissolved Oxygen 4 mg/l or more Free Ammonia (as 1.2 mg/l) or less
5.	Irrigation, Industrial cooling, Controlled Waste Disposal.	E	pH between 6 to 8.5, Electrical Conductivity at 25°C, micro mhos/cm Max 2250 Boron Max. 2 mg/l
		Below E	Not Meeting A, B, C, D & E Criteria

Source: Central Pollution Control Board

Table 1.4 : Pulp and Paper Industry Effluent Standards

S. No.	Parameter	Standard Limit
1	pH	6.5 to 8.5
2	BOD 3 Days at 27 °C	30 mg/l
3	Oil and Grease	10 mg/l
4	Suspended Solid	100mg/l

Source: http://www.cpcb.nic.in/Industry -Standards/Effluent

1.4.2 Per Capita Water Supply in India

- Per Capita Water Supply per day is arrived normally including the following components:
- Domestic needs such as drinking, cooking, bathing, washing, flushing of toilets, gardening and individual air cooling.
- Institutional needs
- Public purposes such as street washing or street watering, flushing of sewers, watering of public parks.
- Minor industrial and commercial uses
- Fire fighting
- Requirements of live stock and
- Minimum permissible Unaccounted for Water (UFW)

Water supply levels in liters per capita per day (lpcd) for domestic & non domestic purpose and Institutional needs, as recommended by CPHEEO for designing water treatment schemes are given at **Table 1.5**. The water requirements for institutions should be provided in addition to the provisions indicated for domestic and non-domestic, where required, if they are of considerable magnitude and not covered in the provisions already made [49].

Table 1.5: Per Capita Water Supply Levels for Design of Scheme

S.No.	Classification of Towns/Cities	LPCD
A.	**Domestic & Non Domestic Needs**	
1	Towns provided with piped water supply but without sewerage system	70
2	Cities provided with piped water supply sewerage system is existing / contemplated	135
3	Metropolitan and Mega cities provided with piped water supply where sewerage system is existing/contemplated	150
B	**Institutional Needs**	
1	Hospital (including laundry)	450 /bed
	a) No. of beds exceeding 100	340 /bed
	b) No. of beds not exceeding 100	180 /bed
2	Hotels	135
3	Hostels	135
4	Nurses home and medical quarters	135
5	Boarding schools / colleges	70 /seat
6	Restaurants	70
7	Air ports and sea ports	70
8	Junction Stations and intermediate stations where mail or express stoppage (both railways and bus stations)	45
		45
9	Terminal stations	45
10	Intermediate stations (excluding mail and express stop)	45
	(Could be reduced to 25 where no bathing facilities)	45
11	Day schools / colleges	45
12	Offices	45
13	Factories(could be reduced to 30 where no bathrooms)	45
14	Cinema, concert halls and theatre	15

Source: Central Pollution Control Board

Note:-

- In Urban areas, where water is provided through public stand posts, 40 lpcd should be considered
- Figures exclude "Unaccounted for Water (UFW)" which should be limited to 15%.

- Figures include requirements of water for commercial, institutional and minor industries. However, the bulk supply to such establishments should be assessed separately with proper justification.

1.5 HISTORY OF RIVER HASDEO

River Hasdeo, a tributary of Mahanadi flows in the stretch of 245 km from Hasdeo mountain North of Sonhat near Mindra village to Barra-Basantpur village, where it meets with the river Mahanadi. Its total catchment area is 9,803 sq.km. It flows towards south of the state, through Koriya, Bilaspur and Korba Districts. During its course, this river merges with its tributaries such as Gej and the Chornai on the left bank and the Tan and the Ahiran on the right before it meets the Mahanadi. Hasdeo has a total length of 245 km and has its origin in Mendra village. Other tributaries of Hasdeo include Jhumka and Bania. Along the river lie rocks and hilly areas, thin forest areas and important settlements such as Sonhat, Ghugra, Manendragarh, Kosgain, Korba and Champa (*Source: Wikipedia the free encyclopedia).*

1.6 STUDY AREA

Korba and Champa is an industrial town in the middle of Chhattisgarh and the Hasdeo river is flowing through the town. The development is growing after starting of mining of coal by South Eastern Coal Limited. Earlier, NTPC, CSEB, Balco was setup at korba and Madhya Bharat Paper mill at Champa open industrial development in that area. They all are located on the bank of the Hasdeo river. This has initiated the massive industrial growth in the area. Some tertiary industries such as laundry, hotel, restaurant, patho-lab and nursing home etc are growing in and around the Hasdeo River. Earlier, the water of Hasdeo River was being used by people for domestic purposes such as drinking, bathing, cleaning and other aesthetics purposes. Now, the water cannot be used for this purpose due to organic pollution and the river carries effluent and domestic sewage from the aforesaid industrial units. Hasdeo river water flow from Dengur to champa. This stretch is study area because water influenced by Korba and Champa urban city due to domestic, agricultural and industrial uses. Hasdeo Basin Map is Shown below in **Fig 1.2** (Source: Central Water Commission, Bhubaneswar)

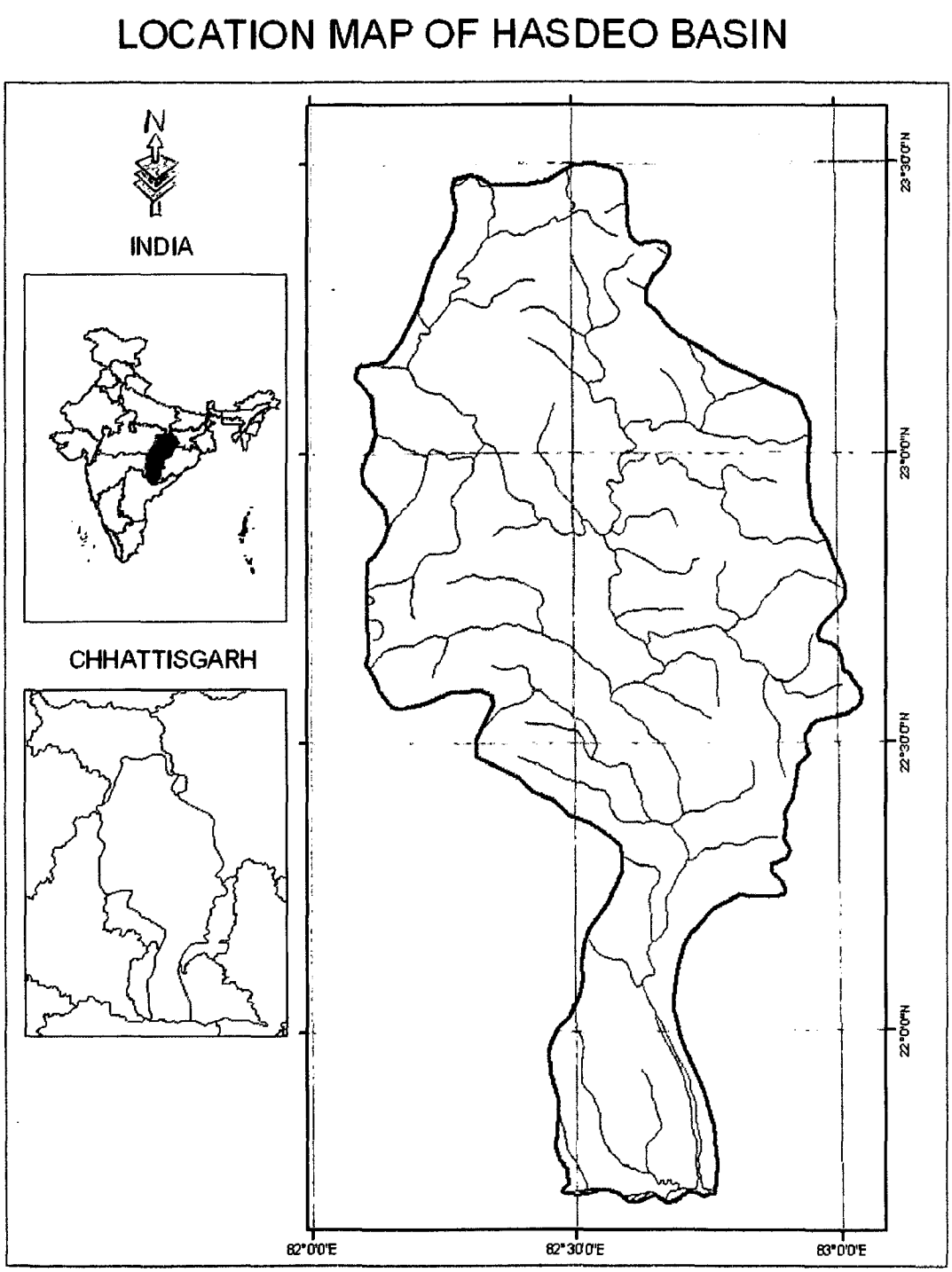


Fig 1.2: Location Map of Hasdeo Basin

1.7 POLLUTION OF HASDEO RIVER

River Hasdeo, a tributory of Mahanadi flows in the stretch of 245 km from Hasdeo mountain North of Sonhat near Mindra village to Barra-Basantpur village, where it meets with the river Mahanadi. Its total catchment area is 9,803 sq. km.

The river is affected during its course by four urban/industrial centers i.e. Manendragarh, Chirmiri, Korba and Champa. Among the four centers, Korba stands first based on the pollution contribution to the river Hasdeo, where four Thermal Power Plants generating 3650 MW power, Bharat Aluminium Company Ltd., producing aluminium. Treated partially or untreated wastewater generated from the industries urban centres finds its way into the river or canals through two major nallahs rivers i.e. Dengur nallah, which carry wastewater from Bharat Aluminium Company Ltd., The ash-dykes/main plant of Chhattisgarh State Electricity Board (CSEB, East) Thermal Power Plant, and Ahiran river carries wastewater from M/s. National Thermal Power Corporation (NTPC), and M/s. BALCO Captive Power Plant located on the right bank of the river. The second contributor is Chirmiri town from which Koria nallah emerges out. Koria nallah carries wastewater from the coal mining areas (underground and open cast) as well as urban wastewater from the Chirmiri. Third contributor is Champa town where M/s. Madhya Bharat Paper Mill and Prakash Industries Ltd., are located on the either side of the river bank. Wastewater from the Manendragarh town also contributes pollution through Hasia, nallah to river Hasdeo but to a lesser degree. Due to distance from river.

The dissolved oxygen (DO) in river Hasdeo ranges from 4.9 mg/l (evening hours) to 8.00 mg/l (morning hours) at Amritdhara and at downstream to Chirmiri. In the tributaries nallah, it varies from 4.6 mg/l to 5.4 mg/l at Dengur in different season. Depletion in the DO is observed due to the presence of organic/inorganic waste and lack of the aquatic life in the water bodies. BOD content in the river water ranges from less than 4.5 to 7.5 at Amritdhara and downstream to M/s. Madhya Bharat Paper Mill respectively. The COD content in the river varies from 24 mg/l to 34 mg/l at downstream to Madhya Bharat Paper Mill respectively. Increased BOD and COD at downstream to M/s. Madhya Bharat Paper Mill observed due to addition of the organic waste from paper mill to the water bodies in the tributaries nallah.

The heavy metal concentration except iron was found well within the limit in the entire river stretch. The iron content in the river water was exceeding the limit at most of the sampling locations including tributaries due to abundance of pyrite ore in the soil of the region. The pesticide content i.e. total BHC, total Endosulfan, Dieldrin & Total DDT were recorded in the river even at Amritdhara because of contribution from agriculture practices in the rural area. The run-off in the catchment area is the prime source of pesticides in the river [1].

1.8 NATIONAL RIVER CONSERVATION PLAN

Those stretches of rivers that are badly polluted were included in the NRCP. NRCP, more than being a river cleaning programme is a long-term plan that would eventually lead to conservation of rivers. The project is entirely funded by the Central Government.

As per the pollution load from industries flowing into rivers, the responsibility for ensuring that industries - whether large scale or small scale - meet pollution standards is that of the State Pollution Control Boards (SPCBs) and not that of NRCP. NRCP can, however, ask heavily polluting industries to either install effluent treatment plants (ETPs) or shut down, although it makes no financial provision for setting up ETPs.

Objective: The objectives of the River Conservation Plan is to improve the water quality of the rivers, which are the major fresh water sources in the country, to achieve 'designated-best-use' water quality criteria through the implementation of pollution abatement schemes. Since the pollution of the rivers is both from the point sources and the non-point sources of pollution, the schemes framed are of the following two categories to achieve the above water quality:

- **Core Scheme**
  - Interception and diversion works to capture the raw municipal sewage flowing into the river through open drains and divert them for treatment.
  - Sewage treatment plant for treating the diverted sewage.
- **Non-core Schemes**
  - Low cost sanitation works to prevent open defecation on river banks.
  - Electric and/ or improved wood based crematoria to conserve the use of wood and help in ensuring proper cremation of bodies brought to the burning ghats.

River from development works such as improvement of bathing ghats, etc. and other misc. works like A forestation, Public Participation & Public Awareness, etc (*Source: NRCP, Ministry of Environment & Forests*).

1.9 OBJECTIVE AND SCOPE OF STUDY

The objectives of the Hasdeo River Conservation Plan is to improve the water quality of the Hasdeo river, which is the fresh water source for champa area , to achieve 'designated-best-use' water quality criteria through the implementation of pollution abatement schemes. Since the pollution of the Hasdeo Rivers is both from the point sources and the non-point sources of pollution, the schemes framed are of the following below:

- Interception and diversion works to capture the raw municipal sewage flowing into the river through open drains and divert them for treatment.
- Sewage treatment plant for treating the diverted sewage.
- Municipal solid waste management.
- Public participation and public awareness programme.

Due to this conservation plan of Hasdeo River. River water quality will improve in future use. Application of this study about river Hasdeo is beneficial for all point of view as irrigation, domestic, industrial requirements of water.

CHAPTER-2

LITERATURE REVIEW

2.1 INTRODUCTION

It seems that almost every day there is another story about pollution of one form or another, in the food we eat, the water we drink and the air we breathe. Very often our own actions lead to that pollution and in many cases we can do something about it. These notes explain how you can investigate pollution and advice on positive action to improve our rivers. As a result, rivers are being studied for the past several years by various institutes and researchers of different discipline. Besides this, various international and national conference were held to focus the attention of the Central and State Government and particularly of the public toward the condition of our Indian rivers. The literature and data is based on river pollution with special reference to urbanization and industrialization and conservation of water body.

2.2 GENERAL

Over 97% of all the water on Earth is salty and most of the remaining 3% is frozen in the polar ice-caps. The atmosphere, rivers, lakes and underground stores hold less than 1% of all the fresh water and this tiny amount has to provide the fresh water needed to support the Earth's population. It is estimated that, with the expected increase in urbanization and indutrilization there will be a 200% increase in world water needs by the year 2000. Fresh water is a precious resource and the increasing pollution of our rivers and lakes is a cause for alarm.

The riverine resources of India containing 113 river basins out of which 14 are major, 44 medium and remaining 55 are minor rivers [3]. The fourteen major river basin account for 83 % of the total area of the basin and contributes 85 % of the total surface flow and covers 80% of the total length (Nilay Chaudhuri, 1983) [4].

Most of the Indian rivers and their tributaries viz., Ganges, Yamuna, Godavari, Krishna, Sone, Cauvery Damodar and Brahmaputra are reported to be grossly polluted due to discharge of untreated sewage disposal and industrial effluents directly into the rivers. These wastes usually contain a wide variety of organic and inorganic pollutants including solvents, oils, grease,

plastics, plasticizers, phenols, heavy metals, pesticides and suspended solids.(Sudheer kumar shukla, 2009)[54]

2.3 WATER QUALITY ASSESSMENT OF RIVER

The overall process of evaluation of the physical, chemical and biological nature of water in relation to natural quality, human effects and intended uses, particularly uses which may affect human health and the health of the aquatic system itself (M. Meybeck and R. Helmer, 1989)[6].

Thirty-four Physical–chemical and chemical variables were analysed in surface water samples collected every month over a period of 24 years. They were determined from thirteen sampling stations located along the Spanish Ebro River affected by anthropogenic and seasonal influence (Bouza-Deanos, R. et al, 2008)[47].

Assess the level of heavy metals (Cd, Cr, Cu, Fe, Mn, Zn and Pb) in water and sediments of Hindon River in industrialized city Ghaziabad, India. A total of 6 stations, covering the upstream and downstream sites of Hindon river (Surindra Sutha, et al, 2009) [48].

Water quality assessment and apportionment of pollution sources of Gomati river (India) using multivariate statistical techniques has been done for exact evaluation of pollution (Kunwar P. Singh, 2005)[69].

2.4 SOURCE OF RIVER POLLUTION

There are three main sources of water pollution – domestic (municipal), industrial, and agricultural. They can be classified further as either point sources, which emit harmful substances directly into a body of water, or non-point sources, which are scattered and deliver pollutants indirectly. The technology to monitor and control point sources is well developed, while non-point sources are difficult to monitor and control.

2.4.1 Point Source

Discharge pollution from specific locations (e.g. drain pipes, ditches, or sewer outfalls). Pollution of river water associated with industrial and sewage discharge is a global problem. It is reported that about 70% of the available water in India (Citizens report, 1982) is polluted [12]. The chief sources of pollution is identified to be industrial pollution constituting 8-16% of the waste water and sewage comprises 84-92% (Chaudhuri, 1982) [4]. The sources of river pollution in India are tabulated in **Table 2.1.**

Municipal and industrial wastewater discharge constitutes a constant polluting source, whereas surface runoff is a seasonal phenomenon, largely affected by climate within the basin (Singh et al., 2004)[70].

Table 2.1 : Source of river pollution in India

Sl. No.	Name of The River	Source of Pollution
1	Ganga	Industrial, urban and agriculture activities.
2	Yamuna, Delhi	Sewage, DDT factory and other industries and power plant.
3	Kali, Meerut (U.P)	Sugar mills, distilleries, paint, soap, silk, yam, tin, and glycerin industries.
4	Bajora, Bareilly	Synthetic rubber factories.
5	Ganga, Kanpur	Jute, chemical, metal, surgical, tanneries and sewage
6	Gomti, Lucknow (U.P)	Paper and pulp mills and sewage.
7.	Suvaon, U.P	Sugar mills
8	Siwan, Bihar	Paper, sulphur, cement, and suger mills.
9	Damodar, Bokaro	Fertilizers, steel mills, coal and paper plant.
10	Sone, Bihar	Cement, pulp and paper mills
11	Hooghly, Kolkata	Paper and pulp, power plant, jute, textile, chemical, paints, varnishes, metal, steel, oil, rayon, soap and sewage.
12	Bhadra, Karnataka	Pulp, paper and steel industries.
13	Cooum, Adyar and Buckingham canal, Madras	Automobile and sewage
14	Cauvery (Tamil Nadu)	Sewage, Tanneries, distilleries, Paper, and rayon mills.
15	Godavari	Paper mills
16	Kulu, Mumbai	Chemical, rayon, tanneries.
17	Brahmaputra	Oil drilling, refineries, paper mills and sewage.
18	Barak	Paper mills

19	Digboi river	Refineries
20	Dilli	Fertilizers
21	Kolong	Paper mills
22	Bharalu	Sewage and small industries
23	Tunia	Refineries and petrochemicals, railways, small industries and sewage

Source: Central Pollution Control Board

Rivers play a major role in assimilating or carrying o€ industrial and municipal wastewater, manure discharges and runoff from agricultural, roadways and streets, which are responsible for river pollution (Stroomberg et al., 1995)[71].

Mining like coal beneficiation and preparation plant also generate huge amount of water effluent which affects the aquatic ecosystem and reduces biodiversity (Tiwary and Dhar, 1994) [39]. Active mining operations are considered point source of pollution. But drainage or runoff from abandoned mining operations often adds to nonpoint source pollution (Sidney draggan, 2009) [60].

2.4.2 Non-Point Source

Pollution is scattered or diffuse, having no specific location where they discharge into a particular body of water (e.g. runoff from farm fields, urban field and agricultural land, lawns, and gardens). Run-off from agricultural land in their vast drainage basins are among the most vulnerable water bodies to pollution

The surface run-off is a seasonal phenomenon, largely affected by climate in the basin. Seasonal variations in precipitation, surface run-off, ground water flow and water interception and abstraction have a strong effect on river discharge and subsequently on the concentration of pollutants in river water (Carpenter, S.R., (1998) and Jarvie, H.P.,(1998)[72]

Runoff from urban and suburban areas is a major origin of nonpoint source pollution. Much of the urban environment is paved with asphalt or concrete, or covered with buildings. These surfaces are usually impervious, meaning that water runs off of them without being absorbed into the soil. These hard, impervious surfaces make it easier for storm water to pick up, absorb, and carry pollutants (Avinash, K. Panikkar., 2009) [59].

2.5 TREND OF POLLUTION

India moves towards stricter regulation of industrial effluents to control water pollution greater efforts are required to reduce the risk to public health as toxic pollutants which are mainly colourless and odourless can be expected to be released into the ecosystems (Rajaram, 2007) [62].

The study revealed that the streams of Shillong are grossly polluted with organic wastes (Nath and Gupta, 1993) [41]. Similarly, Gupta (1984) expressed that hilly town Tura is also polluted in a similar way [42]. The water of Barak river and other resources have also deteriorated due to increasing urban and industrial activities in Silchar town (Dutta, 1983) [43]. The water of the Hasdeo river in Korba and Champa has gradually deteriorated due to industrialization and urbanization of the towns.

2.6 WATER QUALITY PARAMETERS

The concentration of dissolved oxygen (DO) can be used as a good indicator of the polluted river water due to its chemical and biological nature. The rate of deoxygenation reflects the BOD exertion rate in the river water. The reaeration rate is directly proportional to the DO deficit from the saturation value. Regarding this, the state of pollution of a river can be assessed by observing the concentration of dissolved oxygen present in the river water. Similarly, the pollution status of a river can also be judged by using the concentration of BOD present in the river water. Other parameters are pH, COD, Turbidity, Salinity, Metals, Nitrite, Nitrate, Faecal coli form and Conductivity etc.

2.7 EFFECTS ON RIVER WATER

India has a large number of paper manufacturing units, with mills varying in size of operations and type of product, scattered all over the length and breadth of the country (Deepa K. Tikku, 2007) [63] .With the rapid industrialization and urbanization during the last 50 years, most of the Indian rive rs are subjected to indiscriminate discharge of effluents affecting water quality and aquatic life (Verma and Shukla, 1969) [13]. Increasing pollution of rivers and other water bodies has become a matter of great concern in recent years (Ambasht, 1990; Dikshith et al., 1990) [14, 5]. The industrial effluent, domestic and municipal sewage produce hazardous

effects on aquatic life and ecosystem of the receiving water bodies (Ajmal et al., 1985; Anjaneyulu, Y., 2002) [15, 16].

The effect on river water due to discharges of industrial effluents and domestic waste water are considered on the following parameters:

1. Effect on Physico chemical parameters of the river water,
2. Effect on flora and fauna of the river aquatic system,
3. Eutrophication of the river.
4. Effect on Bacteriological parameters,
5. Effect on self purification capacity of the river.

2.7.1 Effect on Physico Chemical Parameters

The physico chemical parameters of a river changes with the receiving of the industrial effluent and sewage water. Most of the effluents have high temperature, high BOD and COD, negligible D.O., high amount of dissolved and suspended solids. Adhikary and Saha (1986) have reported that the effluent from the different types of mills and industries causes the distraction of normal ecosystem of any aquatic system [17].

Sewage consists of urine, night soils, kitchen wastes and detergents. The population of micro-organisms increases due to the process of multiplication which takes place in the presence of high organic load of the sewage. As a result, respiratory activity increase resulting in increase of BOD and depletion of dissolved oxygen. Decomposition of organic matter under low DO condition release, odour into the neighboring system.

Oil is important pollutant released into the Indian rivers with industrial waste. Oil causes much damage to the aquatic environment due to its hydrophobic nature and its impermeability to oxygen. High concentration of oil (Ford, 1976; Gaur, 1981) [18].

Combustion of coals in thermal power plants is one of the major sources of environmental pollution due to generation of huge amounts of ashes, which are disposed off in large ponds in the vicinity of the thermal power plants. This problem is of particular significance in India, which utilizes coals of very high ash content (_55 wt%).Since the thermal power plants and the ash ponds are located in densely populated areas, there is potential chance for

contamination of soil, ground and surface water of the surrounding areas from the toxic trace elements in the ash (Sengupta, D. and Mandal, A. (2007) [19].

2.7.2 Effect on Flora and Fauna

The industrial effluent and domestic sewage have affected the flora and fauna of the receiving water bodies. Haslam (1991) described various effects of sewage and industrial effluent on aquatic organisms [20]. She concluded that main effects are;

1. A decrease and loss of the species most sensitive to such pollution,
2. A decrease in species diversity at the introduction site and,
3. Increase in any species actually favoured by this pollution.

Basically pollution is essentially a biological phenomenon in that its primary effect is on living things (Hynes, 1963) [21].

2.7.2.1 Effect on fauna

The fauna of a river is directly affected due to river pollution. The rivers are more sensitive against pollution with respect to the fauna.

2.7.2.1.1 Effect on fish

The industrial effluent and sewage have directly affected the fish life in the receiving water bodies (Jhingran, A.G., 1991) [22]. Thompson and Hunt (1928) noted that small quantity of domestic waste water enhanced the productivity of streams and resulted in greater size, abundance and variety of fishes [23]. Larger amount of wastes decreased the abundance of fish and vary large amounts virtually eliminated some fishes. Similarly, water pollution by effluents discharged from industries has resulted in a marked increase in the incidence of mass mortality and adversely affect on fish life (Pandey et al., 2000) [24]

2.7.2.1.2 Effect on macro invertebrates

The aquatic macro invertebrates inhabit the bottom substrates of the river bed in a river. Examples of macro invertebrates include aquatic worms, snails, clams, crayfish, leeches and many insects. These are used to detect and evaluate affected river reaches as they are capable of reflecting different human induced deterioration. Thienieman (1954) reported that as conditions

become more extreme, diversity decreases, so the number of individuals of the remaining species increases [25].

2.7.2.1.3 Effect on micro invertebrate

The Industrial effluent and sewage directly affect the micro invertebrate in a river .Micro invertebrates are so small and difficult to sample, identify and analyze. These are rotifers, cladocera, protozoa, and copepods. The river bed micro invertebrates reflect the pollution status of the river. The micro-invertebrates are an integral part of the river (Winner, 1975) [27]. Rotifers play an important role in the ecology of the aquatic ecosystem by serving as an essential food source for invertebrate as well as vertebrate organisms (Herzing, 1987) [28].

2.7.2.2 Effect on flora

The flora has been affected by the industrial effluent and sewage discharging into the river. Sensitive species are eliminated and tolerable species grow more. Phosphorous and nitrogen are limiting factor for the growth of aquatic plants in the river which releases form the domestic sewage and agricultural activities. the pollution of pesticides in rivers and in their various inter compartments. Multiple residues of pesticides discharged from industries or as a result of extensive use of agrochemicals in agriculture have been monitored. These pesticide residues contaminate the river ecosystem and its inter compartments such as sediments, and aquatic biota, and make it harmful to humans when they contaminate food and drinking water. The pesticide contamination in water, sediments, and aquatic biota has been reported to be beyond the acceptable range (Chopra A.K. 2010) [26].

2.7.2.2.1 Effect on water hyacinth

Water hyacinth is one of the aquatic weeds posing serious problems due to its widespread outgrowth the growth of the plants is so fast and starts vegetative multiplication by means of stolons. The favorable growth is influenced by the domestic sewage due to high content of phosphorous, nitrogen and other organic compounds. It produces optimum breeding condition of mosquitoes and snails which favours malaria, filaria and bilharzinsis. Industrial effluents always affects on adversely for their growth (Kumar, A. 2002) [29]

2.7.2.2.2 Effect on algae

Algae are frequently found in polluted and unpolluted water due to the nutritional requirements of algae markedly form one group to another group. Patrick (1949) reported reduction of species diversity due to pollution stress [30].

Green algae live in low pH due to inability of other algae to live at lower level of nutrient supply. Blue green algae live in high pH due to increase ability of organic and inorganic nutrients (Lund, 1945; Mitra, 1961) [31, 32]. Phytoplankton succession is influenced by light fluctuation, temperature and nutrient available. Growth of macrophyte, low pH, DO, High CO2, NH3 are responsible for low algal production. Verma and Mohanty (1995) has observed the positive correlation of different groups of algae with different physicochemical condition [33].

2.7.3 Effect of Eutrophication

Eutrophication has been initiated by the domestic sewage and effluent into river or other water bodies. Seven and Walter (1989) have defined eutrophication is qualitatively as the state of a water body which is manifested by an intense proliferation of algae and other higher aquatic plants and their accumulation in the water body in excessive quantities resulted as bloom due to nutrient enrichment of water [34]. Phosphorus and nitrogen inputs from domestic wastes water and agricultural fertilizers accelerate the process of eutrophication of aquatic environment (Schindler, 1971) [35].

2.7.4 Effect on Bacteriological Parameters

Sewage loaded with human excreta and direct human defecation are the two major sources of the faecal pollution in Indian rivers. Microbiological studies on water quality of major Indian rivers have shown the presence of faecal coliform and faecel streptococci as an indication of faecal contamination (Shukla et al., 1992; Gaur et al., 1997) [36, 37].

The high faecal load indicates the high degree of human defecation by thick urban population on the bank of the river and directly discharge the nutshell into the sewage system ultimately which comes to the river.

2.7.5 Effect on Self Purification

Accumulation of sewage in water bodies retards the self regulatory capabilities of aquatic organisms. Self purifying ability is lost and it becomes unfit for domestic purposes. Sewage containing oxidisable and fermentable matter causes depletion of dissolved oxygen in the receiving water bodies. Presence of solid matter flowing in suspension, colloidal and pseudo-colloidal dispersion in sewage creates severe water problems. When industrial effluents are discharged through sewage system, this adversely affects the biological purification mechanism of sewage treatment and put an adverse effect on the receiving water body (S.K. Garg and R. Garg, 2004)[38].

2.8 WATER QUALITY MONITORING

Indian rivers are polluted due to the discharge of untreated sewage and industrial effluents. The Central Pollution Control Board (CPCB) has established a network of monitoring stations on rivers across the country. The present network is comprising of 870 stations in 26 States and 5 Union Territories spread over the country. The monitoring is done on monthly or quarterly basis in surface waters and on half yearly basis in case of ground water. The monitoring network covers 189 Rivers, 53 Lakes, 4 Tanks, 2 Ponds, 3 Creeks, 3 Canals, 9 Drains and 218 Wells. Among the 870 stations, 567 are on rivers, 55 on lakes, 9 on drains,12 on canals, 4 on tank, 3 on and creeks,2 on pond and 218 are groundwater stations. The monitoring of wa-ter quality at 257 stations is being done on monthly basis, 393 stations on quarterly basis, 216 on half yearly basis and 4 stations on yearly basis. (Bhardwaj, R.M., (2005)) [49].

2.9 WATER QUALITY INDICES

There are various water quality indices (WQI) to compare various physico–chemical and biological parameters such as Bhargava Method, Hortons Method, Ambient water quality, Delphi Method etc (Pandey and Sundaram 2002) [64]; (Chetana and Somashekar 1997)[65]; (Ram and Anandh 1997)[66]. Brown, et al. (1970) presented a WQI, which varied from zero to 100. Brown, et al. also proposed multiplicative from of the index. In the multiplicative index, weights to individual parameters are assigned based on a subjective opinion as they are based on the judgment of the author and a few of his associates. The weight reflects a parameter's

significance for a use and has considerable impact on the index (Bhargava et al. 1983) [67]; Dwivedi et al. 1997) [68].

Among them the Brown, et al, (1970). Method was adopted because of the simplicity involved in handling small to large data for various beneficial uses. The water quality index (WQI) was determined according to Brown method [40].

2.10 SPATIAL AND TEMPORAL VARIATIONS

Meybeck, M. and Helmer, R. (1989) [6] has given idea about water quality assessment of river by using spatial and temporal variation as follows. Spatial variation in water quality is one of the main features of different types of water bodies, and is largely determined by the hydrodynamic characteristics of the water body. Water quality varies in all three dimensions which are further modified by flow direction, discharge and time. Consequently, water quality cannot usually be measured in only one location within a water body but may require a grid or network of sampling sites.

The temporal variation of the chemical quality of water bodies can be described by studying concentrations (also loads in the case of rivers) or by determining rates such as settling rates, biodegradation rates or transport rates. It is particularly important to define temporal variability. Five major types are considered here:

- Minute-to-minute to day-to-day variability resulting from water mixing, fluctuations in inputs, etc., mostly linked to meteorological conditions and water body size (e.g. variations during river floods).
- Diel variability (24 hour variations) limited to biological cycles, light/dark cycles etc. (e.g. O2, nutrients, pH), and to cycles in pollution inputs (e.g. domestic wastes).
- Days-to-months variability mostly in connection with climatic factors (river regime, Lake Overturn, etc.) and to pollution sources (e.g. industrial wastewaters, run-off from agricultural land).
- The seasonal hydrological and biological cycles (mostly in connection with climatic factors).
- Year-to-year trends, mostly due to human influences.

2.11 RIVER CONSERVATION PLAN

The river-cleaning programme of the Ministry of Environment and Forests was started with the launching of the Ganga Action Plan (GAP) in 1985. A Central Ganga Authority under the Prime Minister was constituted to finalize the policy framework and to oversee the implementation of the Action Plan.

Table 2.2: Chronology of approval and cost of various components of NRCP

Sl. No.	Component	Approved cost with 50:50 funding / date of approval	Present approved cost on 100 % funding cost sharing date of approval by CCEA
1	Yamuna Action Plan	357.00/April 93	
2	Gomti Action Plan	64.00/April 93	61.11 /Nov 98
3	CETP, Calcutta	65.00/Aug 95	65.00/Nov 98
4	National River Conservation Plan	772.09/July95	737.14/Nov 98
5	GAP-II (main stem including West Bangal)	416.36/Oct 96	396.16/Nov 98
6	Yamuna Action Plan (first revision)	479.56/ April 96	
7	Damodar Action Plan	24.54/ Oct 96	23.58/Nov 98
8	GAP-II (SC towns)	231.70/Oct 96	220.96/Nov98
9	Yamuna Action Plan (2nd revision)	526.71/ Sept 98	509.45/Nov 98
10	Chennai Waterways		491.52/Sept 2000
11	7 additional town of Tamil Nadu		575.3(cost sharing) Jan-01
12	Yamuna Action Plan (Extended Phase		222.60/May 2001
13	2 additional town of Punjab		14.97(70:30)/ July 2001
14	1 additional town of Maharashtra		11.64(70:30)/ 08.01.02
15	1 additional town of Goa		14.09(70:30)/27.05.02
		Total	**3343.52**

Chief Ministers of concerned States, Union Ministers and Secretaries of the concerned Central Ministries and experts were its members. GAP was later extended to GAP Phase-II in 1993 and then to NRCP in 1995. GAP Phase-II was merged into NRCP in December 1996. Since then a single scheme of NRCP is under implementation as a Centrally Sponsored Scheme. The Chronology of approval and cost of various components of NRCP is given in **Table 2.2.**

The CGA was re-named as National River Conservation Authority (NRCA) with a large mandate to cover all the programmes supported by the National River Conservation Directorate. [44] .The functions of the NRCA are as follows:

a. To lay down, promote and approve appropriate policies and programmes (long and short- term) to achieve the objectives.

b. To examine and approve the priorities of the National River Conservation Plan

c. To mobilize necessary financial resources.

d. To review the progress of implementation of approved programmes and give necessary directions to the Steering Committee, and

e. To take all such measures as may be necessary to achieve the objectives.

2.12 WATER CONSERVATION MEASURES

Water is a finite resource, and in many areas, future water supplies are uncertain. Individuals are usually aware when there is a drought; however, because water is inexpensive, there are often few incentives to reduce water loss. Water has no viable substitutes, and its depletion bodes profound economic and social impacts. Citizens and utilities need to consider water conservation programs The water demand management methods described in this fact sheet incorporate the methods the August 1998 U.S. Environmental Protection Agency (EPA) *Water Conservation Plan Guidelines* recommend for water systems [73].

2.13 SEWAGE TREATMENT

Much of the river pollution problem in India comes from untreated sewage. Domestic sewage is one of the most important point source pollutants of river. Domestic sewage is the major source of pollution in India in surface water which contributes pathogens, the main source of water borne diseases along with depletion of oxygen in water bodies. A large part of the domestic sewage is not even collected. This results in stagnation of sewage within city, a good

breeding ground for mosquitoes and contaminates the groundwater, the only source of drinking water in many cities.

For any river abatement plan sewage treatment is must. Domestic sewage is one of the major pollution sources of Hasdeo river. There is a need of treatment before discharging into Hasdeo river. Techno Economic evaluation of various waste water treatment Plant has been studied for proposing STP in present study this is given by Sanjeev Kumar, 2008[9].

The potential of UASB technology in other developing countries with its future within India as well based on the evaluation of life cycle cost. Other treatment technology are also include while evaluating LCC has been done by Khalil, N. et al, 2008 [74].

2.14 MUNICIPAL SOLID WASTE MANAGEMENT

Municipal Solid wastes damage Hasdeo river in a number of ways hence it is necessary to ensure that solid waste is managed in a proper manner. If solid wastes are not managed properly it has a number of adverse consequences. First it pollutes the river. Secondly the sediments deposit on the bed in the river. Thirdly it makes the town ugly. Hence management of solid wastes becomes an essential component of the conservation and management plan of any river.

Detail study about status of Municipal Solid Waste generation, collection treatment, and disposal in class 1 cities has been given in CPCB, (2000) report [56].Cost estimation of solid waste management has been given by NEERI, (1995)[10,15]. Per Capita solid waste generation in Indian scenario has been given by Asnani, P.U. (2004) [75].

2.15 SUMMARY

The river water quality is a subject of serious concern today. Rivers water is life line for human life. Due to their role in carrying off the municipal and industrial wastewater and run-off from agricultural. The growing population and urbanization and industrialization are polluting all rivers in the world in increasing rates. Increasing pollution of river area has become a subject of great concern regarding study of the river pollution status, eco system and river management. Most of the studies have been carried out on the basis of physico chemical characteristics of the river and effects of the river pollution on the morphology and physiology of the flora and fauna.

Physico chemical and bio indicators indicate the pollution status of a river system. water quality indices are used for assessing and evaluating the organic pollution load in a river at a particular region.

All the studies indicate that it is essential for the proper management of rivers to preserve the river eco-system on the most priority basis in favour of the whole natural environment. NRCP has given guidelines for the better management of rivers and lakes like sewage management, solid waste management and public participation is needed for successfully completion of this river management plan.

CHAPTER-3

NATURAL ENVIRONMENT OF THE STUDY AREA

3.1 INTRODUCTION

The natural environment is most affecting factor for the study of any area. Lifestyle of any area specific people is differing from area wise. The habitats and lifestyle is depending upon the natural environment of area specific. The mutual inter dependence of all lifes, microbial, plant and animals has been influenced by the environmental parameters along with the physical environment of land, air, water and solar energy.

The various environmental factors influence the environment setting of the Hasdeo river eco-system. The general information of the Hasdeo river environment is given below.

3.2 ORIGIN OF HASDEO RIVER

It rises from Pathar in the Chhota Nagpur valley and tributary of Mahanadi flows in the stretch of 233 km from Hasdeo mountain at an elevation of 1200 m. From the source it flows for about 29 kms towards the South. With a left turn, the Hasdeo river widens and with it the sand content increases. Its tributaries are Gagechorai, Tan and Ahiran. A number of small islands form near Bango, Samgurha para, Dhangaon, and Chicholi due to the amount of sand deposition. Tributaries like Ahiran, Gagechorai and Tan join with the Hasdeo river on the way. The total catchment area for Hasdeo river is 9803 sq. km. The river is considered sacred and also used for religious purposes by the local people.

3.3 LOCATION

The main Hasdeo river basin covers an area of 10405.99 km2. It is nearly peer shaped towards its upper and central part and funnel shaped in lower part. It is located between the north latitude of 210 43' to 230 32' and eastern longitude of 820 07' to 830 03'.The Hasdeo River is the most important regional river of the Indian state of Chhattisgarh. For Conservation Plan of Hasdeo River study area is down stream flow from city Dengur to Champa and length is 55 km. Drainage Pattern of Hasdeo river at study area stretch is shown in **Fig 3.1.**

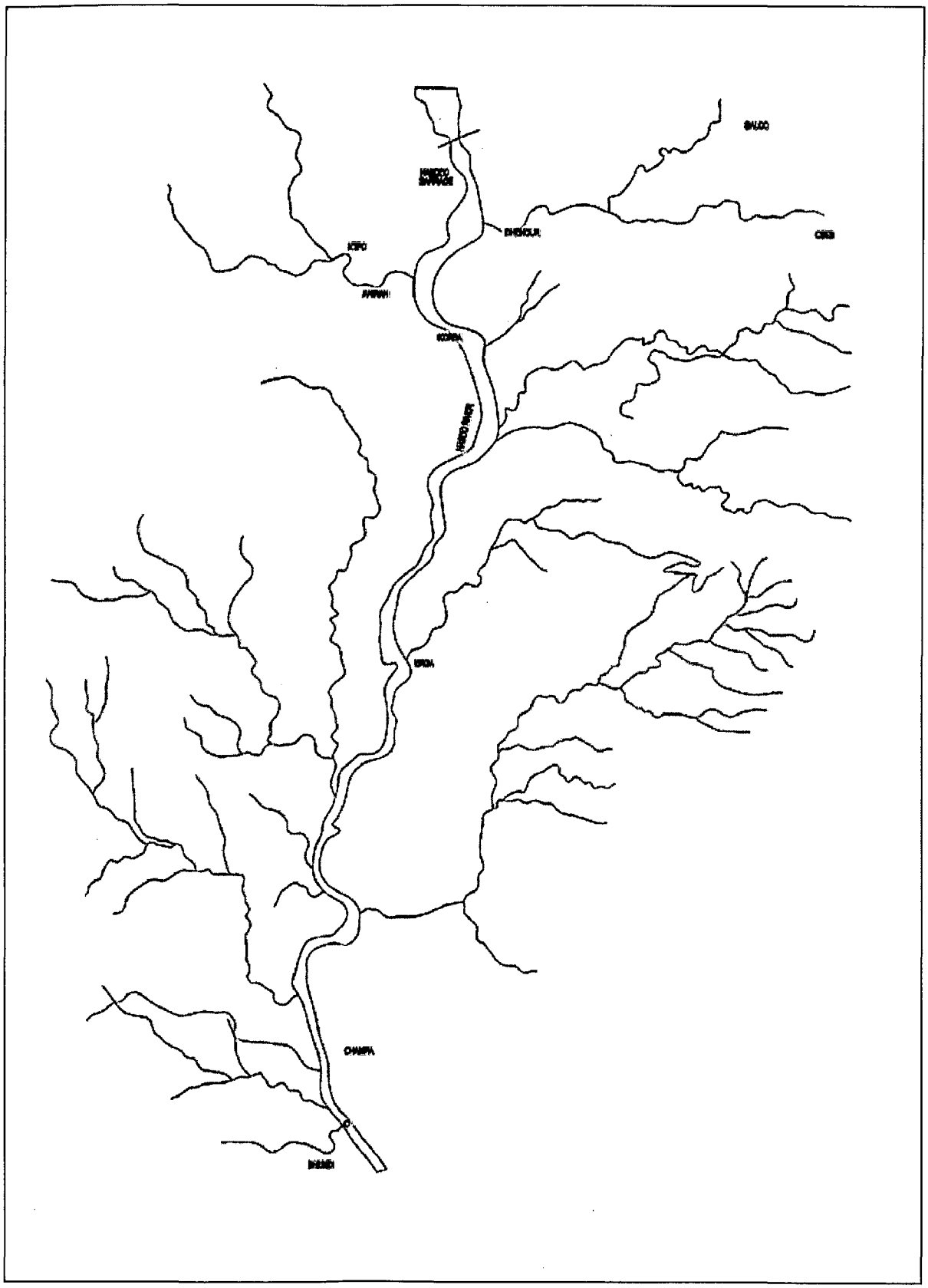


Fig. 3.1: Drainage Pattern of Hasdeo River at Study Stretch

3.4 TOPOGRAPHY AND BOUNDRY

The area of Hasdeo River is plain small hills such as Madwarani are situated. Hasdeo River Surrounded by the districts Korea, Surguja, bilaspur, Janjgir-champa etc. From the capital city Raipur. Korba is the power capital of the newly formed state Chhattisgarh. The district comes under Bilaspur division and is inhabited mainly by tribals including the protected tribe Korwas (Pahadi Korwa). Korba is blessed with lush green forest cover, where a sizable number of tribal population is found. The *Adivaisis* in the forest areas leave in tantum with the environment and have retained their distinctive cultural characteristics and traditional observances and Champa is situated in the center of Chhattisgarh and so it is considered as Heart of Chhattisgarh. The District Head Quarter of Champa is the city of Maharaja Jajawalya Dev of Kulchury dynasty. The Champa district is a major producer of Food Grains in the state Chhattisgarh. [45].

3.5 GEOLOGY

This area is sprawled in a very wide area, includes large coal-mines and many thermal power houses with analuminum heavy industry. The main source of water in the area is Hasdeo River. The study area is occupied by rocks of different age from Archaean to Permian. Broadly, Korba city area iscomprised of two major geological units. One is Archaean Granite Gneiss and other is Gondwana Supergroup rocks. Archaean Granite Gneiss is exposed at the northern andnorth-western part of the study area. Gneiss is massive in nature and made up of plagioclase feldspar, biotite, quartz,etc. Gondwana Supergroup of rocks overlies the Archaean Gneiss, shalysandstone of Talchir Formation of GondwanaSupergroup overlies the gneiss and it is in turnoverlain by sandstone of Barakar Formation. At northeasternpart, sandstone of Barakar Formation is over lain by ferruginous sandstone of Kamthi Formation. Rocks of Gondwana Supergroup are dipping towards south. Several intrabasinal faults are present within the GondwanaSupergroup. These faults have been formed in the period from Talchir sedimentation to close of Gondwana sedimentation. [46].

3.6 SOIL AND LAND USE

The main soil type found is Yellow and Red. Classified by four type of soils.

1. Bhata (Lateritic)
2. Matasi (Sandy loam)
3. Dorsa (clay loam)
4. Kanhar (clay)

Basic land use of Hasdeo area is agriculture. Agriculture is the main occupation of more than 80 per cent of the population. Paddy is the main crop. Mono cropping of rice is predominant while other crops grown are lathyrus, linseed and chickpea as relay crops (Utera) HasdeoCatchment area comes under sub-humid climate and receives 1000 m.m. to 1600 mm of rainfall. Though this amount is quite sufficient for growing rice crop but due to erratic distribution of rainfall, frequent dry spells and heavy rainfall at times causes crop failure and adversely affects the economic conditions of the former. [45].

3.7 FOREST AND WILDLIFE

Forests play an important role in the social and financial structure. Hasdeo river Catchment is rich in forest. Deccan bio-geographical area, houses an important part of that rich and unique biological diversity. Catchment area is significantly rich in respect of many plants having medicinal importance. The Forests fall under two major forest types, i.e., Tropical Moist Deciduous Forest and the Tropical Dry Deciduous Forest. Sal (*Shorea robusta*) and Teak (*Tectona grandis*) are the two major tree species in the State. Other notable overwood species are Bija (*Pterocarpus marsupium*), Saja (*Terminalia tomentosa*), Dhawra (*Anogeissus latifolia*), Mahua (*Madhuca indica*), Tendu (*Diospyros melanoxylon*) etc. Amla (*Embilica officinalis*), Karra (*Cleistanthus collinus*) and Bamboo (*Dendrocalamus strictus*) constitute a significant chunk of middle canopy of the State's forests. The cover of Korba and Champa is given in **Table 3.1.**

Table 3.1: Location Wise Forest Cover :Area in Sq. Km.

Location	Geographical Area	Forest Cover			
		Very Dense	Dense Forest	Open Forest	Total
Korba	6599	149	2,186	1,016	3351
Champa	3852	4	51	101	156

Source:- State of Forest Report 2005: Forest Survey of India

The State is a proud possessor of rare wildlife like the Wild Buffalo (*Bubalus bubalis*) and Hill Myna (*Gracula religiosa*) which have been declared as State animal and State bird respectively. Apart from the species diversity, the State is also endowed with rich genetic diversity. The variation in the genetic composition of individuals within or among floristic and faunal species is large. [45].

3.8 CLIMATE

The area experiences a subtropical humid climate. The climate of the Korba and Champa area is similar to entire study area. The people enjoy 4 seasons such as pre monsoon, monsoon and winter. The year is climatologically classified as:

Pre monsoon	:	March to May
Monsoon	:	June to August
Post monsoon	:	September to November
Winter	:	December to February

The summer is fairly hot and highly humid, the winter is moderately cold. Pre monsoon and post monsoon have moderate temperature and humidity. [45].

3.9 TEMPERATURE

The Hasdeo catchment, May is the hottest month and December the coldest. The diurnal range of temperature is the maximum during February and March; it is less during July and August. The temperature varies from 12 °C to 40 °C.

Station	Temp (°c)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Champa	MaxT.	27.2	30.7	35.5	40.2	42.7	38.2	31.3	30.7	31.6	31.7	29.7	27.3
	Min T.	13.0	15.6	19.6	24.4	27.9	27.0	24.5	24.3	24.3	21.4	16.4	13.0

Source: Central Water Commission Office, Bamnidih (Year 2009)

3.10 RAIN FALL

Rainy season due to the South-West Mansoon is from mid June till the end of September. The average rainfall in the district is 1506.7 mm. and normal rainfall is 1287.6 mm. The rainfall data of three location is given in **Table 3.2.**

Table 3.2: Annual rainfall data

S.N.	Location	2001	2002	2003	2004	2005	2006	2007	2008
1	Korba	1411	1021	1779	1250	1310	972.8	1236	1277
2	Champa	1273	931	1561	1102	1168	1114	1299	1228
3	Bamnindih	1320	879	1490	1032	1315	1272	1433	1172

source : http:/ agridept.cg.gov.in

The rainy Season generally starts form the june and extends up to the end of September.

3.11 POPULATION

The total population of Korba District is 1012121. Males constitute 52% of the population and females 48%. Korba has an average literacy rate of 69%, higher than the national average of 59.5%; male literacy is 77%, and female literacy is 59%. In Korba, 14% of the population is under 6 years of age. Population under Korba Municipal Corporation is 3,67,006 at 2001 census and growth rate 25.50 percent per 10 year. Dengur, Ahiran and Urga come under Korba district. These populations are 15,000, 18,534 and 2,453 according to 2001 census.

Champa had a population of 37,949 at 2001 census growth rate 18.55 percent per 10 year. Males constitute 52% of the population and females 48%. Champa has an average literacy rate of 67%, higher than the national average of 59.5%; with male literacy of 77% and female literacy of 56%. 14% (*source: http://censusindia.gov.in*).

3.12 GEOGRAPHY

This is situated in the Northern Rocks and Hills area. Most of the land, which has plateaued from the Maikal ranges of the Satpura hills, is high and low and open. The biggest area of this open land is spread near Pasan. River Hasdeo has three tributaries Gajechorai, Tan and Ahiran. On the banks of the rivers are small obstructions, thin forest area and bastties. The area's most important hill, the Karela Hill (Height 3253 Ft./991Mtr.). To the north of Katghora, the slope of the valleys of the Hasdeo and Gage is very less and joined the Sarguja District in the north. The Tan and Chorai Rivers joins the River Hasdeo from opposite directions - from the East and the West. Towards the northern banks are the Gurudwari Hill, Janta Hill, Matin and Dhajag Hills [46].

3.13 INDUSTRIES

This area is surrounded by Korba and Champa the Industrial hub of Chhattisgarh is known for its black diamond and Kosa silk industry. Endowed with mineral deposit it has a widespread inustrial area spread over 100 acres with several industrial units. The major industries include:

- Bharat Aluminum Company Limited (BALCO)
- South Eastern Coalfields Limited (SECL)
- Chhattisgarh State Electricty Board (CSEB)
- National Thermal Power Corporation Limited(NTPC)
- Prakash Industries Limited
- Madhya Bharat Paper Mill Limited.
- Vinay Industries.

3.14 PROJECTS ON HASDEO RIVER

3.14.1 Minimata Hasdeo Bango Project

The construction work of all the three units was completed in four stages. In the first stage the Hasdeo Bango barrage near Korba city and the 4 km long left Bank main canal were constructed. In the second stage, the right bank main canal system was constructed. The main Dam, construction of water treatment plant and extension of right and left bank main canal system were completed. In the third stage, the remaining work of completion of left bank main canal system and Canal distributaries net work was done in the forth stage. The complete project cost was around Rs.693 crores.

Its Objectives are:

1. To provide water for irrigation.
2. Generation of hydroelectric power
3. To provide water for cooling purpose to the industrial units.
4. To provide domestic water supply.

Location -North Latitude: 22^0 36',East Longitude : 82^0 36.The main dam, which is situated 42 kms away from the district headquarter. The Dam has 11 gates, out of which 10 are operational. The dimension of each gates are 15 x 14.2 meters. The length of the main Dam is 554.5 meter which constitutes.

Spill way	:	203.5 Mtrs.
Hydro- Electric Dam	:	055.5 Mtrs.
Non- Over flow Dam	:	295.5 Mtrs.
Total	:	554.5 Mtrs.

The total length of the dam is 2509.05 Mtrs. The left side of the Main Dam there is one rock filled dam, which has 177 Mtrs long and the right side have an earthen dam of 27 Mtrs height and 1778 Mtrs long

Other Details -

Catchment Area	6730 Sq.Km.
Maximum height of Dam	366.00 Mtr.
Maximum water Level	363.08 Mtr.
Full Reservoir Level	329.79
Full Reservoir level	359.66 Mtr.
Spill Water Level	345.66 Mtr.
Area's Average Rainfall	1500 mm (Max.1920mm.,Min940mm.)
Minimum River Level	292.60 Mtr.(River Bed)
Water storage Capacity	0.3416 Million hectare or 34160 Lakhs M^3
Useful water storage capacity	0.3046 Million hectare or 30460 Lakhs M^3
Unuseful water storage capacity	03700 Million hectare or 03700 Lakhs M^3

Source: http://www.korba.nic.in

3.14.2 Hasdeo Barrage

Hasdeo Barrage is situated 12 kms away from the District Head Quarter. It was constructed in 1967. Total cost was Rs.10.14 crores.

Location District: korba Latitude: 22° 24'N Altitude: 286 m above MSL Longitude: 88° 42'E

Year of Commissioning: 1967

Other Detail:

Length	283.76 m
Depth	8.76 m
Volume	75.50 Million M^3
Surface area at full reservoir level	2510 hectare
At Dead reservoir level	1000 hectare
Catchment area	7723 Sq. k.m.
Average Rainfall	1727 mm
Capacity at R.L.	60.50 M CUM.

Source : http://www.korba.nic.in

3.14.3 Canals

The main part of this project is the canals, which can irrigate about 2 lakhs and 55 thousand hectare of land. For this two canal systems are being constructed, which branch out from the Hasdeo Barrage at Darri.

In this way an area of 2 lakhs, 55 thousand hectare of land can be irrigated and excess about 17.70 lakhs MT. food grains can be produced from these 287 KM. long canals. If the maximum capacity of these canals is utilized, an area of 4,33,500 hectare of land can be irrigated. The water intake from Hasdeo barrage in year 2009 for industrial and irrigation purpose is shown in **Table 3**

Other Detail:

	Left Bank Canal	Right Bank Canal
Max. Flow	138 M^3/Sec.	117 M^3/Sec.
Length	50 k.m.	48 k.m.
Branch canals	Champa Branch- 51 k.m. Sakti Branch – 32 k.m. Kharsia - 42 k.m.	Janjgir Branch-22 k.m. Akaltara Branch- 42 k.m.
Irrigated Area	1,38,000 Hectare	1,17,000 Hectare

Source : http:// Korba.nic.in

Table 3.3: Water Intake for Irrigation and Industrial supply

Year-2009	Discharge (cubic ft/sec)						
Month	NTPC	S.E.C.L	L.B.C	C.S.E.B	R.B.C	Irrigation	Total
Jan	125.40	35.40	160.80	648.13	648.13	750	1558.93
Feb	124.30	34.20	158.50	645.20	645.20	0	803.70
March	127.40	36.40	163.80	650.50	650.50	910	1724.30
April	128.97	36.85	165.82	655.20	655.20	0	821.02
May	128.57	37.25	165.82	652.30	652.30	820	1638.12
June	129.40	38.20	167.60	653.80	653.80	0	821.40
July	115.30	34.50	149.80	635.50	635.50	0	785.30
August	114.60	33.40	148.00	630.20	630.20	0	778.20
Sep	113.50	33.20	146.70	629.30	629.30	0	775.30
Oct	113.80	34.00	147.80	628.50	628.50	0	776.30
Nov	113.50	33.50	147.00	625.40	625.40	0	772.40
Dec	114.20	34.30	148.50	630.50	630.50	0	779.00

Source: Irrigation Department, Korba

3.15 ENVIRONMENTAL FLOW

Environmental water requirement, also referred to as 'environmental flow', is a compromise between water resources development and maintenance of a river in ecologically acceptable or agreed conditions. For instance, between a major storage and downstream, the quantity and also seasonality of water flow in a river may be greatly changed from the natural condition. The way for drastic changes in the riverine ecosystem. Water is a river's most essential element. "In stream flow" refers to the water in a river's channel. In a healthy river, water levels fluctuate naturally. The flow of a river is cyclical, varying greatly on a time scale of hours, days, years, decades, and longer. For example, snowmelt makes many rivers flow deeper and faster in the spring; in hotter summer weather, flows tend to decrease. Flow varies from place to place, depending on regional differences in climate, geology, and vegetation. Every river is different with its own seasonal pulse. Flow of water by season site of Hasdeo river is in given in **Table 3.4** and **Fig 3.2**: Gauging Stations [55].

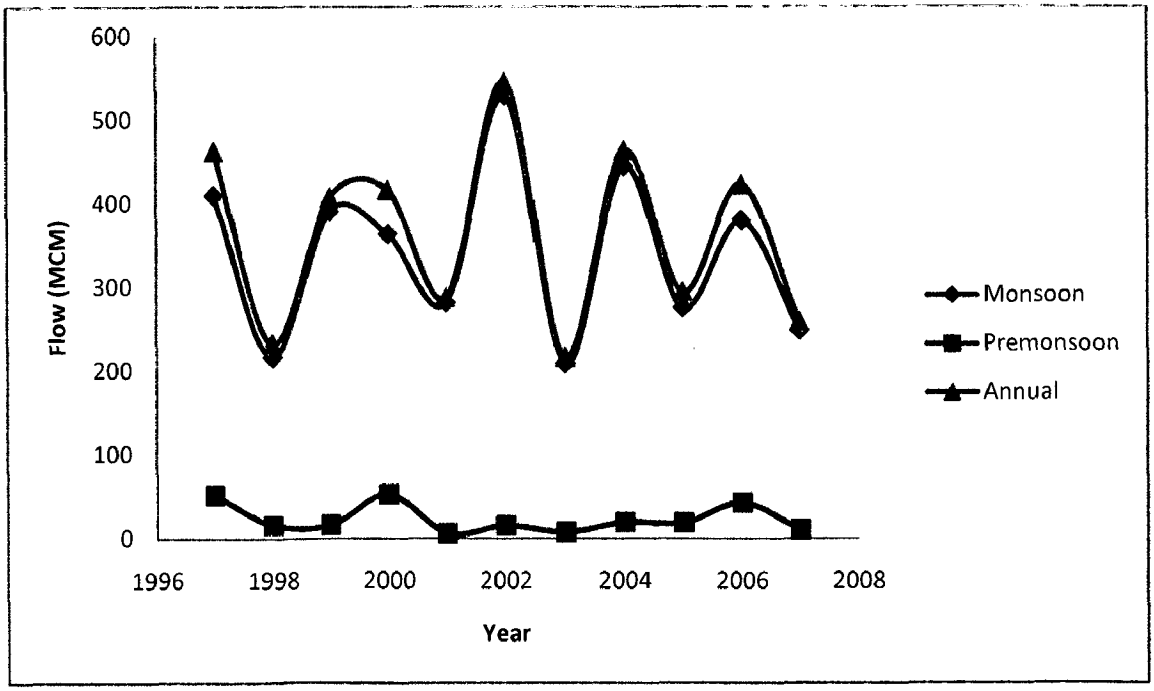


Fig. 3.3: Flow of Hasdeo River at C.W.C. Gauging Station Manendragarh

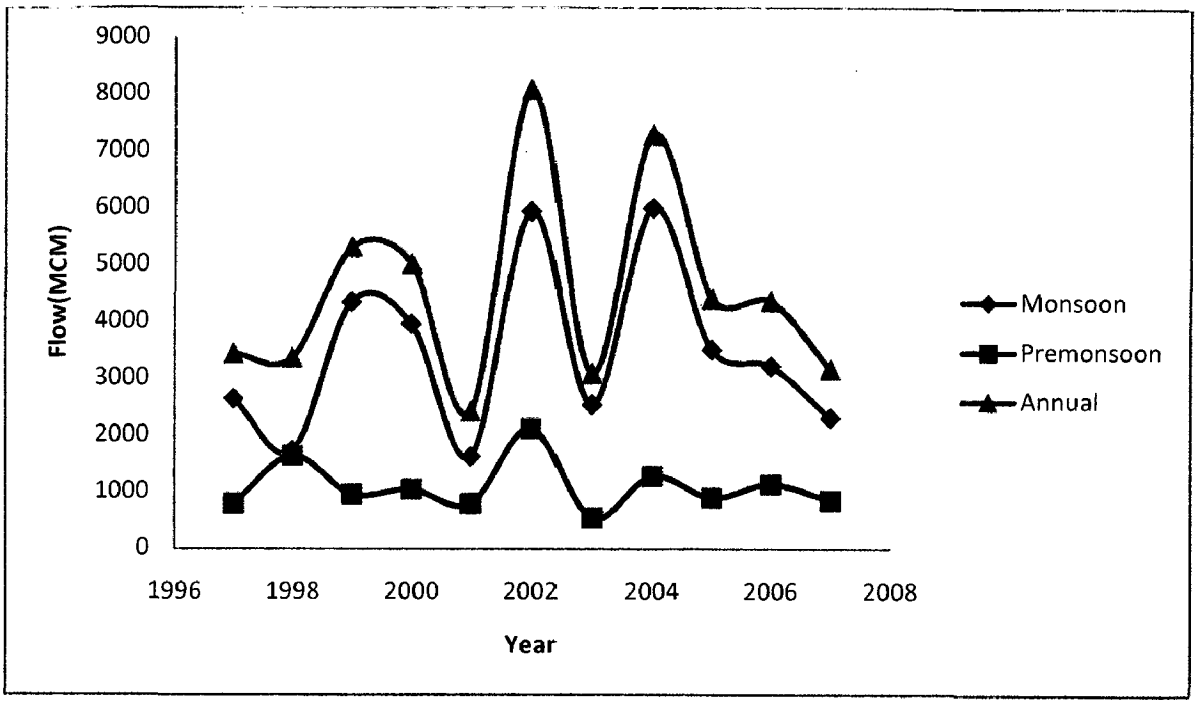


Fig. 3.4: Flow of Hasdeo River at C.W.C. Gauging Station Bamnindih

Flow of Hasdeo river at gauging station Manendragarh and Bamnindih are plotted in above graph **Fig. 3.3** and **Fig. 3.4** at monsoon and Non- monsoon season and unit of flow is MCM. Graph shows flow of water at Hasdeo river in Monsoon season is very high as comparison to Non-monsoon season. It means the in monsoon period environmental flow of river is very good so health of river in terms of water quality will be good as comparison to Non-monsoon period. But in monsoon season due to rainfall in catchment area agricultural runoff, urban runoff will also join river so it will affect the water quality of Hasdeo river at some extent. This can be clear after the analysis of water quality at monsoon season and Non-monsoon season.

Flow of water at gauging station Bamnindih is large as comparison to Manendragarh. It shows the upstream flow of river is low but downstream flow is large in monsoon season. Environmental flow of any river is affecting the ecology of river and the flow of Hasdeo river is good in monsoon period but less in Non-monsoon period.

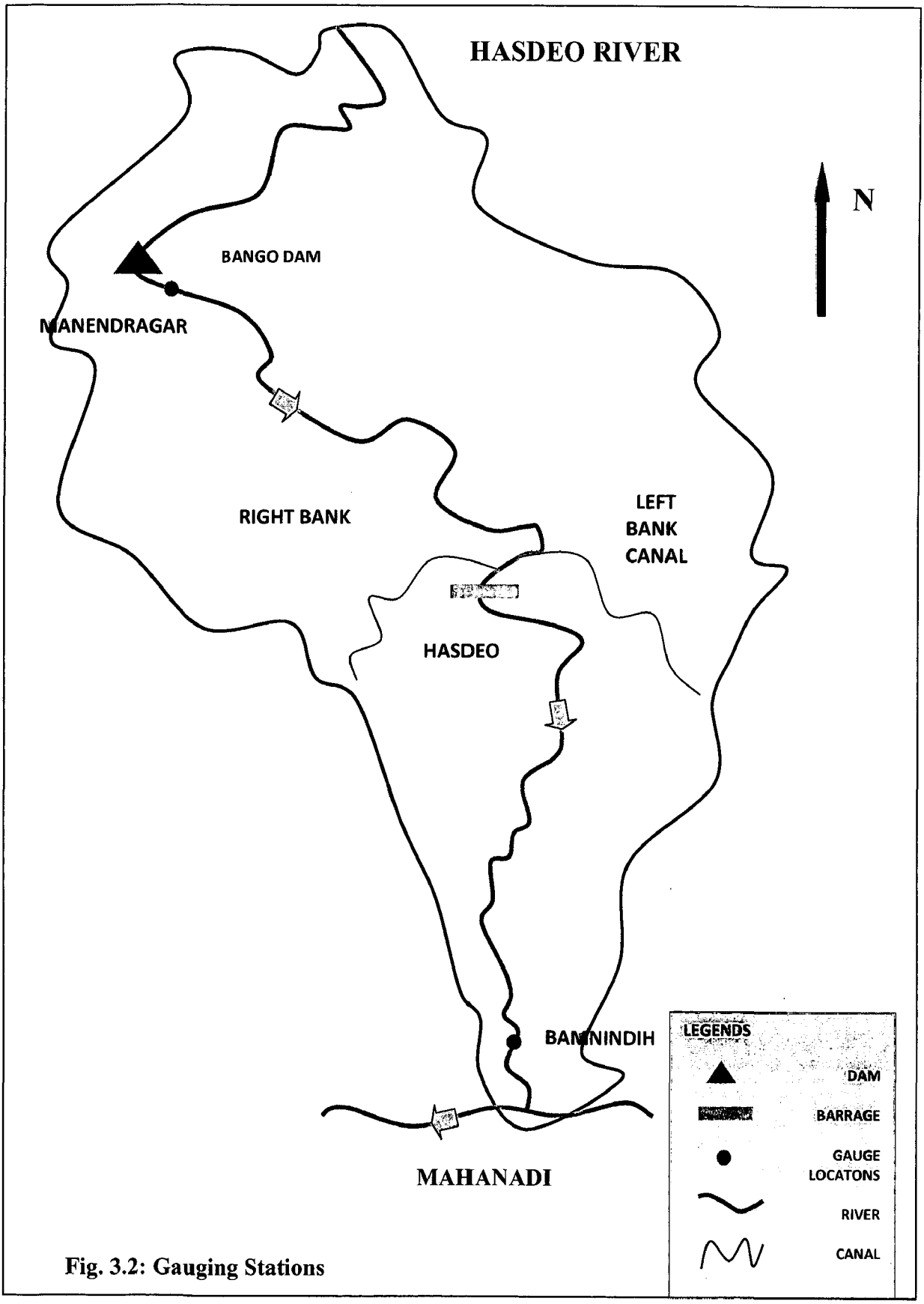


Fig. 3.2: Gauging Stations

Table 3.4: Flow of Hasdeo River

Unit : MCM

Sl.No.	Site Name	Season	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
1	**Manendragarh**	**Monsoon**	410.4	216.9	391.5	364.3	281.6	529	208.7	444.4	275.2	379.7	248.5
		Non-Monsoon	52.63	16.45	16.59	52.87	6.089	15.76	7.789	19.47	19	42.96	10.5
		Annual	463	233.4	408.1	417.2	287.7	544.7	216.5	463.9	294.2	422.7	258.6
2	**Bamnindih**	**Monsoon**	2648	1728	4360	3974	1632	5946	2540	5998	3506	3218	2309
		Non-Monsoon	799.4	1648	969.1	1055	801.3	2126	549	1289	904	1146	862.8
		Annual	3447	3376	5329	5029	2433	8073	3089	7287	4410	4364	3172

Source: Hydrological Data Book Central Water Commision, 2007

3.16 SUMMARY

For making of conservations plan of any river, basically, there is a need of study of natural environment of study area because the natural environment is playing a very important role for a sound and stable eco-system. The mutual inter dependence of all the living system is influencing by the existing natural environment. The geography, temperature and rainfall are most driving force for maintaining a sound and stable ecosystem.

The Environmental flow of any river affect the quality and self purification capability of any river. The Hasdeo river is a small tributary of the Mahanadi river. The water flow is minimum in pre monsoon season and maximum in monsoon season. The river water used for domestic agriculture and Industrial uses located in study area affect the water quality of Hasdeo river.

CHAPTER-4

POLLUTION SOURCES AND MONITORING

4.1 GENERAL

Water is the basic unit of life. The nature of the water cycle implies that pollution control, water supply and effective sewerage system in a country are parts of the closely knitted elements of water resources management. The water of the Hasdeo river is gradually getting polluted due to industrialization and urbanization of Korba and Champa city. Basically, water is polluted by industrial and domestic activities. The industrial pollution is more severe than the pollution due to urban activities. The pollution loads are concentrated in between Hasdeo Barrage to Champa city area along the flow path of Hasdeo river.

Water quality monitoring of Hasdeo River is performed by State Pollution Control Board of Chhattisgarh at strategic locations. For assessment of water quality of river and water-related environmental problems, it is must to have exact knowledge and information about what the problem is, where it is occurring, how dangerous it is, and what is causing it. Such information is important and required for estimating cost-effective and long lasting solutions to water-related problems of Hasdeo river.

4.2 SOURCES OF WATER POLLUTION

There are three main sources of water pollution – domestic (municipal), industrial, and agricultural. They can be classified further as either point sources, which emit harmful substances directly into a body of water, or non-point sources, which are scattered and deliver pollutants indirectly. The technology to monitor and control point sources is well developed, while non-point sources are difficult to monitor and control. The sources of pollution of the Hasdeo river can be classified as;

- Point sources
- Non point sources.

4.2.1 Point Sources

Discharge pollution from specific locations (e.g. drain pipes, ditches, or sewer outfalls). The sources are:

4.2.1.1 Industries: Industries like as power plant, coal mining, and Paper mill other small industrial units which discharges their treated effluents directly into the Hasdeo river.

4.2.1.2 Drainage: The sewage of Korba and Champa city municipal area are going to the Hasdeo river without any treatment. Presently there is no facility available for diversion and treatment of domestic sewage. The domestic sewage of NTPC, SECL, CSEB town ship is discharged. Korba has many automobile service center and Hospital so the waste coming from these directly goes to Hasdeo river through Sewerage line. In champa city domestic waste are in small amount directly discharged. Consequently, this river area is polluted by the sewage water and at downstream due to Madhya Bharat Paper mill effluent Water.

4.2.1.3. Run-off water: The storm water in rainy season directly goes to the Hasdeo water through the small drain. It carries agricultural run-off from catchment area. It increases the turbidity and organic load in the Hasdeo river.

4.2.2 Non Point Sources

Pollution is scattered or diffuse, having no specific location where they discharge into a particular body of water (e.g. runoff from farm fields, Urban field and agricultural land, lawns, and gardens). Considering to the Hasdeo river, the sources are:

4.2.2.1. Urban storm water runoff: This source leads to siltation and organic pollution load in the river water.

4.2.2.2. Agricultural runoff: The chemical fertilizers, insecticide, chemical manure, pesticides and irrigation water from agricultural land: This sources are minimum with respect to other sources due of very small amount are used such types of chemicals. Besides, about 50 square km area are used as cultivated land out of total catchment area (154 square km) of the Hasdeo River. Therefore, their bad affect can be neglected in comparison to the other sources. Basically, non point sources of pollution are widely diffused, hard to estimate and difficult to control. **Fig 4.1** shown the pollution sources of Hasdeo River

4.3 POLLUTION BY INDUSTRIES

Industrial development in Hasdeo river catchment has made significant beneficial contributions to the overall economic development of area. It has generated employment, promoted socio-economic and infrastructural development. However, it has profound effects on the environmental resources because all industries require the use of both renewable and nonrenewable resources from the environment. It is obvious that the conversion of these resources into finished or semi-finished industrial products results in residues that are often discharged as wastes into water. These wastes are in solid, liquid or gaseous forms and when discharged indiscriminately could adversely affect the quality of the water.

The Hasdeo River is polluted by the several industrial units and these sources play major role to polluting the Hasdeo river. Industrial units are considered as polluting units in regards of the Hasdeo River and detail of Hazardous and Liquid waste generated by industries are given in **Table 4.1.**

Table 4.1 :Hazardous and Liquid waste generated by industries of year 2009

S.NO.	Name of Industry	Waste Description	Waste Quantity
1	Madhya Bharat Paper Mill	1.Used /spent oil 2. Corrosive waste 3. Sludge 4. Used water 5.Effluent water	5 MLD 6 T/Year 1.5 T /Day 4.4 MLD 3.6 MLD
2	Balco Aluminium Co. Ltd	1.Used oil 2.Spent oil 3.Waste /residue 4.Sludge 5. Effluent water	30 T/Year 0.25 T/year 1.5 T/Year 350 T/year 5 MLD
3	Balco Capataive Power Plant	1.Used oil 2.Waste residue 3. Used water 4.Effluent hot water 5. Effluent water	31.04 T/Year 0.25 T/Year 42045 M^3/hour 37224 M3/hour 4821M3/hour

S.NO.	Name of Industry	Waste Description	Waste Quantity
4	National Thermal Power Corporation Ltd,(2100 MW)	1. Used oil 2. Toxic Metal 3. Used Water 4 Effluent hot water 5.Effluent water	150.5 KL/Year 2.0 T/Year 109000 M3/hour 96500 M3/hour 12500 M3/hour
5	Korba Thermal Power Station, CSEB(East) Korba(2x250 MW)	1. Used oil 2. Toxic Metal 3. Used Water 4 Effluent hot water 5.Effluent water	23.5 KL/Year 1.0 T/Year 25952 M3/hour 22975 M3/hour 2976 M3/hour
6	Hasdeo Themal Power Station, CSEB (West) Korba(4 x 210MW)	1. Used oil 2. Toxic Metal 3. Used Water 4 Effluent hot water 5.Effluent water	65.5 KL/Year 2.0 T?Year 43600 M3/hour 38600 M3/hour 5000 M3/hour
7	Manikpur Open Cast Mine S.E.C.L., Korba Area	1.Used oil 2.Waste residue 3. oil and grease 4. Effluent water	7.5 KL/Year 1.0 T/Year 30.0 T/year 928 KLD
8	Kusmunda Open Cast Mine S.E.C.L., Korba Area	1.Used oil 2.Waste residue 3. oil and grease 4. Effluent water	7.5 KL/Year 1.0 T/Year 35.0 T/year 806 KLD
9	Gevra Open Cast Mine S.E.C.L., Korba Area	1.Used oil 2.Waste residue 3. oil and grease 4. Effluent water	184 KL/Year 6.0 T/Year 50.0 T/year 1500 KLD

S.NO.	Name of Industry	Waste Description	Waste Quantity
10	Dipka Open Cast Mine S.E.C.L., Korba Area	1.Used oil 2.Waste residue 3. oil and grease 4. Effluent water	115.5 KL/Year 3.0 T/Year 40.0 T/year 1057 KLD
11	Central Workshop (E&M), S.E.C.L., Korba Area	1.Used oil 2.Waste residue 3. oil and grease 4. Effluent water	1.5 KL/Year 1.15 T/Year 0.1 T/year 210 KLD
12	Vinay Industries	1.Lead slag 2.Lead ash 3. oil and grease 4. Effluent water	3.0 T/Year 3.0 T/Year 0.1 T/year 235 KLD
13	Prakash Industries Ltd (100 MW)	1 Used/ spent oil 2. Used Water 3. Effluent Water	16000 Lt/Year 5000 M3/hour 125 M3/hour

Source : Chhattisgarh Environmental Conservation Board

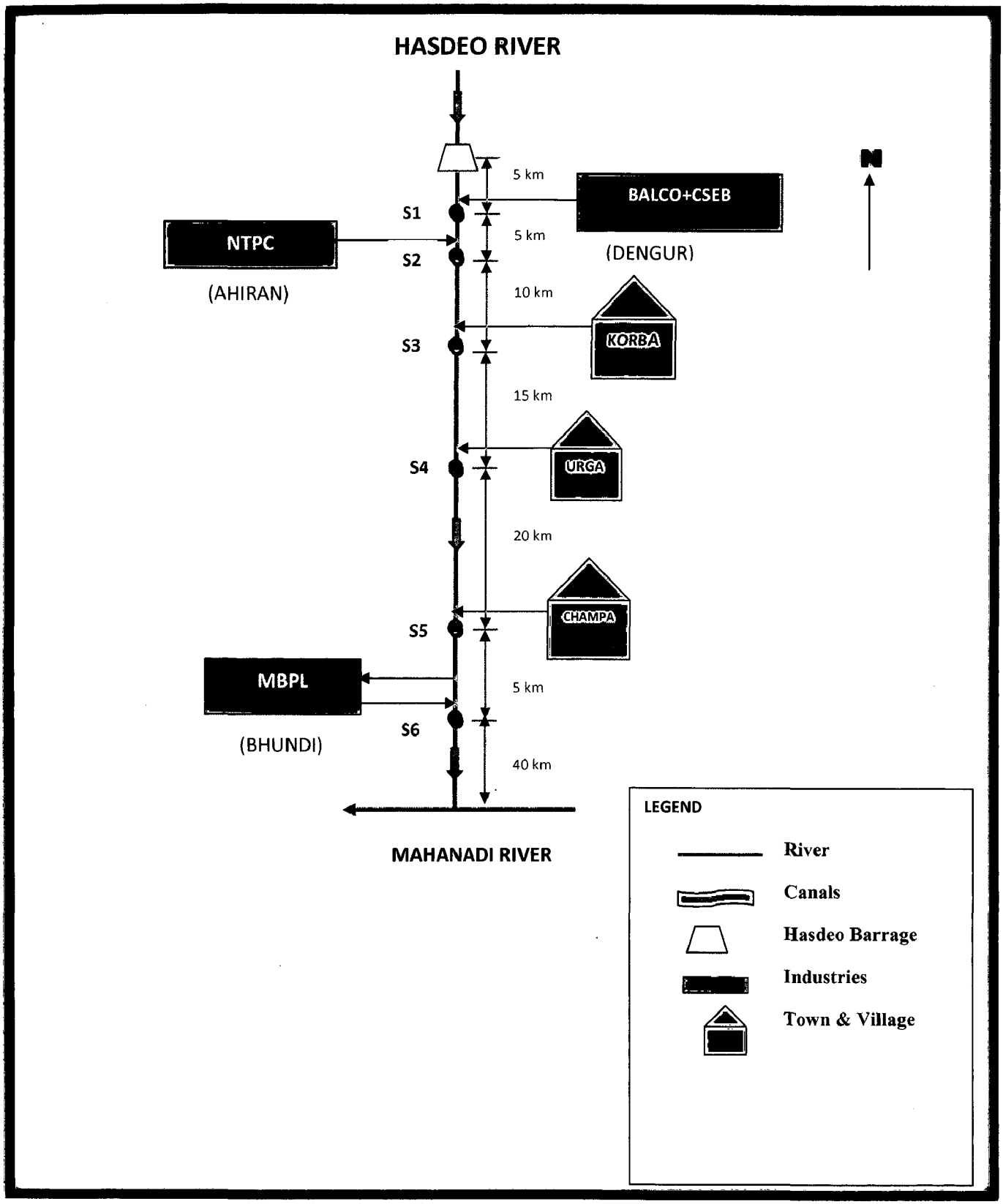


Fig.4.1: Line Diagram for Pollution sources of Hasdeo river

4.4 HOSPITAL WASTE WATER

There are about11 hospitals, 10 nursing homes, 50 patho-labs in Korba and 3 hospitals, 4 nursing homes and 10 path labs are function in Champa city.

The total bed of said hospital and nursing homes are about 1200. Therefore, nearly 476 m^3 of water used and 378 m^3 of hospital waste water is discharged to their respective drain which is ultimately go to Hasdeo River. Presently there is no any special arrangement is available for treatment of this waste water. Waste water generating from hospital join river through small drains coming from city area. It is very difficult to estimate the exact amount of waste water generation from Hospitals. [53]

4.5 AUTOMOBILE WASTE WATER

There are about 15 automobile showrooms, 30 garages, 15 service centers in korba city and 2 automobile showrooms, 5 garages, 3 service centers are performing their function in Champa city. Near about 150 m^3 waste water in a day is discharged to their respective drain which is ultimately discharge to Hasdeo River. Further there is no facility available for the treatment of waste water coming from automobile units. [53].

4.6 POLLUTION BY DOMESTIC SOURCES

Both urban and rural area which is living surrounding the Hasdeo river catchment area. Discharges waste water into the surrounding area ultimately which goes to the Hasdeo river. Through the sewer lines.

4.6.1 Rural Area

There are about 30 thousand people live in and around the Hasdeo River along its 35 km distance of flow path in the rural area. It is depending upon the habits and standard of living of the people, about 75 liter of water is used by a person in a day. Due to large catchment area and diverse nature, nearly 20 % of its use of water is going to the Hasdeo river as a sewage water. Consequently, about 450 m^3 of sewage water is reached into the Hasdeo river in a day against 2250 m^3 use of water. The bad affect of this sewage water is very small due to that waste water

contains less effective and easily oxidized pollutant. It's due the self purification process of the Hasdeo river [53].

4.6.2 Urban Area

The total population of Korba and Champa Municipal area is 4,48,416 and 46,367. Depending upon the habits and standards of living of the people, about 135 liter water is used per capita per day. Due to a Large Disposal area and diverse nature, nearly 80 percent of its use water is going to Hasdeo River as a sewage water as given standard by CPCB in **Table 1.4.** Consequently, about 53.5 MLD sewage water reached to Hasdeo River. Presently in Korba and Champa town Sewage water directly goes to river no treatment facility is available. So domestic waste has a large contribution in the pollution of Hasdeo River [53].

4.7 POLLUTION BY AGRICULTURAL CHEMICALS

The agriculture waste water generated from the agricultural activity. The fertilizers and agricultural chemicals like as pesticide, insecticide, weedicide and insecticides may be ignored along the flow path of the Hasdeo river in rural area under the catchments area of the Hasdeo River. There is small amount pesticide; weedicide and insecticide are present in the water analysis of the Hasdeo river given in the report of CPCB Highlights 2003. Besides, use of fertilizers is also very less with respect to the other parts of the country. Average 10.12 kg of fertilizers are used in a bigha (0.1456 hectares) in the state which is very less amount as compare to the needed amount of the soil. The use of fertilizers and chemical manure in the agricultural land of the catchments area of Hasdeo river is more less than the state mean because of this area is less agricultural developed. Only paddy is taken majorly as crop. Which required fewer amounts of chemical fertilizers with respect to the other parts of the state? Therefore, the bad affect of fertilizers and agricultural chemicals can be assumed small with compare to the water pollution load in the Hasdeo River [53].

4.8 ORGANIC POLLUTION

Each source carries pollutants as organic nature into the Hasdeo river. Both industries and domestic activities are responsible for polluting the Hasdeo River., industrial effluent and domestic waste water both contains organic pollutant. Pollution due to both activities are as flowing below:

4.8.1 Domestic

Pollution generated from domestic source is directly proportional to the population .Urbanization contribute the most the part of organic pollution load on river than the rural communities. The sources of pollution in rural and urban area for the Hasdeo river are considered as:

4.8.1.1 Rural area

The organic pollution in the form of BOD contribution of rural area has been considered as 15 grams per person in a day into the Hasdeo river due to the diffused nature of disposal system. This assumption has been generally used to estimate pollution load in Brahmaputra river as referred from "The Brahmaputra Basin" which is published by the CPCB, October, 2000 [Assessment and development study of river basin series : ADSORBS/33/2000-2001] [52].

There are about 35 thousand people live in rural area of the Hasdeo river catchment area and the BOD load is contributed by the rural people to the Hasdeo river for about 525 kg in a day. This small amount of organic load joins the river but again this organic load is distributed as a divergent nature and easily removed their adverse affect by the self purification process of the Hasdeo river due to large flow path in rural area.

4.8.1.2 Urban area

The total population forecasted for year 2010 of Korba and Champa municipal area is 4,48,416 and 46,367 contributes 7421.05 kg of BOD load in a day into a the Hasdeo river. This amount concentrates as a point source in a close area of Hasdeo River. Consequently, it affects the entire ecosystem of the Hasdeo river.

4.8.2 Industries

The industrial unit's discharges organic load through its effluents. The total quantity of organic load discharged into the Hasdeo River is shown in the **Table 4.2.**

Table 4.2: Organic pollution load of industrial units as per (CECB)

Sl. No.	Name of Industries	Discharge of effluent (m^3/hour)	BOD (kg/Day)
1	Madhya Bharat Paper Limited	150	12
2	Bharat Aluminum Corporation	4821	55
4	National Thermal Power Corporation Limited	12500	0.2
5	Korba Super Thermal Power Station	2976	0.2
6	Hasdeo Thermal Power Station	5000	0.2
7	Manikpur Open Cast Mine	928	3
8	Kusmunda Open Cast Mine	806	2
9	Gevra Open Cast Mine	900	3
10	Dipka Open Cast mine	1057	3.5
11	Vinay Industries	235	0.1
12	Praksh Industries	3000	0.15
13	Hospital Waste	378	8.10
14	Automobile service waste	150	1.8

Source : Chhattisgarh Environmental Conservation Board.

4.9 WATER QUALITY MONITORING

Water quality monitoring is an important exercise, which helps in evaluating the nature and extent of pollution control required, and effectiveness of pollution control measures already in existence. It also helps in drawing the water quality trends and prioritizing pollution control efforts. SPCB identifies areas of high priority based on the severity of the problem. These water bodies are not meeting the desired level of water quality for defined use with respect to bio-chemical oxygen demand. In the present analysis, those water bodies having BOD more than 6mg/l are identified as polluted water bodies. In some of the states few surface water bodies are identified as that they are having polluted stretches. The SPCB were requested to take remedial measures and formulate action plans to restore the water quality of the water bodies by CPCB. The government of India has taken so many steps to control pollution through various

legislations, Water Act, Environmental protection Act and Action plans such as Ganga Action plan, Yamuna Action Plan and other river action plan. Under this plans water quality is monitoring is done by SPCB.

4.9.1 Hasdeo River Water Quality Monitoring

The water of the Hasdeo River is gradually deteriorated due to industrialization and urbanization of Korba and Champa town. Basically, water is polluted by industrial and domestic activities. The industrial pollution is more complex than the pollution due to urban activities. The pollution loads are concentrated in between Dengur (korba) and Champa town area along the flow path of Hasdeo river. Which is presently my study stretches.

The strategic locations on Hasdeo river. Where the river is affected by industrial, sewage, agricultural run-off and waste generation by city. These locations are identified by Chhattisgarh Environmental Conservation Board. Water quality monitoring is done in this strategic location. In my study area on Hasdeo river from korba to champa 6 locations are monitored by CECB.

4.9.2 Description of Sampling Location

The objective of sampling is to collect the water samples from the river at the sampling station. The following sampling stations of the Hasdeo river are monitored by CECB. The water quality data for present assessment of pollution status of Hasdeo river of various year, current monsoon, post monsoon, winter and pre monsoon season have been taken from CECB regional office Korba. This data has been used in the calculation of NSF water quality indices. The general layouts, photographs of the sampling location are shown in enclosed maps and description of sampling locations is given in **Table 4.3**. The study area covers about 50 km stretch of river starting from Dengur and end at Bhundi points.

The details of these sampling locations are given below in **Table 4.3** and shown in **Figure 4.2:-**

Table 4.3 : Detail of Sampling Location

S.No.	LOCATION	CODE	DISTANCE FROM ORIGIN (KM)	DISCRIPTION
1	Dengur	S1	0	Wastewater from Bharat Aluminium Company Ltd., the ash-dykes/main plant of Chhattisgarh State Electricity Board (CSEB, East) Thermal Power Plant. And domestic sewage from colony discharge into river.
2	Ahiran	S2	5	Wastewater from M/s. National Thermal Power Corporation (NTPC), and M/s. BALCO Captive Power Plant located on the right bank of the river and domestic sewage from colony area.
3	Korba	S3	15	The sampling location is at downstream of korba city, basically Sewage is discharged into river; bathing and washing activity also take place.
4	Urga	S4	30	The sampling location is at down steam of urga. At this point, river basically affected due to sewage and domestic waste coming from Urga.
5	Champa	S5	50	The Sampling Location is near to Gemon Pool. At this point, river basically affected by sewage water and domestic waste coming from city champa.
6	Bhundi	S6	55	Madhya Bharat Paper Mill is discharged effluent water and sewage discharge from colonies.

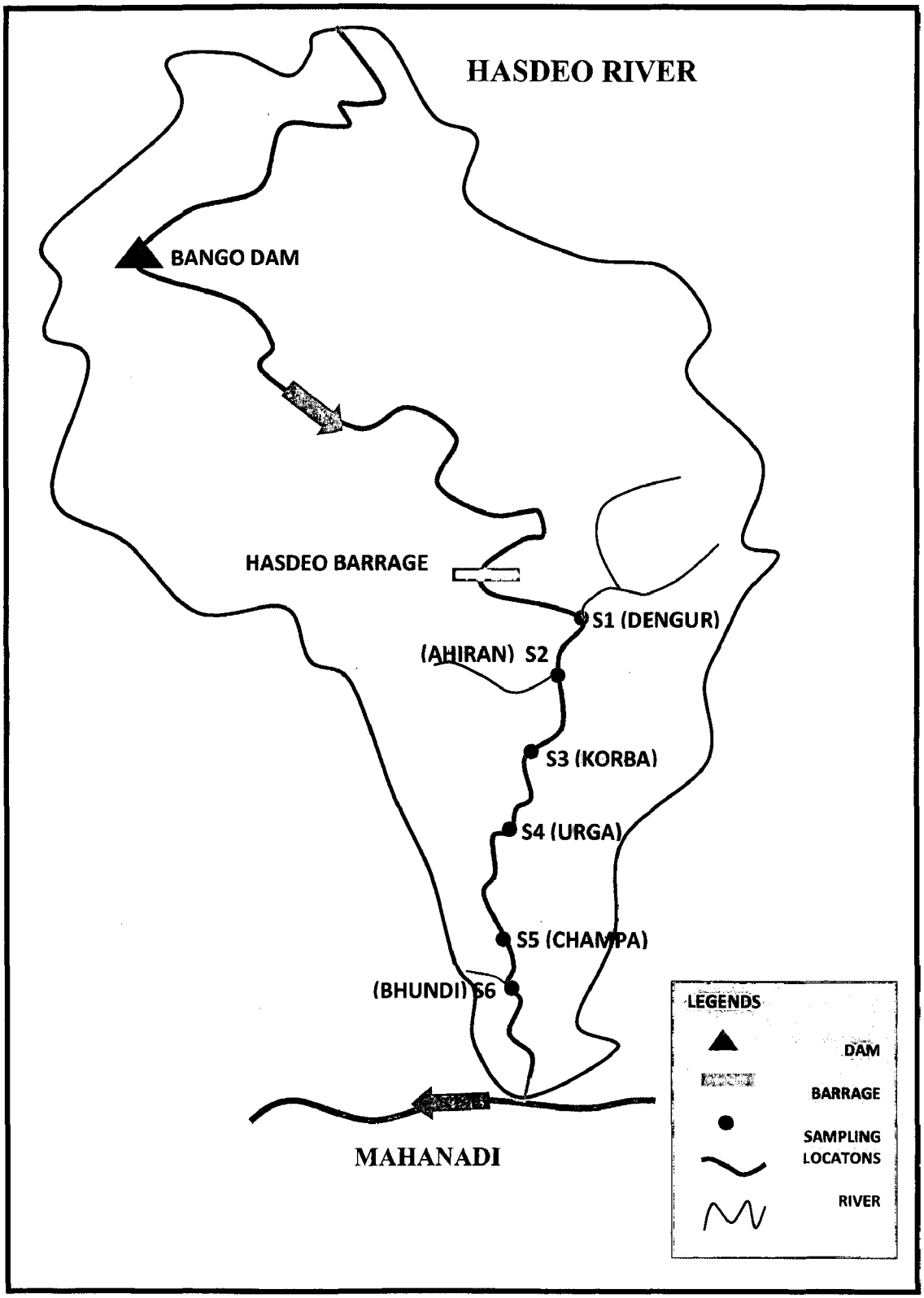


Fig. 4.2 : Sampling Location

4.9.3 WATER QUALITY DATA

The water of the Hasdeo river are monitored for the physicochemical parameters such as physical, organic and other inorganic parameters and in monsoon, postmonsoon, winter and premonsoon and time series data of six sampling location at the Hasdeo river are selected for analyzing the water quality parameters.

The effluents of various industries such as NTPC, CSEB, BALCO and MBPL have been analyzed for the physicochemical, organic and inorganic parameters. Similarly, the sewage water of Korba, Urga and Champa city are also analyzed during the monsoon, post monsoon winter pre monsoon and for year 2002 to 2008.

4.9.3.1 Time Series Water Quality Data

Time series water quality data of Hasdeo river at all six sampling location from year 2002 to 2008 are collected. Time series data is used for analyzing the trend of pollution of Hasdeo River. In time series water quality data eight parameter value DO, pH, BOD, COD, Temperature, Nitrite, Nitrate, and Faecal Coliform is given in **Table 4.4-4.11.**

4.9.3.2 Water Quality During Monsoon

Average rainfall has been occurred in study area in June and July, 2009 therefore, the pollution problem of the Hasdeo river is not severe due to dilution in river water of the Hasdeo river. The details of average water quality of physicochemical organic and inorganic parameters at the various sampling stations of the Hasdeo river in the **Table 4.12** for the monsoon.

4.9.3.3 Water Quality During Post Monsoon

The season is moderate temperature and less rainfall with respect to the summer. six water samples in November, 2009 from six sampling station of the Hasdeo river. The details of average water quality of physicochemical organic and inorganic parameters at the various sampling stations of the Hasdeo river in the **Table 4.13** for the post monsoon.

4.9.3.4 Water Quality During Winter

This season is lower temperature and less humidity..Six water samples in January, 2010 are collected at six sampling stations of the Hasdeo river. The details of average water quality of physicochemical organic and inorganic parameters at the various sampling stations of the Hasdeo River in the **Table 4.14** for the winter.

4.9.3.5 Water Quality during Pre Monsoon

Temperature and humidity is gradually increasing trend in the premonsoon period in the study area. The river is under lean flow due to scanty rainfall and hence the water quality is deteriorated. Six water samples in January, 2010 are collected at six sampling stations of the Hasdeo river. The details of average water quality of physicochemical organic and inorganic parameters at the various sampling stations of the Hasdeo river in the **Table 4.15** for the post monsoon.

Table 4.4 : Water Quality of Hasdeo River at various Locations,Year-2002

Location	Temp. (°c)	pH	DO (mg/l)	B.O.D. (mg/l)	C.O.D. (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	Faecal Coliform (MPN/100ml)	Ammo. Nitro. (mg/l)
S1	26.2	7.7	5.3	5.6	26	0.24	1.3	1000	1.6
S2	27.0	7.8	4.5	5.8	27	0.14	1.2	700	1.5
S3	26.0	7.9	5.5	5.0	25	0.12	1.0	712	1.4
S4	24.0	7.5	6.0	1.5	24	0.10	1.2	695	1.7
S5	22.0	7.5	7.0	1.1	21	0.03	1.1	680	1.3
S6	26.0	7.8	5.1	5.8	28	0.05	1.2	700	1.4

Table 4.5 : Water Quality of Hasdeo River at various Locations,Year-2003

Location	Temp. (°c)	pH	DO (mg/l)	B.O.D. (mg/l)	C.O.D. (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	Faecal Coliform (MPN/100ml)	Ammo. Nitro. (mg/l)
S1	27.3	8.3	5.0	6.0	28.5	0.280	1.3	1100	1.75
S2	26.0	8.2	4.2	6.2	29.0	0.180	1.3	805	1.80
S3	26.5	8.0	6.8	5.2	29.0	0.138	1.0	798	1.70
S4	26.0	7.8	5.5	2.0	28.0	0.060	1.2	700	1.90
S5	25.8	7.9	6.8	1.7	28.0	0.038	1.1	725	1.60
S6	27.0	8.2	4.5	6.0	29.0	0.070	1.2	800	1.80

Table 4.6 : Water Quality of Hasdeo River at various Locations ,Year-2004

Location	Temp. (°c)	pH	DO (mg/l)	B.O.D. (mg/l)	C.O.D. (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)
S1	28.0	7.8	5.2	6.2	28.5	0.25	1.30
S2	29.0	7.8	4.6	6.4	28.0	0.18	1.25
S3	27.0	7.5	7.9	5.4	28.0	0.14	1.00
S4	26.0	8.0	7.0	2.5	28.0	0.06	1.20
S5	27.0	7.5	7.3	1.8	27.0	0.04	1.05
S6	28.0	7.7	4.7	6.7	30.0	0.05	1.20

Table 4.7 : Water Quality of Hasdeo River at various Locations ,Year-2005

Location	Temp. (°c)	pH	DO (mg/l)	B.O.D. (mg/l)	C.O.D. (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)
S1	27.5	7.7	4.9	5.4	31.5	1.10	1.35
S2	29	7.85	4.4	5.8	32	1.20	1.40
S3	26	7.57	5.4	5.2	31.9	1.08	1.08
S4	25	7.8	7.2	2.8	30.0	0.05	1.20
S5	26	7.8	7.6	1.7	31.9	0.02	1.14
S6	28	7.95	4.5	6.5	33.0	0.04	1.30

Table 4.4 : Water Quality of Hasdeo River at various Locations,Year-2002

Location	Temp. (°c)	pH	DO (mg/l)	B.O.D. (mg/l)	C.O.D. (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	Faecal Coliform (MPN/100ml)	Ammo. Nitro. (mg/l)
S1	26.2	7.7	5.3	5.6	26	0.24	1.3	1000	1.6
S2	27.0	7.8	4.5	5.8	27	0.14	1.2	700	1.5
S3	26.0	7.9	5.5	5.0	25	0.12	1.0	712	1.4
S4	24.0	7.5	6.0	1.5	24	0.10	1.2	695	1.7
S5	22.0	7.5	7.0	1.1	21	0.03	1.1	680	1.3
S6	26.0	7.8	5.1	5.8	28	0.05	1.2	700	1.4

Table 4.5 : Water Quality of Hasdeo River at various Locations,Year-2003

Location	Temp. (°c)	pH	DO (mg/l)	B.O.D. (mg/l)	C.O.D. (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	Faecal Coliform (MPN/100ml)	Ammo. Nitro. (mg/l)
S1	27.3	8.3	5.0	6.0	28.5	0.280	1.3	1100	1.75
S2	26.0	8.2	4.2	6.2	29.0	0.180	1.3	805	1.80
S3	26.5	8.0	6.8	5.2	29.0	0.138	1.0	798	1.70
S4	26.0	7.8	5.5	2.0	28.0	0.060	1.2	700	1.90
S5	25.8	7.9	6.8	1.7	28.0	0.038	1.1	725	1.60
S6	27.0	8.2	4.5	6.0	29.0	0.070	1.2	800	1.80

Table 4.6 : Water Quality of Hasdeo River at various Locations ,Year-2004

Location	Temp. (°c)	pH	DO (mg/l)	B.O.D. (mg/l)	C.O.D. (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	Faecal Coliform (MPN/100ml)	Ammo. Nitro. (mg/l)
S1	28.0	7.8	5.2	6.2	28.5	0.25	1.30	1020	1.85
S2	29.0	7.8	4.6	6.4	28.0	0.18	1.25	725	1.80
S3	27.0	7.5	7.9	5.4	28.0	0.14	1.00	762	1.70
S4	26.0	8.0	7.0	2.5	28.0	0.06	1.20	650	1.90
S5	27.0	7.5	7.3	1.8	27.0	0.04	1.05	680	1.60
S6	28.0	7.7	4.7	6.7	30.0	0.05	1.20	745	1.80

Table 4.7 : Water Quality of Hasdeo River at various Locations ,Year-2005

Location	Temp. (°c)	pH	DO (mg/l)	B.O.D. (mg/l)	C.O.D. (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	Faecal Coliform (MPN/100ml)	Ammo. Nitro. (mg/l)
S1	27.5	7.7	4.9	5.4	31.5	1.10	1.35	1125	2.3
S2	29	7.85	4.4	5.8	32	1.20	1.40	800	2.2
S3	26	7.57	5.4	5.2	31.9	1.08	1.08	789	2.0
S4	25	7.8	7.2	2.8	30.0	0.05	1.20	700	2.2
S5	26	7.8	7.6	1.7	31.9	0.02	1.14	610	2.0
S6	28	7.95	4.5	6.5	33.0	0.04	1.30	805	2.1

Table 4.8 : Water Quality of Hasdeo River at various Locations,Year-2006

Location	Temp. (°c)	pH	DO (mg/l)	B.O.D. (mg/l)	C.O.D. (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	Faecal Coliform (MPN/100ml)	Ammo. Nitro. (mg/l)
S1	30.4	7.8	4.6	6.2	31.0	0.15	1.4	1200	2.4
S2	31.0	7.9	4.0	6.0	30.0	0.09	1.4	805	2.3
S3	28.0	7.6	7.7	5.4	30.0	0.06	1.1	790	2.0
S4	27.0	8.0	7.0	3.0	28.0	0.08	1.3	720	2.2
S5	29.0	7.7	7.4	2.2	27.0	0.08	1.2	625	2.0
S6	30.0	8.0	4.2	7.0	32.0	0.09	1.3	845	2.2

Table 4.9 : Water Quality of Hasdeo River at various Locations,Year-2007

Location	Temp. (°c)	pH	DO (mg/l)	B.O.D. (mg/l)	C.O.D. (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	Faecal Coliform (MPN/100ml)	Ammo. Nitro. (mg/l)
S1	29	8.1	3.80	7.4	32.0	0.11	1.4	1450	1.5
S2	28	8.2	3.75	7.5	32.5	0.09	1.4	850	1.6
S3	27	8.0	4.35	7.0	29.0	0.07	1.2	822	1.4
S4	26	7.4	6.80	4.0	28.0	0.12	1.4	755	1.6
S5	28	8.0	7.00	3.4	27.0	0.10	1.0	650	1.2
S6	30	8.1	3.70	8.5	33.0	0.12	1.2	974	1.4

Table 4.10 : Water Quality of Hasdeo River at various Locations,Year-2008

Location	Temp. (°c)	pH	DO (mg/l)	B.O.D. (mg/l)	C.O.D. (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	Faecal Coliform (MPN/100ml)	Ammo. Nitro. (mg/l)
S1	32	7.90	3.6	7.6	31.5	0.09	1.6	1500	1.7
S2	33	8.00	3.8	8.0	32.0	0.10	1.5	1000	1.8
S3	30	7.80	4.0	7.5	29.0	0.08	1.4	912	1.6
S4	26	7.24	6.4	4.8	30.0	0.07	1.7	900	1.8
S5	30	8.20	6.8	4.2	32.0	0.06	1.6	600	1.3
S6	31	8.30	4.0	9.0	35.0	0.08	1.7	1110	1.6

Table 4.11 : Water Quality of Hasdeo River at various Locations,Year-2009

Location	Temp. (°c)	pH	DO (mg/l)	B.O.D. (mg/l)	C.O.D. (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	Faecal Coliform (MPN/100ml)	Ammo. Nitro. (mg/l)
S1	32.0	8.12	3.2	8.5	42	1.50	2.0	1690	2.0
S2	33.0	8.22	2.8	8.3	46	1.40	2.1	1015	1.9
S3	29.5	8.10	3.9	8.0	34	0.08	1.6	1089	1.8
S4	28.0	7.95	6.2	5.0	32	0.08	1.8	955	1.9
S5	29.0	8.00	6.3	4.5	30	0.07	1.7	722	1.5
S6	31.0	8.10	3.0	11	45	1.20	1.7	1231	1.8

Table 4.12 : Water Quality of Hasdeo River at various Locations,monsoon,2009

Location	Temp. (°c)	pH	DO (mg/l)	B.O.D. (mg/l)	C.O.D. (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	Faecal Coliform (MPN/100ml)	Phosphate (mg/l)	Total Solid (mg/l)	Turbidity NTU
S1	32	7.82	4.0	10.0	40	1.40	1.8	2000	2.0	450	90.0
S2	32	7.90	3.2	10.5	43	1.30	1.7	950	1.9	455	58.0
S3	29.5	7.60	6.0	9.5	42	0.08	1.6	1000	1.6	312	40.0
S4	30	7.85	6.2	5.5	40	0.08	1.8	942	2.8	490	61.0
S5	28	7.75	6.3	5.2	38	0.07	1.7	800	2.6	545	58.0
S6	31	7.80	3.5	11.8	42.5	1.10	1.6	1234	1.80	423	62.0

Table 4.13 : Water Quality of Hasdeo River at various Locations,postmonsoon,2009

Location	Temp. (°c)	pH	DO (mg/l)	B.O.D. (mg/l)	C.O.D. (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	Faecal Coliform (MPN/100ml)	Phosphate (mg/l)	Total Solid (mg/l)	Turbidity NTU
S1	32.5	8.15	3.2	11.6	44	1.50	2.3	1700	2.3	440	95
S2	33	8.20	2.8	10.5	46	1.40	1.8	780	2.1	500	52
S3	29.5	7.78	4.0	10.0	43	0.08	1.6	953	1.3	434	42
S4	30	7.95	5.4	5.8	42	0.08	1.8	863	2.4	523	63
S5	28	7.80	4.6	5.3	40	0.07	1.7	812	2.5	555	65
S6	31	8.10	4.0	12.0	50	1.20	1.9	1159	1.92	460	54

Table 4.14 : Water Quality of Hasdeo River at various Locations ,winter,2010

Location	Temp. (°c)	pH	DO (mg/l)	B.O.D. (mg/l)	C.O.D. (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	Faecal Coliform (MPN/100ml)	Phosphate (mg/l)	Total Solid (mg/l)	Turbidity NTU
S1	32.0	8.12	3.2	11.1	42	1.50	2.0	1690	2.2	424	78.0
S2	33.0	8.22	2.8	10.5	46	1.40	2.1	655	2.0	455.0	54.0
S3	29.5	8.10	3.9	9.5	40	0.08	1.6	1200	1.8	445.0	46.0
S4	30	7.95	6.2	5.3	38	0.08	1.8	1100	2.5	460.0	65.0
S5	28	7.82	6.3	5.0	36	0.07	1.7	1000	2.8	512.0	63.0
S6	30.0	7.97	3.0	12.2	45	1.20	1.7	1312	1.89	456	55.0

Table 4.15 : Water Quality of Hasdeo River at various Locations ,premonsoon,2010

Location	Temp. (°c)	pH	DO (mg/l)	B.O.D. (mg/l)	C.O.D. (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	Faecal Coliform (MPN/100ml)	Phosphate (mg/l)	Total Solid (mg/l)	Turbidity NTU
S1	33.0	8.00	3.0	12.0	40	1.50	1.50	1850	2.3	436	82.0
S2	32.0	8.10	2.5	11.8	45	1.40	1.40	700	2.1	465	56.0
S3	29.5	8.20	3.5	11.0	41	0.08	0.08	1300	1.5	456	65.0
S4	30	7.90	5.0	5.5	39	0.08	0.08	1212	2.4	513	62.0
S5	28	7.80	6.3	6.5	37	0.07	0.07	1100	2.5	534	63.0
S6	32.0	8.00	3.5	13.4	48	1.20	1.20	1400	1.92	489	58.0

The photograph of the approximate location of the sampling station are shown in the following Figure 4.3- 4.8

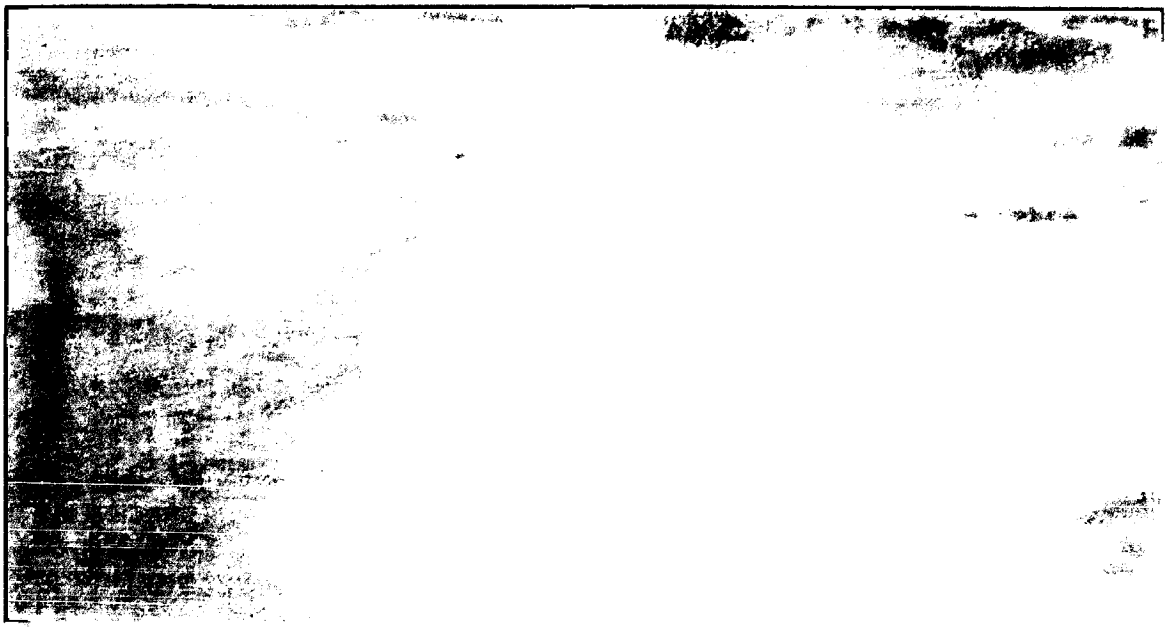


Fig 4.3: Dengur Nallah Before Confluence with Hasdeo River

Fig 4.4: Ahiran Nallah Before Confluence with Hasdeo River

Fig 4.5: Sampling Location , Korba (S3)

Fig 4.6: Sampling Location Urga (S4)

Fig 4.7: Sampling Location Champa (S5)

Fig 4.8: Sampling Location, Bhundi (S6)

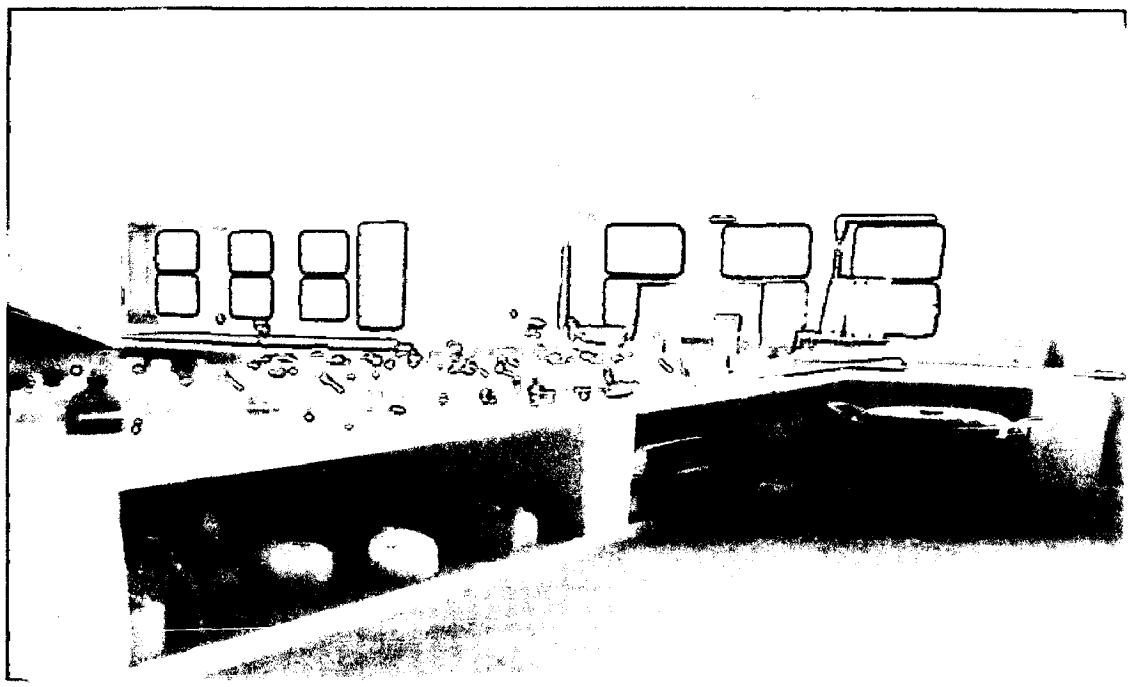


Fig 4.9: Water Quality Testing Laboratory of CECB Regional office Korba

CHAPTER-5
ASSESSMENT OF WATER QUALITY

5.1 GENERAL

The water quality assessment is most important part for ascertaining the pollution level in a water body. The water quality analysis, algal analysis and water quality indexing are essential for measuring the pollution level of the river. Only one type of assessment is not possible to ascertain the exact pollution level of a water system.

Water quality assessment, analysis and water quality indexing has been performed in the study period. Besides effluent of various industries such as NTPC, BALCO, CSEB, MBPL and domestic sewage water of Dengur, Ahiran, Korba, urga and champa city area.

For assessment of water quality of Hasdeo river time series and current seasonal water quality data of strategic location required. For Present study secondary water quality data is used. Water quality data for seasonal and time series is shown in **Table 4.1 to 4.12**

5.2 WATER QUALITY INDEX

Water Quality Index indicates a single number (like a grade) that expresses the overall water quality at a certain location and time based on several water quality parameters. It is also defined as a rating reflecting the composite influence of different water quality parameters on the overall quality of water. According to the concept of indices to represent gradation in water quality was first proposed by Horton (1965). The use of an index top grade water quality is controversial among water quality scientists.

The main objective of Water Quality Index is to turn complex water quality data into information that understandable and useable by the public a general idea of the possible problem with water in a particular region. The indices are among the most effective ways to communicate the information on water quality trends to the public or to the policy makers and water quality management.

5.2.1 National Sanitation Foundation Water Quality Index

Brown et al. (1970) had presented a water quality index similar in structure to Horton's index. It is also called National Sanitation Foundation Water Quality Index (NSFWQI) [40]. NSF WQI is an excellent management and general administrative tool in communicating water

quality information. This index has been widely field tested and applied to data from a number of different geographical areas all over the world in order to calculate Water Quality Index (WQI) of various water bodies critical pollution parameters were considered.

It is calculated after aggregating the sub indices for 9 parameters as weighted sum, using the following equation.

$$\mathbf{NSFWQI} = \sum_{i=1}^{n} \mathbf{Wi\ Ii}$$

Where,

I_i is the sub-index for i_{th} water quality parameters.

W_i is the weight (in terms of importance) associated with i_{th} water quality parameter shown in **Table 5.1**.

n is the number of water quality parameter.

Table 5.1: Parameters and their weights for NSFWQI

Parameters	Weights
Dissolved oxygen	0.17
Faecal coliform	0.16
pH	0.11
BOD	0.11
Nitrates	0.10
Phosphates	0.10
Temperature	0.10
Turbidity	0.08
Total solids	0.07
Total	**1.00**

A decreasing scale, 0 – 100 is used for expressing the water quality index. A system of reporting NSFWQI which relates the index values to 5 discriptor words and colours was also suggested by Brown et al. (1970) [51] as shown in the following **Table 5.2.**

Table 5.2: Classification of NSFWQI

Index (range)	Colours	Discriptor Word
1 (91-100)	Blue	Excellent
2 (71- 90)	Green	Good
3 (51- 70)	Yellow	Medium
4 (26 - 50)	Orange	Bad
5 (0 - 25)	Red	Very Bad

The NSFWQI is most commonly employed easy to use index. Most of the state in the USA has modified it to suit their requirement and standards. Higher value of the index indicates better water quality of the river.

The Council of Environmental Quality had proposed the following five criteria for the WQI formulation.

a. It should facilitate communication of environmental quality information to the public.

b. It would be readily derived from available monitoring data.

c. It should strike a balance between over simplification and complex technical conceptualization.

d. It should impart an understanding of significance of data represented.

e. It would be objectively designed but amenable to comparison with expert judgment so that their validity can be assessed.

The NSFWQI has confirmed all the above five criteria. This index is most widely accepted to evaluate the water quality index instead of many water quality indices developed so far. The NSFWQI has got the effectiveness and flexibility, while it is simple to formulate. It indicates higher value of the index is to be better water quality.

The water quality index of the Hasdeo river at the various sampling stations has been calculated by the NSFWQI in **Table 5.3-5.8** for the monsoon, postmonsoon, winter and premonsoon period and for year 2002-2008 respectively

Table 5.3 :Calculation of NSFWQI for monsoon, 2009

Sl. No.	Parameters	Weights	S1		S2		S3		S4		S5		S6	
	(Q_0)	(w)	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0
1	pH	0.11	7.82	89	7.9	87	7.6	92	7.85	89	7.75	91	7.8	90
2	Temp.	0.10	0	93	0	93	0	93	0	93	0	93	0	93
3	DO(%)	0.17	53	48	47	40	80	87	83	89	82	89	41	32
4	BOD	0.11	10	34	10.5	32	9.5	36	9.5	53	10.2	55	11.8	28
5	Nitrates	0.10	1.8	95	1.7	95	1.6	95	1.8	95	1.8	95	1.6	95
6	Phosphate	0.10	2	27	1.9	28	1.6	30	2.8	22	2.6	24	1.8	29
7	Turbidity	0.08	90	22	58	34	40	45	61	33	58	31	62	32
8	TS	0.07	450	40	455	39	312	58	490	33	545	20	423	44
9	FC	0.16	2000	18	950	22	1000	22	942	23	800	24	1234	21
		NSFWQI		51		52		62		60		60		49

Table 5.4 :Calculation of NSFWQI for post monsoon, 2009

Sl. No.	Parameters	Weights	S1		S2		S3		S4		S5		S6	
	(Q_0)	(w)	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0
1	pH	0.11	8.15	79	8.2	77	7.78	90	7.95	86	7.8	90	8.1	80
2	Temp.	0.10	0	93	0	93	0	93	0	93	0	93	0	93
3	DO(%)	0.17	45	37	40	30	53	48	73	79	82	89	55	51
4	BOD	0.11	11.6	29	10.5	32	10	34	5.8	52	5.3	54	12	28
5	Nitrates	0.10	2.3	94	1.8	95	1.6	95	1.8	95	1.7	95	1.9	95
6	Phosphate	0.10	2.3	25	2.1	26	1.3	34	2.4	25	2.5	24	1.92	28
7	Turbidity	0.08	95	20	52	38	42	44	63	32	63	31	54	37
8	TS	0.07	440	25	500	26	434	34	523	25	555	24	460	28
9	FC	0.16	1700	19	780	24	953	22	863	23	812	24	1159	21
		NSFWQI		45		47		54		57		50		49

Table 5.5:Calculation of NSFWQI for winter, 2010

Sl. No.	Parameters	Weights	S1		S2		S3		S4		S5		S6	
	(Q_0)	(w)	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0
1	pH	0.11	8.1	70	8.2	73	8.1	84	7.9	79	7.8	82	7.9	85
2	Temp.	0.10	0	93	0	93	0	93	0	93	0	93	0	93
3	DO(%)	0.17	45	37	40	30	65	60	80	87	82	89	40	30
4	BOD	0.11	11.1	30	10.5	32	9.5	38	5.3	54	5	56	12.2	27
5	Nitrates	0.10	2	95	2.1	95	1.6	95	1.8	95	1.7	95	1.7	95
6	Phosphate	0.10	2.2	26	2	27	1.8	29	2.5	24	2.8	22	1.89	24
7	Turbidity	0.08	78	26	54	37	46	41	65	31	63	32	55	36
8	TS	0.07	424	43	455	39	445	41	460	38	512	20	456	39
9	FC	0.16	1690	19	655	26	1200	21	1100	22	1000	22	1312	21
		NSFWQI		47		48		54		60		59		48

Table 5.6 :Calculation of NSFWQI for pre monsoon, 2010

Sl. No.	Parameters	Weights	S1		S2		S3		S4		S5		S6	
	(Q_0)	(w)	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0
1	pH	0.11	8	66	8.1	73	8.2	84	7.9	66	7.8	90	8	77
2	Temp.	0.10	0	93	0	93	0	93	0	93	0	93	0	93
3	DO(%)	0.17	43	34	29	18	47	40	67	70	82	89	49	42
4	BOD	0.11	12	28	11.8	28	11	30	5.5	53	5.3	48	13.4	24
5	Nitrates	0.10	2	95	1.9	95	1.6	95	1.8	95	1.7	95	1.8	95
6	Phosphate	0.10	2.3	25	2.1	26	1.5	30	2.4	25	2.5	24	1.92	28
7	Turbidity	0.08	95	20	56	35	65	31	60	33	63	32	58	34
8	TS	0.07	436	42	465	37	456	39	513	20	534	20	489	33
9	FC	0.16	1850	19	700	25	1300	21	1212	21	1100	22	1400	20
		NSFWQI		47		45		49		56		59		48

Table 5.7 :Calculation of NSFWQI for Year, 2002

Sl. No.	Parameters	Weights	S1		S2		S3		S4		S5		S6	
	(Q_0)	(w)	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0
1	pH	0.11	7.7	91	7.8	90	7.9	87	7.5	93	7.5	93	7.8	90
2	Temp.	0.10	0	93	0	93	0	93	0	93	0	93		93
3	DO(%)	0.17	66	68	57	53	62	60	75	81	68	72	60	57
4	BOD	0.11	5.6	53	5.8	52	5.0	56	1.5	90	1.1	94	5.8	52
5	Nitrates	0.10	1.3	96	1.2	96	1.0	96	1.2	95	1.1	96	1.2	96
6	FC	0.16	1000	22	700	25	712	25	695	25	680	26	700	25
		NSFWQI		50		48		50		57		56		48

Table 5.8 :Calculation of NSFWQI for Year, 2003

Sl. No.	Parameters	Weights	S1		S2		S3		S4		S5		S6	
	(Q_0)	(w)	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0
1	pH	0.11	8.3	90	8.2	87	8.0	80	7.8	73	7.9	77	8.2	77
2	Temp.	0.10	0	93	0	93	0	93	0	93	0	93	0	93
3	DO(%)	0.17	64	64	52	46	59	56	67	70	84	90	57	53
4	BOD	0.11	6.0	51	6.2	50	5.2	55	2.0	80	1.7	86	6.0	51
5	Nitrates	0.10	1.3	96	1.3	96	1.0	95	1.2	95	1.1	96	1.2	96
6	FC	0.16	1100	22	805	24	798	24	700	25	725	25	800	24
		NSFWQI		49		46		48		52		50		46

Table 5.9 :Calculation of NSFWQI for Year,2004

Sl. No.	Parameters	Weights	S1		S2		S3		S4		S5		S6	
	(Q_0)	(w)	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0
1	pH	0.11	7.8	90	7.8	90	7.5	93	8.0	84	7.5	93	7.7	91
2	Temp.	0.10	0	93	0	93	0	93	0	93	0	93	0	93
3	DO(%)	0.17	67	70	61	59	61	59	89	94	93	97	61	59
4	BOD	0.11	6.2	50	6.4	49	5.4	54	2.5	70	1.8	84	6.7	47
5	Nitrates	0.10	1.3	96	1.25	96	1.0	95	1.2	95	1.05	96	1.2	95
6	FC	0.16	1020	22	725	25	762	25	650	26	680	26	745	25
		NSFWQI		50		48		49		51		59		48

Table 5.10:Calculation of NSFWQI for Year, 2005

Sl. No.	Parameters	Weights	S1		S2		S3		S4		S5		S6	
	(Q_0)	(w)	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0
1	pH	0.11	7.7	91	7.85	89	7.57	92	7.8	90	7.8	90	7.95	86
2	Temp.	0.10	0	93	0	93	0	93	0	93	0	93	0	93
3	DO(%)	0.17	63	62	58	55	67	70	93	97	95	98	58	55
4	BOD	0.11	5.4	54	5,8	52	5.2	68	2.8	86	1.7	67	6.5	48
5	Nitrates	0.10	1.35	96	1.4	96	1.08	96	1.2	96	1.14	96	1.3	96
9	FC	0.16	1125	21	800	24	789	24	700	25	610	27	805	24
		NSFWQI		50		48		52		51		59		48

Table 5.11 :Calculation of NSFWQI for Year, 2006

Sl. No.	Parameters	Weights	S1		S2		S3		S4		S5		S6	
	(Q_0)	(w)	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0
1	pH	0.11	7.8	90	7.9	87	7.6	92	8.0	84	7.7	91	8.0	84
2	Temp.	0.10	0	93	0	93	0	93	0	93	0	93	0	93
3	DO(%)	0.17	62	60	55	51	67	70	92	97	98	99	56	52
4	BOD	0.11	6.2	50	6	51	5.4	54	3.0	67	2.2	76	7.0	46
5	Nitrates	0.10	1.4	96	1.4	96	1.1	96	1.3	96	1.2	96	1.3	96
6	FC	0.16	1200	21	805	24	790	24	720	25	625	26	845	24
		NSFWQI		48		47		50		56		58		46

Table 5.12 :Calculation of NSFWQI for Year, 2007

Sl. No.	Parameters	Weights	S1		S2		S3		S4		S5		S6	
	(Q_0)	(w)	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0
1	pH	0.11	8.1	80	8.2	77	8.0	84	7.4	93	8.0	84	8.1	80
2	Temp.	0.10	0	93	0	93	0	93	0	93	0	93	0	93
3	DO(%)	0.17	50	44	49	42	55	51	85	91	91	96	50	44
4	BOD	0.11	7.4	44	7.5	44	7.0	46	4.0	61	3.4	65	8.5	40
5	Nitrates	0.10	1.4	96	1.4	96	1.2	96	1.4	96	1.0	96	1.2	96
6	FC	0.16	1450	20	850	24	822	24	755	25	650	26	974	22
		NSFWQI		43		43		46		55		56		43

Table 5.13 :Calculation of NSFWQI for Year, 2008

Sl. No.	Paramete	Weights	S1		S2		S3		S4		S5		S6	
	(Q_0)	(w)	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0
1	pH	0.11	7.9	87	8	84	7.8	93	7.2	92	8.2	77	8.3	73
2	Temp.	0.10	0	93	0	93	0	93	0	93	0	93	0	93
3	DO(%)	0.17	50	44	54	49	51	45	92	97	91	96	55	51
4	BOD	0.11	7.6	44	8.0	42	7.5	44	4.8	57	4.2	60	9.0	38
5	Nitrates	0.10	1.6	95	1.5	96	1.4	96	1.7	95	1.6	95	1.7	95
6	FC	0.16	1500	20	1000	22	912	25	900	23	600	27	1110	22
		NSFWQI		44		44		45		60		54		43

Table 5.14 :Calculation of NSFWQI for Year, 2009

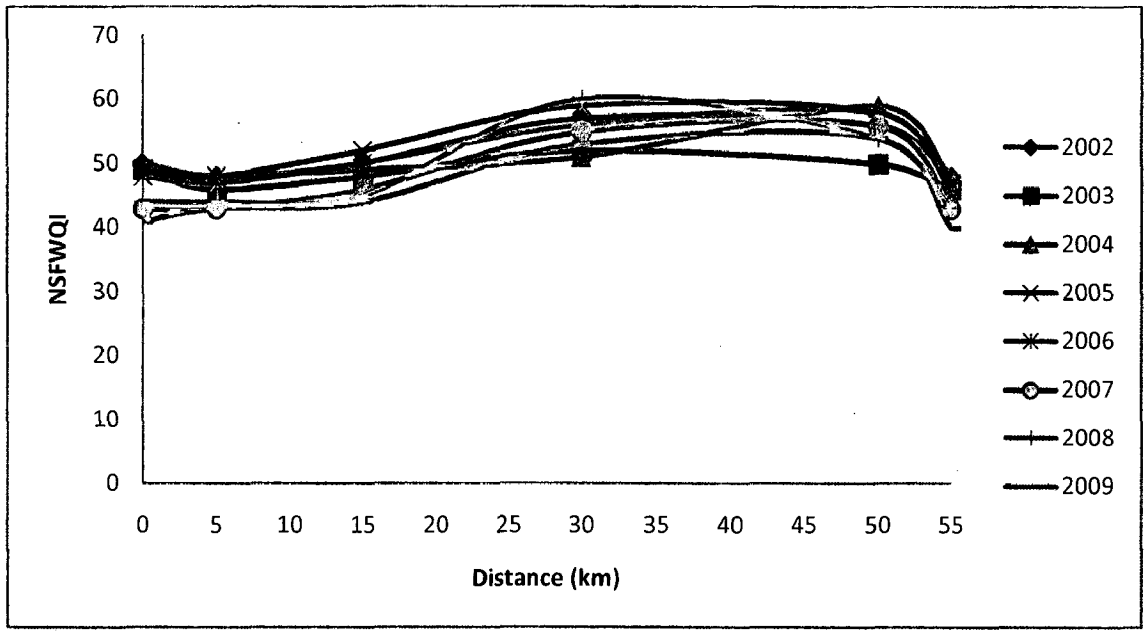
Sl. No.	Paramete	Weights	S1		S2		S3		S4		S5		S6	
	(Q_0)	(w)	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0	Q_0	I_0
1	pH	0.11	8.12	80	8.22	76	8.1	80	7.95	86	8.0	84	8.1	80
2	Temp.	0.10	0	93	0	93	0	93	0	93	0	93	0	93
3	DO(%)	0.17	45	37	40	30	52	46	80	89	83	89	41	32
4	BOD	0.11	8.5	40	8.3	41	8.0	42	5.0	56	4.5	58	11	30
5	Nitrates	0.10	2.0	95	2.1	95	1.6	96	1.8	95	1.7	95	1.7	95
6	FC	0.16	1690	19	1015	22	1089	22	955	22	722	25	1231	21
		NSFWQI		41		43		43		53		54		40

Table 5.15: Water Quality Index of Hasdeo River in Year 2002-2009

Sl. No.	Sampling Location	2002			2003			2004			2005			2006			2007			2008			2009		
		DW	IV	C	DW	IV	C	DW	IV	C	DW	IV	C	DW	IV	C	DW	IV	C	DW	IV	C	DW	IV	C
1	S1	M	50	Y	B	49	Y	M	50	O	B	49	Y	B	49	Y	B	43	Y	B	44	Y	B	41	Y
2	S2	B	48	O	B	46	Y	B	48	Y	B	48	Y	B	48	Y	B	43	Y	B	44	Y	B	43	Y
3	S3	M	50	Y	B	48	Y	M	49	O	M	52	O	M	50	O	B	46	Y	M	45	O	B	44	Y
4	S4	M	57	Y	M	52	O	M	51	O	M	59	O	M	56	O	M	55	O	M	60	O	M	55	O
5	S5	M	56	Y	M	50	O	M	59	O	M	58	O	M	58	O	M	56	O	M	54	O	M	54	O
6	S6	B	48	O	B	46	Y	B	48	Y	B	47	Y	B	46	Y	B	43	Y	B	43	Y	B	40	Y

5.2.2 Comparison of Water Quality Index

The water quality index of the Hasdeo river for 4 seasons such as monsoon, postmonsoon, winter, premonsoon and for year 2002 - 2009 at the various sampling stations are tabulated in the following **Table 5.3 and 5.16**.The temporal and spatial variation of water quality index shown in **Figure 5.1 and 5.13**. Ascertain the water quality at the respective stations.



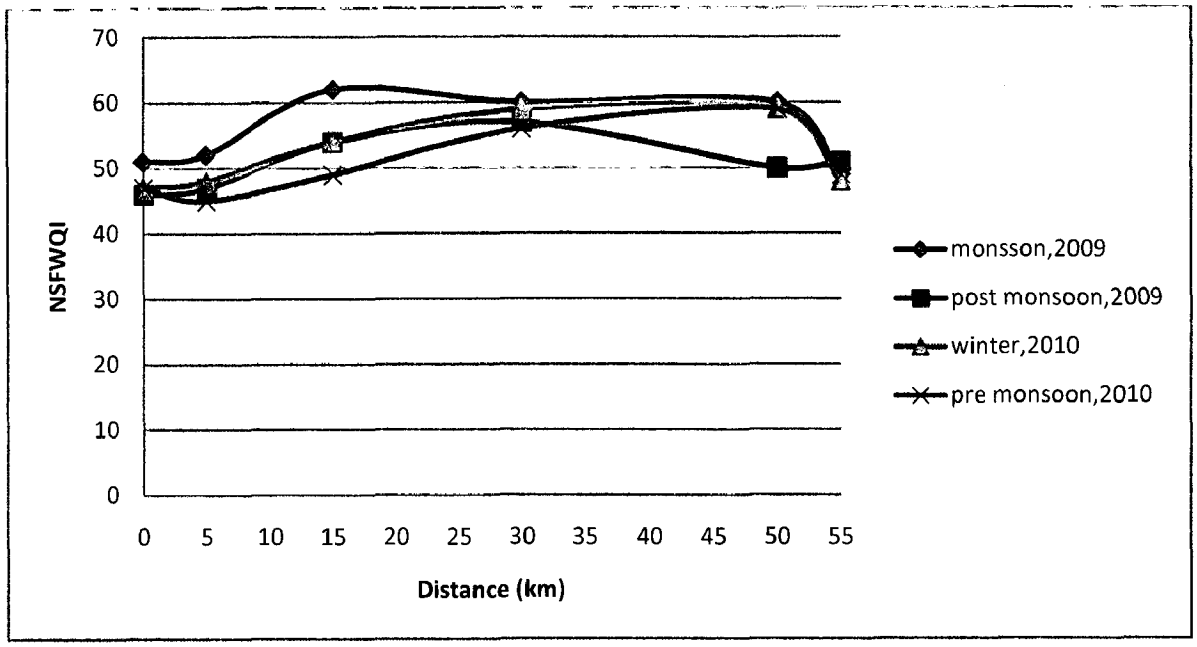
S1- 0 km.	S2- 5 km.	S3- 15 km.	S4-30 km.	S5- 50 km.	S6-55km.

Fig 5.1: Temporal and spatial variation of WQI from 2002 to 2009

Table 5.16: Water Quality Index of Hasdeo River during July 2009 – April 2010

Sl. No.	Sampling Location	Monsoon 2009			Post monsoon 2009			Winter 2010			Pre monsoon 2010		
		DW	IV	C	DW	IV	C	DW	IV	C	DW	IV	C
1	S1	M	51	O	B	46	Y	B	47	Y	B	47	Y
2	S2	M	52	O	B	47	Y	B	48	Y	B	45	Y
3	S3	M	62	O	M	54	O	M	54	O	B	49	Y
4	S4	M	60	O	M	57	O	M	59	O	M	56	O
5	S5	M	60	O	M	50	O	M	59	O	M	59	O
6	S6	B.	49	Y	M	51	O	B	48	Y	B	49	Y

DW= Discriptor words, IV = Index Value , C= Colour, VB= Very Bad, B= Bad
M= Medium, G= Good, E = Excellent, R = Red, O= Orange, Y= Yellow
G= Green, B= Blue.



S1- 0 km.	S2- 5 km.	S3- 15 km.	S4-30 km.	S5- 50 km.	S6-55km.

Fig. 5.2: Seasonal Temporal and spatial variation of WQI during monsoon 2009 – pre monsoon 2010

5.2.2.1 Good Quality of Water

The good quality of water has not been found at any sampling location in my whole study stretch in all season and whole year. Due to the regular impact of effluent and domestic waste coming into the Hasdeo River.

5.2.2.2 Medium Quality of Water

The medium quality of water has been observed at the all sampling location left S6 in monsoon season due to the high flow of water. At post monsoon and winter sampling location S3, S4, S5 and S6 is in medium quality left S5 in winter Season. Sampling location S4, S5 is in medium quality in pre monsoon season. In year wise sampling location S3, S4 and S5 are in medium quality but index value is gradually decreasing.

5.2.2.3 Bad Quality of Water

The bad quality of water is found at S1, S2 at post monsoon, winter and pre monsoon season. Sampling location S6 at winter and pre monsoon season and S3 at pre monsoon season. Sampling location S1, S2 and S6 index value shows the water quality is bad from 2002 but year

wise index value is going on decreasing. The excellent, very good and good qualities are not found in along all sampling location of Hasdeo River. The stretch which is under bad quality shown in **Fig 5.3**

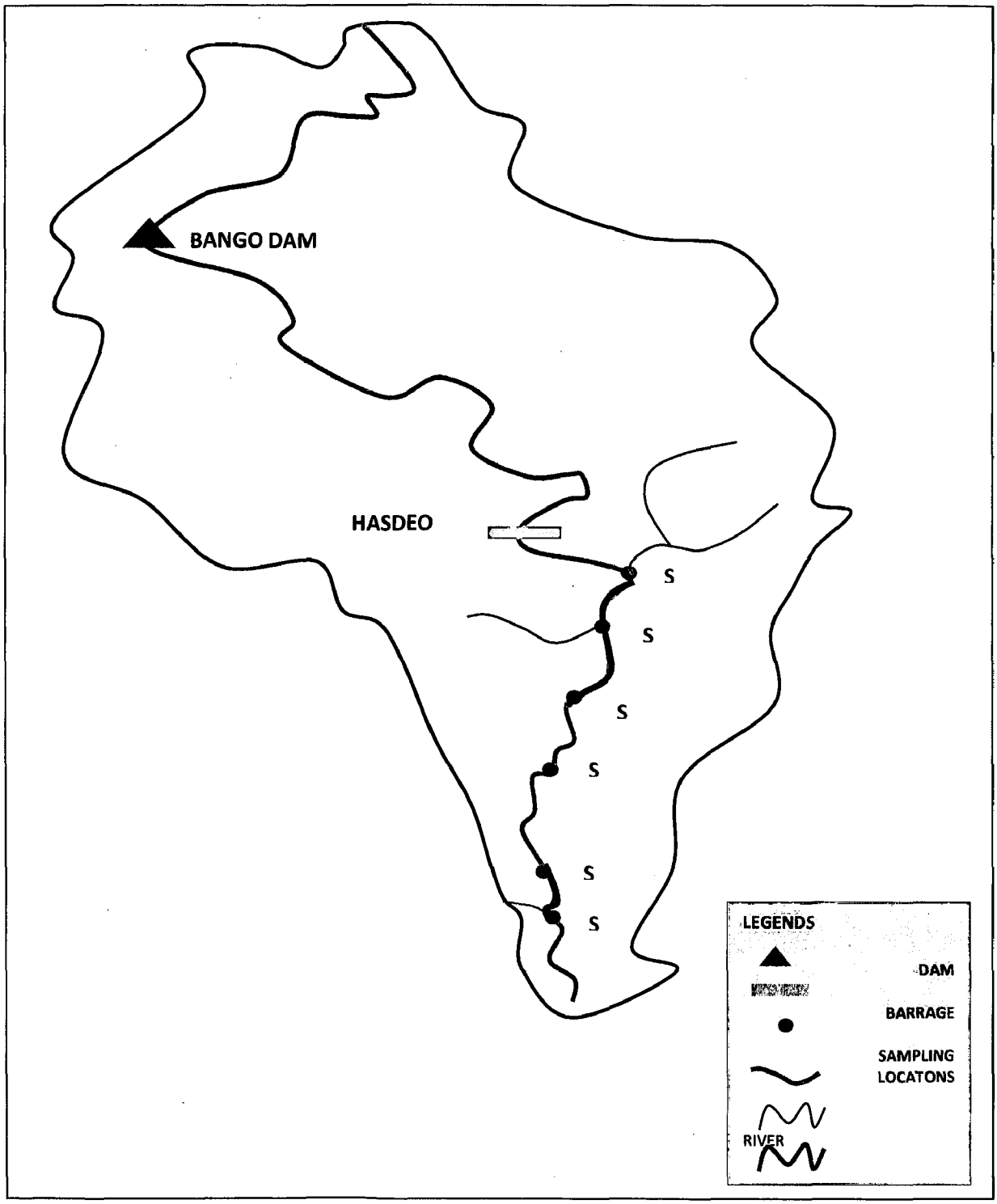


Fig. 5.3: Bad quality Stretch

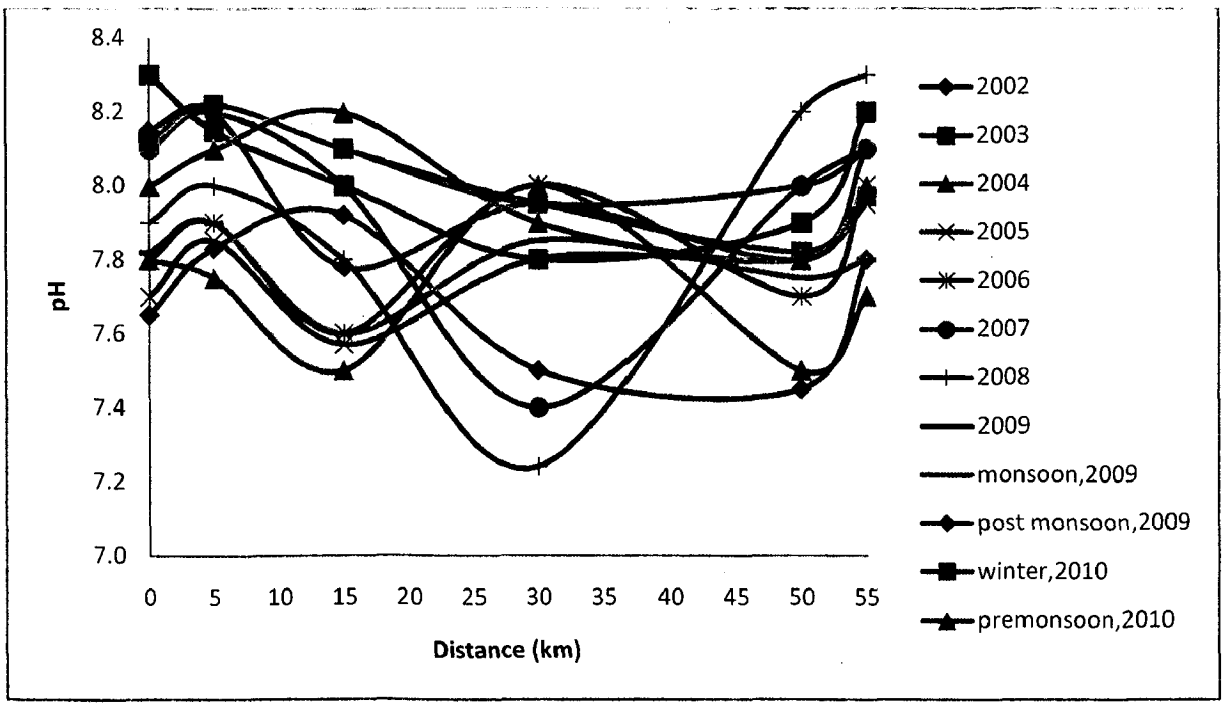
5.3 ANALYSIS OF WATER QUALITY PARAMETER

The variations in physicochemical parameters are most important for ascertaining the water quality of a river system. The parameters such as physical, organic and inorganic parameters are analyzed regarding to the study of Hasdeo river. The physico chemical parameters are analyzed through spatial and temporal variation of these parameters and compaired with the water quality criteria given by CPCB. This gives the exact idea about water quality status of Hasdeo river in present and previous years.

5.3.1 Hydrogen ion concentration (pH)

Since most of the human body consists of (50–60%) water, the pH level has profound effect on all body chemistry, health and disease. All regulatory mechanism (including breathing, circulation, digestion, hormonal production) serves the purpose of balancing pH.

The pH is an important parameter in the Hasdeo river. It is fluctuated by receiving of effluents from the various industrial units such as NTPC, CSEB, BALCO, SECL and MBPL etc.



S1- 0 km.	S2- 5 km.	S3- 15 km.	S4-30 km.	S5- 50 km.	S6-55km.

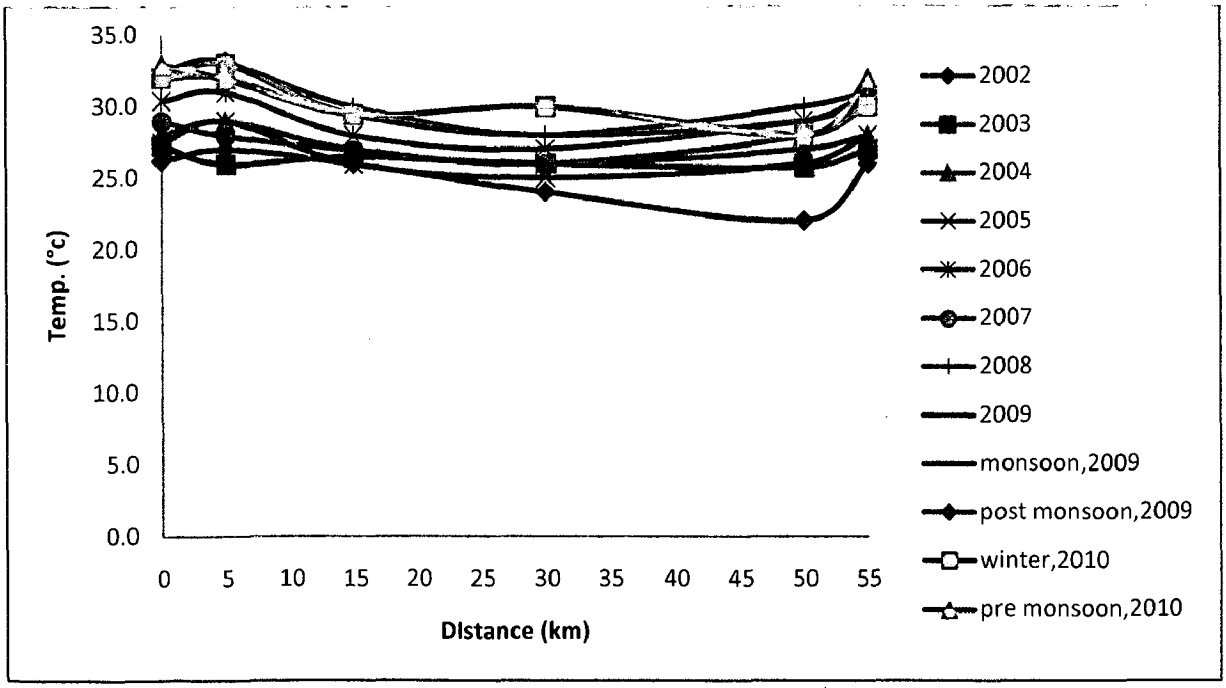
Fig. 5.4: Temporal and spatial variation of pH

and domestic waste water from colony of Dengur, Ahiran, Korba, Urga, and Champa City area. The temporal and spatial variation of the pH is given in the **Figure 5.4**:

The pH is gradually fluctuating from sampling location S1 to S6. The fluctuation of pH ranges from 7.32 to 8.3 in the whole stretch of the river from year 2002 to 2009. The variation is under tolerable for swimming, outdoor, bathing and other aesthetics purpose. The CPCB has also specified the pH value is less than 4.5 and more than 9 is hazardous to fish and other aquatic lifes. Therefore the pH is normal for use of river water for any purposes. The value of pH is large at location S1, S2, S3 and S6.Which is affected by industries and domestic waste water coming from korba city. Value of pH variation is increasing year by year so there is a need to control the rapidly increasing the value of pH.

5.3.2 Temperature

The Temperature is gradually fluctuated from sampling location S1 to S6 due to receiving of effluents and domestic sewage water from the various sources. The temporal and spatial variation of temperature is given in the following **Figure 5.5**:



S1- 0 km.	S2- 5 km.	S3- 15 km.	S4-30 km.	S5- 50 km.	S6-55km.

Fig. 5.5: Temporal and spatial variation of Temperature

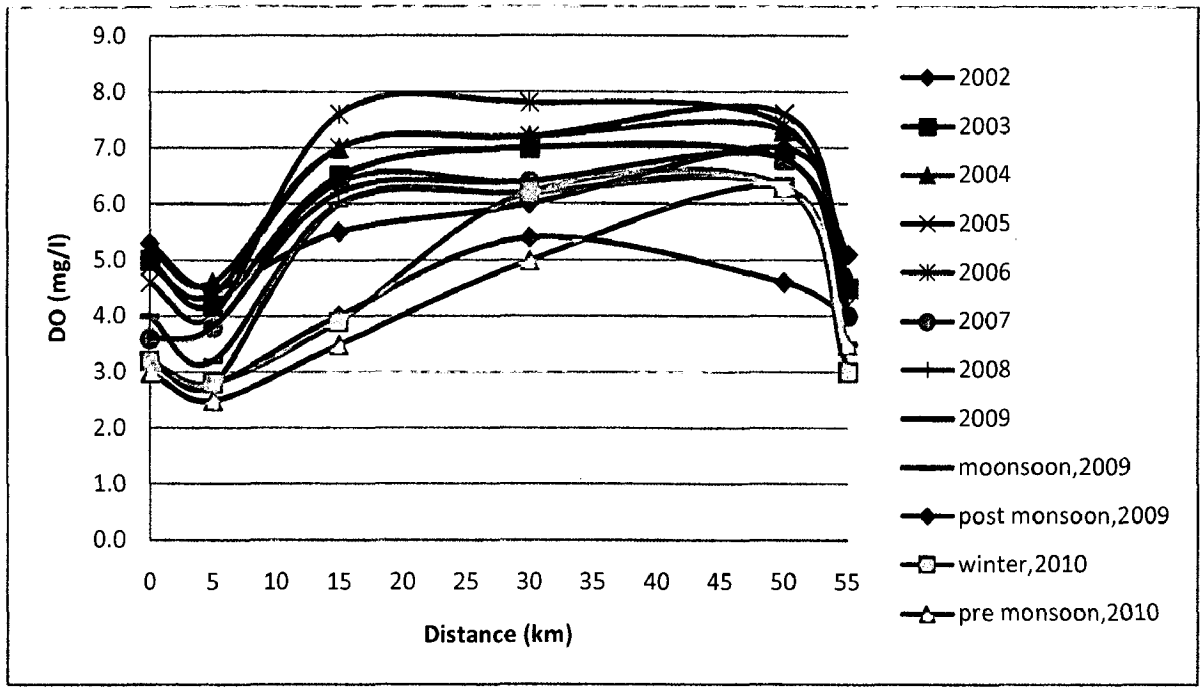
The temperature fluctuation in the Hasdeo river ranges from 22°C to 33°C in the study stretch from seasonal and yearly 2002 to 2009.fluctuation of upward trend has been occurred due to receiving of hot water and effluent water and sewage from various sources. The trend of temperature gradually decreasing from the sampling location S3 to S6 in order to self purification and natural process of Hasdeo river environment and increase in the value of temperature seen at sampling location S6 due to waste water coming from MBPL and Champa city sewage.

Temperature is one of the most important parameter for the aquatic environment because almost all the physical, chemical and biological properties are governed by it. The temperature range is increasing year by year so there is a need of control measure for temperature so the water quality of Hasdeo river will be maintained for future use.

5.3.3 Dissolved Oxygen

Natural waters in equilibrium with the atmosphere will contain dissolved oxygen concentrations ranging from about 5 to 14.5 mg O2 per liter depending on the water temperature, salinity, and altitude. The dissolved oxygen (DO) concentration present in water reflects atmospheric dissolution, as well as autotrophic and heterotrophic processes that respectively, produce and consume oxygen. DO is the factor that determines whether biological changes are brought by aerobic or anaerobic organisms. Thus, dissolved–oxygen measurement is vital for maintaining aerobic treatment processes intended to purify domestic and industrial wastewaters. The optimum value for good water quality is 4 to 6 mg/l of DO, which ensures healthy aquatic life in a water body.

The dissolved oxygen (DO) content show the health and ability of the stream to purify itself through the bio chemical process. The variation of DO has been occurred gradually due to receiving of effluents and sewage water from the sources. The temporal and spatial variation given in the **Figure 5.6**:



S1- 0 km.	S2- 5 km.	S3- 15 km.	S4-30 km.	S5- 50 km.	S6-55km.

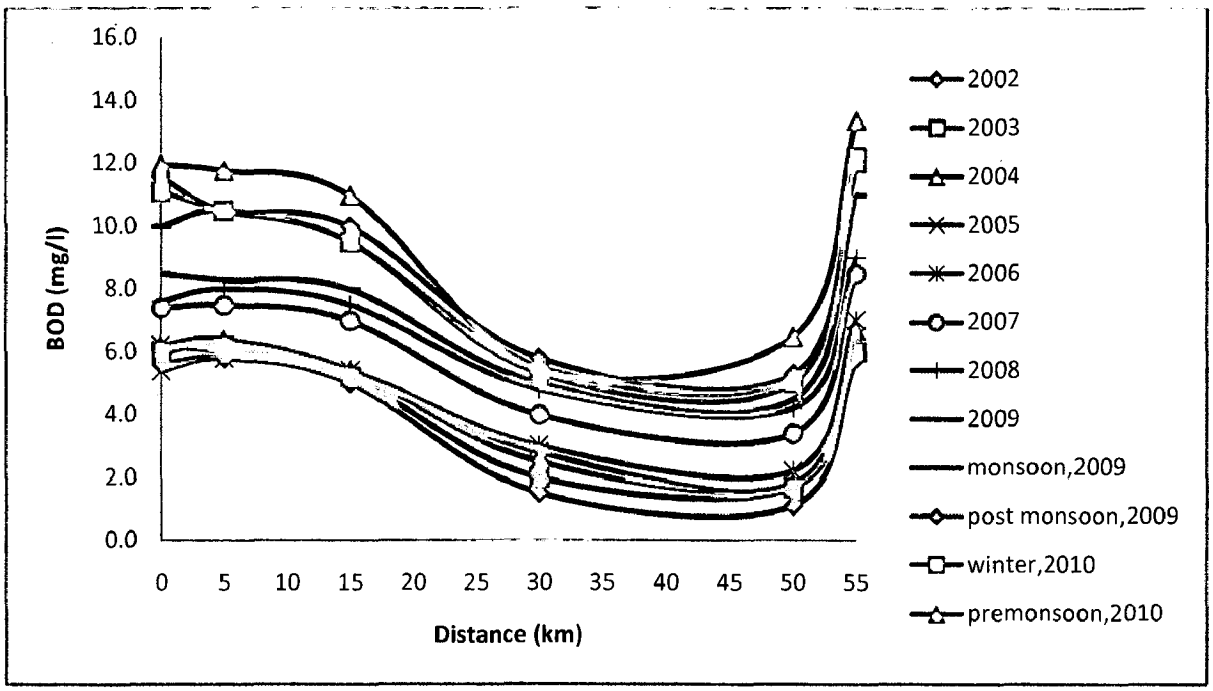
Fig. 5.6: Temporal and spatial variation of DO

The dissolved oxygen is fluctuated from sampling location S1 to S6. Value of DO at starting sampling location S1 to S3 is less than required 6 mg/l as prescribed by the CPCB. Due to the impact of discharge of effluent water from various industries and sewage.

The fluctuation range from 2.5 to 7.8 mg/l which is serious cause of depleting fish and other aquatic fauna in the water system of Hasdeo river. The DO value at the sampling location S1, S2 and S6 is a critical limit for sustaining the river ecosystem. Dissolved oxygen content is to be further depleted from the critical limit, fish and other high aquatic fauna are totally disappeared and river shift towards anaerobic environment. High depletion of oxygen content produce odour due to anaerobic decomposition of organic wastes leading to the formation of hydrogen sulphide. The dissolved oxygen gradually increased from the sampling location S3 to S4 due to self purification process of the river and consequently reappear the fish and other high aquatic fauna at downstream of the river.

5.3.4 Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD) determines the strength in terms of oxygen required to stabilize domestic and industrial wastes. BOD represents the intensity of biodegradable organic matter remaining in the stream at any time and BOD test show the amount of molecular oxygen required by bacteria to reduce the carbonaceous materials. The temporal and spatial variation of BOD is shown in the **Figure 5.7**:



S1- 0 km.	S2- 5 km.	S3- 15 km.	S4-30 km.	S5- 50 km.	S6-55km.

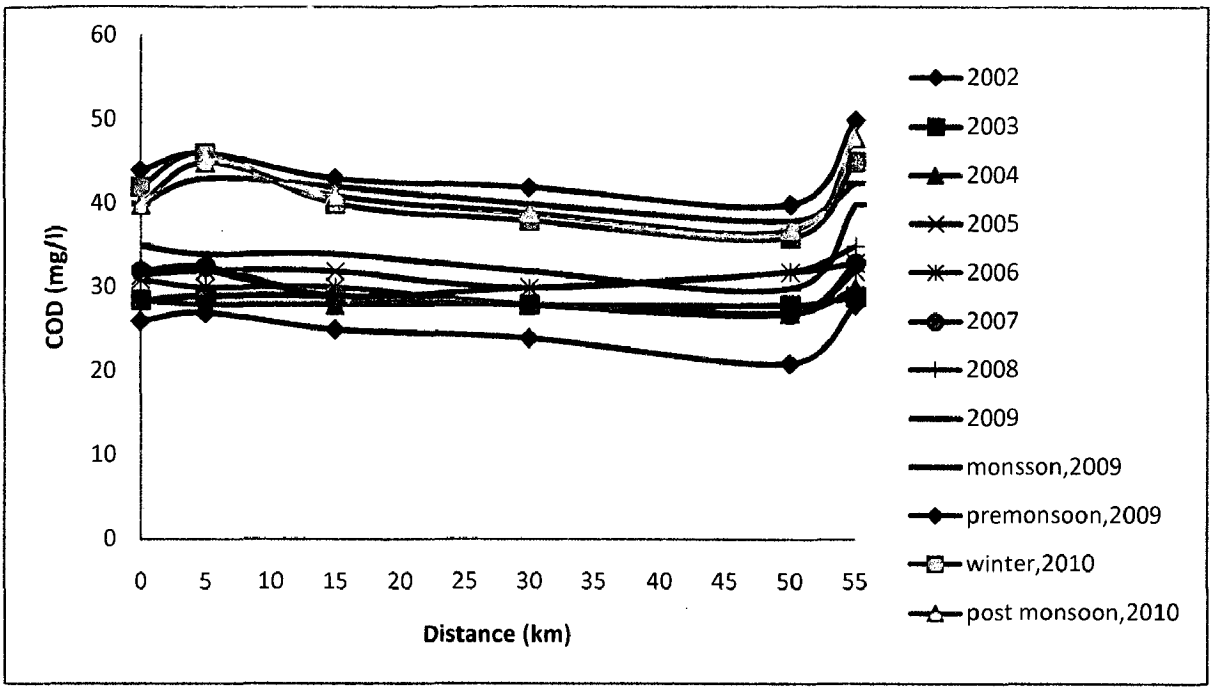
Fig. 5.7: Temporal and spatial variation of BOD

The BOD value is more at source of Hasdeo river in order to receiving of effluents and domestic waste water from various sources. BOD is also further increased by direct discharging of domestic waste into the river water through the open defecation. But gradually decreasing from the sampling location S4 to S5 in order to self purification capacity of Hasdeo river.

The high fluctuation range from 1.1 to 13.4 mg/l is shows presently the BOD fulfill the criteria of BOD range but year by year values are increasing so there is need to control of further increase in the value of BOD. Otherwise in future the river water quality will be in worst condition and uncontrollable. It influences eutrophication in the river system and depleting the dissolved oxygen ultimately which aquatic fauna are unable to sustain in the river environment.

5.3.5 Chemical Oxygen Demand (COD)

The COD test shows the oxygen equivalent of the organic matter that can be oxidized by using strong oxidizing agent. The temporal and spatial variation of COD is shown in the following **Fig. 5.8**:



S1- 0 km.	S2- 5 km.	S3- 15 km.	S4-30 km.	S5- 50 km.	S6-55km.

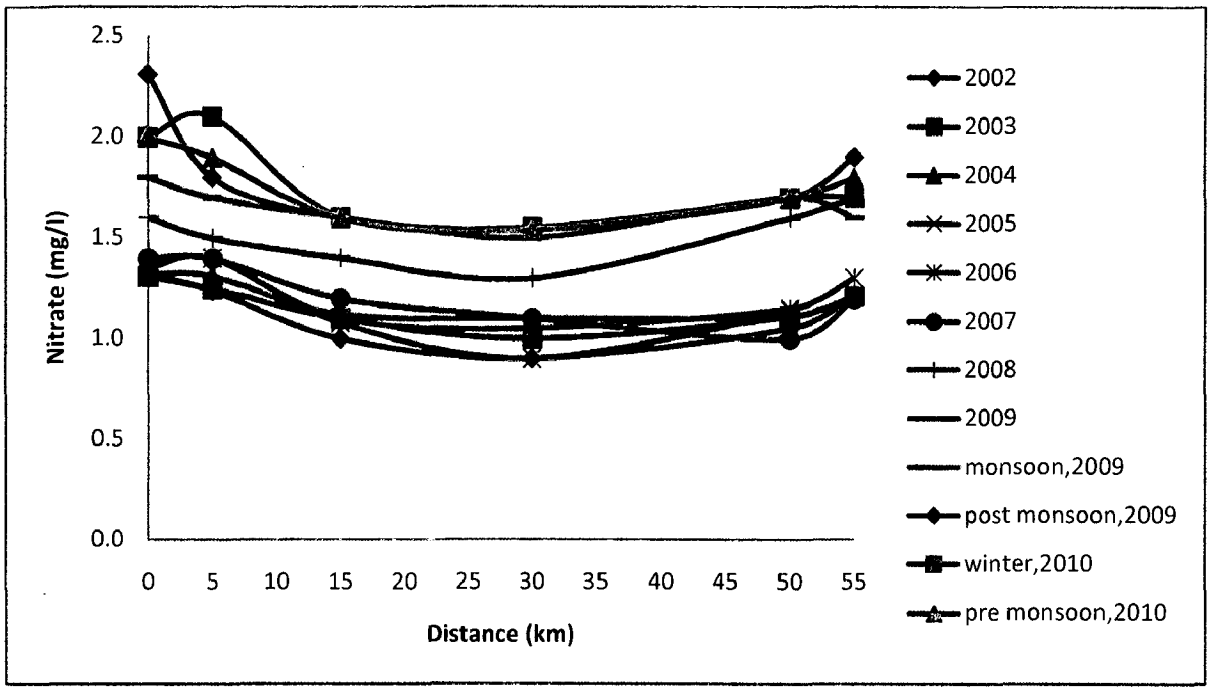
Fig. 5.8: Temporal and spatial variation of COD

The COD value is large at location S1, S2, S3 and S6 in order to receiving of industrial effluents and domestic sewage water. At location S5 value of COD large as compaired to other location because MBPL discharge effluent at this point. This contains non-biodegradable organic matter into the river water.

There is decreasing trend of COD variation from the sampling location S3 to S4 due to natural purifying system of the river.

5.3.6 Nitrate

Nitrate is another pollutant in the Hasdeo river water. It has been observed that nitrate nitrogen content varies from 0.04 to 5.0 mg/l in the river of the world. The temporal and spatial variation of nitrate shown in **Figure 5.9**:



S1- 0 km.	S2- 5 km.	S3- 15 km.	S4-30 km.	S5- 50 km.	S6-55km.

Fig. 5.9: Temporal and spatial variation of Nitrates

The fluctuation range is 0.03 to 2.30 mg/l in the Hasdeo river water.The upward trend from the sampling location S1 to S3 due to receiving of effluent and sewage from the various sources and downward from sampling location S4 and S5 in order to bacterial activity along with self purification.

At S6 location increase in value of nitrate due to MBPL effluent which contain chemical. The presence of about 0.30 mg/l of nitrate nitrogen initiate to excessive growth of algae blooms and aquatic weeds causing undesirable colour, test and odour, thereby degrading the aesthetic quality of surface water bodies. Basically, the river is facing the eutrophication hazards. Nitrates accelerates more growth of algae along with higher aquatic plants in the Hasdeo river water system.

5.3.7 Ammonical Nitrogen

High concentration of ammonical nitrogen indicates that the pollution is fresh water. Most sensitive indicator of sewage pollution in a river water is sudden increase in its ammonia content and it gradually decreases by aerobic oxidation into nitrites and then into nitrates. The temporal and spatial variation of ammonical nitrogen is shown in the following **Figure 5.10**:

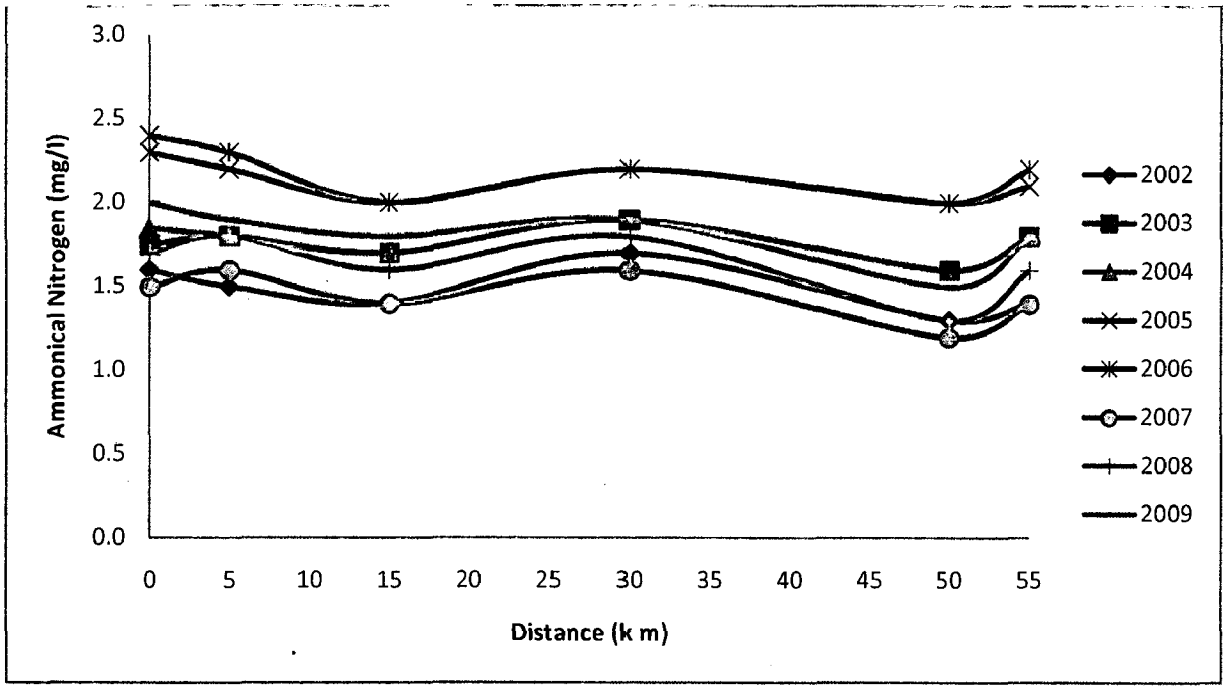


Fig. 5.10: Temporal and spatial variation of Ammonical Nitrogen

The fluctuation range is 1.2 to 2.4 mg/l in the Hasdeo river water indicate that the organic nitrogen is gradually converted to ammonia nitrogen and consequently, the river water is to be polluted. There is a downward fluctuation trend from the sampling station S5 to S6 due to natural activity and self-purification process of the river. large value of ammonical nitrogen seen at sampling location S1, S2 and S6 due to effluent and domestic waste discharge into river water.

5.3.8 Faecal Coliform

Faecal Coliform is most important bacteriological parameter in Hasdeo river. This colifrom group has limitation that has been know to multiply in water with the environmental factors tend to promote and may give an exaggerated index of pollution. The Temporal and spatial variation of faecal coliform is shown in **Figure 5.11**.

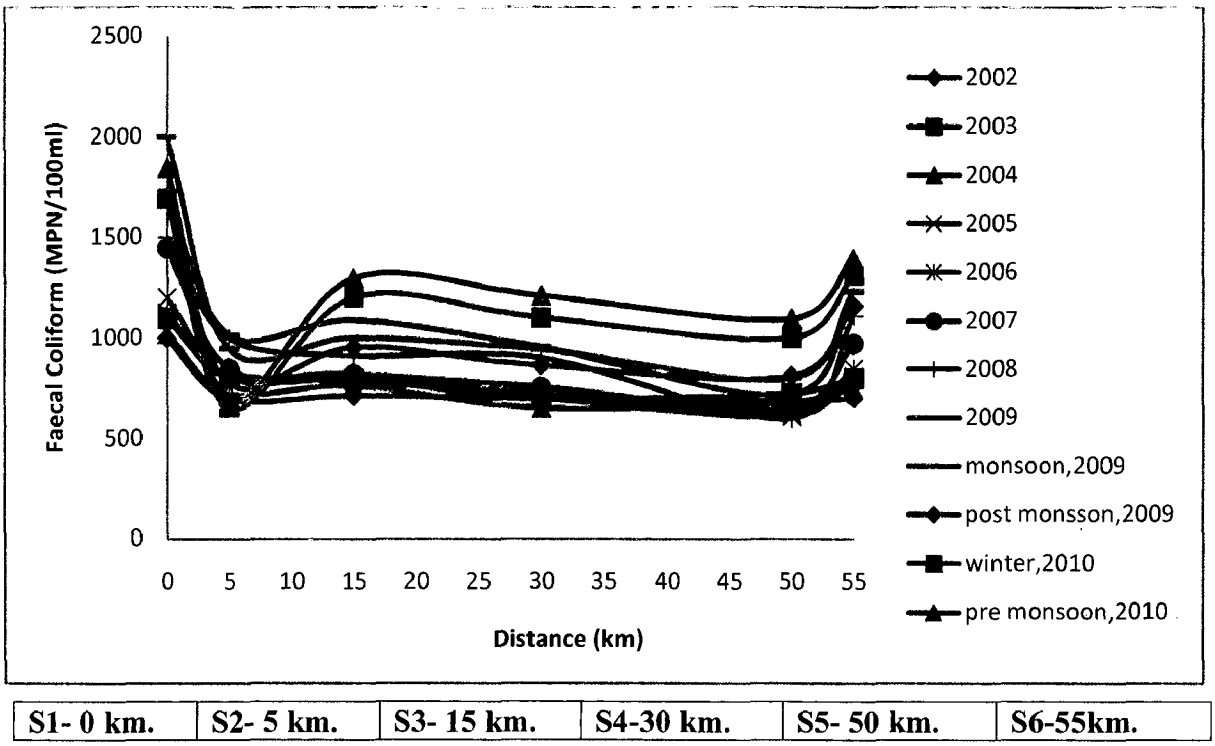


Fig. 5.11: Temporal and spatial variation of Faecal Coliform

The fluctuation range of the faecal coliform is 600 -2000 MPN/100ml in Hasdeo river. There is higher value of faecal coliform at locations S1, S3, S5 and S6 in order to receiving of sewage from Industrial colonies, city street runoff, domestic sewage from cities. Lower value at S2 and S4 due to less amount of sewage discharge and self purification natural activity of the river. In monsoon season value of faecal coliform increases due to agricultural, urban runoff and industries discharges in huge amount. Regarding to above the river is grossly polluted and therefore, it is unsafe and unfit for drinking purpose and outdoor bathing.

5.4 RESULT AND DISCUSSION

The water quality assessment is most important part for ascertaining the pollution level of the river. Only one type water quality assessment is not enough for ascertaining the exact pollution level of a river. The detail assessment of water quality of Hasdeo river has been done through water quality indexing and spatial and temporal variation of physico-chemical parameter. This both assessment is giving the exact idea about the water quality of Hasdeo river.

The result come out with comparison of both assessments is given in **Table 5.17** at each sampling location.

Table 5.17: Comparison of water quality parameter, class and NSFWQI

Location	pH	DO (mg/l)	BOD(mg/l)	FC(MPN/100ml)	Class	NSFWQI
S1	7.7-8.2	3-5.3	5.4-12	1000-2000	D	BAD
S2	7.8-8.22	2.5-4.6	5.8-11.8	700-1015	D	BAD
S3	7.5-8.2	3.5-7.8	5-11	712-1300	D	BAD
S4	7.24-8	5-7.2	1.5-5.8	650-1212	B	MEDIUM
S5	7.5-8.1	4.6-7.6	1.1-6.5	600-1100	B	MEDIUM
S6	7.7-8.3	3-5.1	5.8-13.4	700-1100	D	BAD

In above table the class decided at each location by comparing the pH, DO, BOD and FC with water quality criteria given in **Table 1.2.** , NSFWQI value is referenced from **Table 5.15** and **Table 5.16.** The above table shows following results about the water quality of Hasdeo river.

1. The water quality of Hasdeo river is class D at location S1, S2, S3 and S6. It means water cannot use for drinking without conventional treatment, disinfection, outdoor bathing and propagation of wildlife and fishers.
2. Water quality index value at location S1, S2, S3 and S6 is Bad. Due the industrial effluent and sewage along flow path join Hasdeo river.
3. Water of Hasdeo river at location S4, S5 is class B. It means water cannot use for drinking without conventional treatment and outdoor bathing.

4. Water quality index value at location S4 and S5 is medium. Due to flow path along this region is not densely populated and flow path is long from location S1, S2 and S3 so self purification and natural activity take place at this location.

So the water quality of Hasdeo river is Bad and under class D at location S1, S2, S3 and S4. There is a need of conservation measure at this location so that the quality of water will improved at this location if we apply conservation measures steps at this point so the river quality will improve at study stretch.

5.4 SUMMARY

The water quality index of the Hasdeo River has been calculated under the NSFWQI. The calculation of NSFWQI is performed for the period such as monsoon, post monsoon, winter pre monsoon, and for year 2002 to 2009.

The status of water quality of Hasdeo river is analyzed by the selected parameter. Which show the variation of water quality of Hasdeo river and present status of Hasdeo river and trend of pollution.

CHAPTER -6

CONSERVATION MEASURES

6.1 GENERAL

Aim of this study has been to arrive at a comprehensive conservation plan for Hasdeo river for the sustainable and beneficial development of the river environment. In the following section of this chapter, it has been attempted to suggest the aimed "Conservation Plan for Hasdeo River" on the basis of the findings of the previous chapters. Measures require in the river catchment have been dealt separately. These are following below.

6.2 SEWAGE TREATMENT

The water scarcity is fast becoming a predominant phenomenon around the world. The answer obviously lies in multi prolonged approach whereby available water resource need to utilized judiciously at the same time resorting to recycling, waste water treatment, etc. One of the unavoidable causes is sewage in water. Sewage is the waste water released by residences, business houses, offices and industries in a community. The colour of sewage is caused by solids which is untreated sewage range from 100-350 mg/l. A measure of the strength of the waste water is biochemical oxygen demand or BOD_5.

Present study area across Hasdeo river is from Dengur to Champa. Hasdeo river water is mostly affected at upward location due to effluent coming from industries and Dengur, Ahiran korba municipal area sewage and at downward due to Champa town sewage explained in previous chapters. So that conservation measures has been taken at this locations. Location Bhundi (S6) water quality is bad and class D type but it is not include in conservation measures area due the MBPL effluent discharge which is under permissible limit given in CPCB standards shown in **Table 1.4**. The population under Dengur, Ahiran, Korba and Champa area is 18,534, 15000, 3,67,006 and 37,949 (2001 census).

These area do not have adequate and well designed sewerage and sewage treatment system. There is a wide gap between existing facilities and present demand not to say about future loads. Whole of the sewage generated in the portion of this area which falls in the catchment had been discharged into the river from the time immemorial.

6.2.1 Source and Quantity of Sewage

Source of sewage in all case shall be generated from all houses constructed, from the commercial/market complex, guest houses, canteen, office complex, schools, etc. Total sewage generated from the catchment has been being discharged without any treatment which used to end up into the river. Sewage generated in the urban portion was used to be discharged into the river through big nullahs and numerous drains unabated. Sewage generated from the rural area of the catchment has been mixes with river through drains.

Assuming a standard rate of water usage of 135 lpcd and waste generation rate as 80 percent of the water used as per given criteria by CPCB given in **Table 1.5.** Present total sewage generation of Dengur, Ahiran, Korba and Champa area estimated according to the population. Growth rate of area Dengur, Ahiran and korba for 1991 and 2001 census is 22.75 and 25.50 percent per 10 year bacause these three area come under same district(Source: http://censusindia.gov.in). Percentage increase in growth rate is 10% used for calculation of population in year 2010 and 2020.

Champa growth rate in census 1991 and 2001 is 14.67 and 18.55 percent per 10 year. Percentage increase in growth rate is 20% used for calculation of population in year 2010 and 2020 (Source: http://censusindia.gov.in). Formula used for calculation of population and sewage generation is given below [7]. For estimation of sewage generation of Dengur, Ahiran, korba and champa area shown in **Table 6.1- 6.4**

a) Population after n year = before n year population (1+Percentage growth rate per year/100)^{n}

   n = Number of year

b) Sewage generation = (Population x 135 lpcd x 0.80)/10^{6} MLD

Table 6.1: Estimated Sewage Generation of Dengur Area

S. No.	Year	Population	Sewage Generated
1.	1991	11661	1.3 MLD
2.	2001	15,000	1.6 MLD
3.	2010	19,790	2.14MLD
4.	2020	26,829	3 MLD
5.	2030	37,448	4 MLD

Table 6.2: Estimated Sewage Generation of Ahiran Area

S. No.	Year	Population	Sewage Generated
1.	1991	14,408	1.6 MLD
2.	2001	18,534	2 MLD
3.	2010	24,452	2.6 MLD
4.	2020	33,153	3.58 MLD
5.	2030	46,279	5 MLD

Table 6.3: Estimated Sewage Generation of Korba City

S. No.	Year	Population	Sewage Generated
1.	1991	2,85,310	30 MLD
2.	2001	3,67,006	40 MLD
3.	2010	4,84,202	52 MLD
4.	2020	6,56,435	72 MLD
5.	2030	9,16,349	100 MLD

Table 6.4 : Estimated Sewage Generation of Champa City

S. No.	Year	Population	Sewage Generated
1.	1991	32,053	3.5 MLD
2.	2001	37,949	4.0 MLD
3.	2010	47,294	5MLD
4.	2020	61,551	6.65 MLD
5	2030	84,380	9 MLD

6.2.2 Characteristics of Sewage

The characteristics of municipal waste water vary from place to place and depend on various condition like economic status and food habits of the community, water supply and weather condition of locality. Suspended solids and biological oxygen demand are the usual parameters in domestic waste water. In absence of actual information sewage characteristics, The following sewage characteristics may be assumed [8]:

pH	:	6-9.5
BOD	:	250 mg/l
COD	:	400 mg/l
TSS	:	250 mg/l
Oil & Grease	:	15 mg/l

6.2.3 Sewage Treatment Proposed before Final Disposal

Projected population of 2030 seems more realistic to develop sewage treatment facility for the population in the urban portion of the catchment. In 2030 at Dengur, Ahiran, Korba and Champa area sewage shall be required to be treated to check it from going to the river. Therefore, one 4 MLD, one 5 MLD two STP of 50 MLD each starting and one 9MLD STP for Dengur, Ahiran, Korba and champa area.

Taking into the consideration the assumed characteristics and the anticipated flow of sewage, typical low cost biological system shall be considered. The treatment system recommended include two alternatives which are shown in **Figure 6.1 and 6.2**:

Treatment Alternative I – Activated Sludge Process

The activated-sludge process is an aerobic, continuous-flow system containing a mass of activated micro-organisms that are capable of stabilizing organic matter. The process consists of delivering clarified waste-water, after primary settling, into an aeration basin where it is mixed with an active mass of microorganisms, mainly bacteria and protozoa, which aerobically degrade organic matter into carbon dioxide, water, new cells, and other end products. The bacteria involved in activated sludge systems are primarily Gram-negative species, including carbon

oxidizers, nitrogen oxidizers, floc formers and non-floc formers, and aerobes and facultative anaerobes. The protozoa, for their part, include flagellates, amoebas and ciliates. An aerobic environment is maintained in the basin by means of diffused or mechanical aeration, which also serves to keep the contents of the reactor (or mixed liquor) completely mixed. After a specific retention time, the mixed liquor passes into the secondary clarifier, where the sludge is allowed to settle and a clarified effluent is produced for discharge. The process recycles a portion of the settled sludge back to the aeration basin to maintain the required activated sludge concentration (see **Figure 6.1**). The process also intentionally wastes a portion of the settled sludge to maintain the required solids retention time (SRT) for effective organic removal.

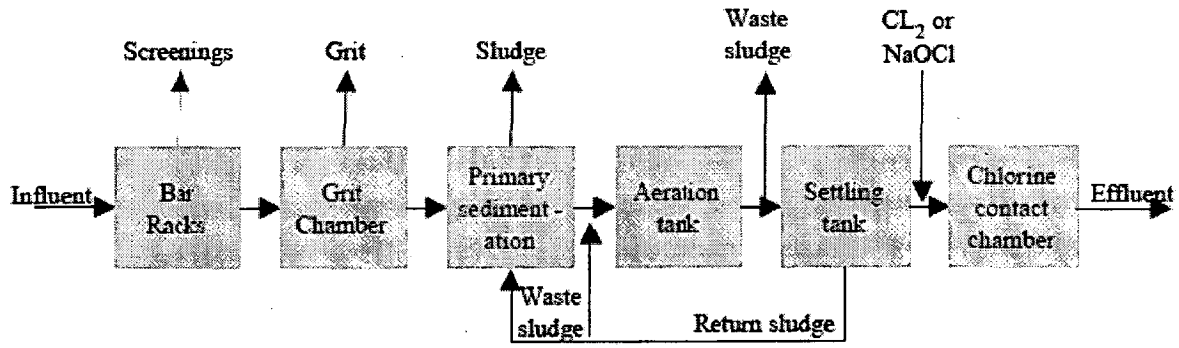


Fig 6.1: Activated Sludge Process

Advantage:-

1. The treated effluent quality is very good.
2. Methane gas be recovered having energy value can be utilized as fuel.
3. It is very flexible and can be adopted to almost any type of biological waste treatment problem.

Disadvantage:-

1. The major problems encountered in the operation of an ASP are sludge bulking rising sludge and Naeardia foam

Treatment Alternative II – Upward flow anaerobic sludge blanket (UASB) + Final Polishing Unit

UASB, Technology, normally referred to as UASB (see **Figure 6.2**) reactor is a form of anaerobic digester that is used in treatment of anaerobic digester that is used in treatment of waste water it is an anaerobic treatment system where in the organic matter digested, absorbed and metabolized into bacterial cell mass and biogas. Anaerobic digestion is the degradation of organic material without aid oxygen. The UASB process is a combination of physical and biological process. The main feature of physical process. The main feature of physical process is a separation of solids and gases form liquid and that biological process is degradation of decomposable organic material under anaerobic condition. The biogas produced is collected in a gas collector (gas holder) from where it is withdrawn, the remaining water sludge. Mixture enters a settling compartment where the sludge can settle and flow back into the digestion compartment, after settling, the water is collected in effluent gutters and discharged out of the reactor to the final polishing unit (FPU) to meet discharged standards.

The domestic waste water treated in UASB reactor is suitable for discharged in river water or for irrigation after polishing in a high rate pond. The biogas generated can be utilized for generating electricity. Sludge cakes after de-watering and drying on sludge dry bed is suitable for use ad manure.

Advantage:-

1. The cost UASB plant is significantly, lower than that of aerobic plant.
2. This has a negligible number of electrical and mechanical components, thus requiring low degree of maintenance and and saves operational and maintenance cost.
3. This also eliminates possibilities of problem that may arise in case of brake down of highly maintained intensive process.
4. The energy requirement in the YASB reactor is very low.
5. UASB system generates energy in the form of biogas which can be used for the production of electricity and which can make UASB plant self sustaining for requirements.
6. This system reduces the space requirement, which is big advantage for developing cities.

7. The production of excess sludge in a UASB reactor is very low. This reduces the load on sludge treatment system however the sludge from UASB plant is very stabilized and can be used as manure.
8. Final polishing pond can be used for culture, which can source of revenue.

Disadvantage:-

1. The capital cost of the UASB system will be higher if post- treatment is required for meeting discharged standards.
2. The corrosive of anaerobic system is a major negative point and makes it important to choose the right construction materials.
3. The SS concentration in the feed to the reactor should not exceed 500 mg/l.

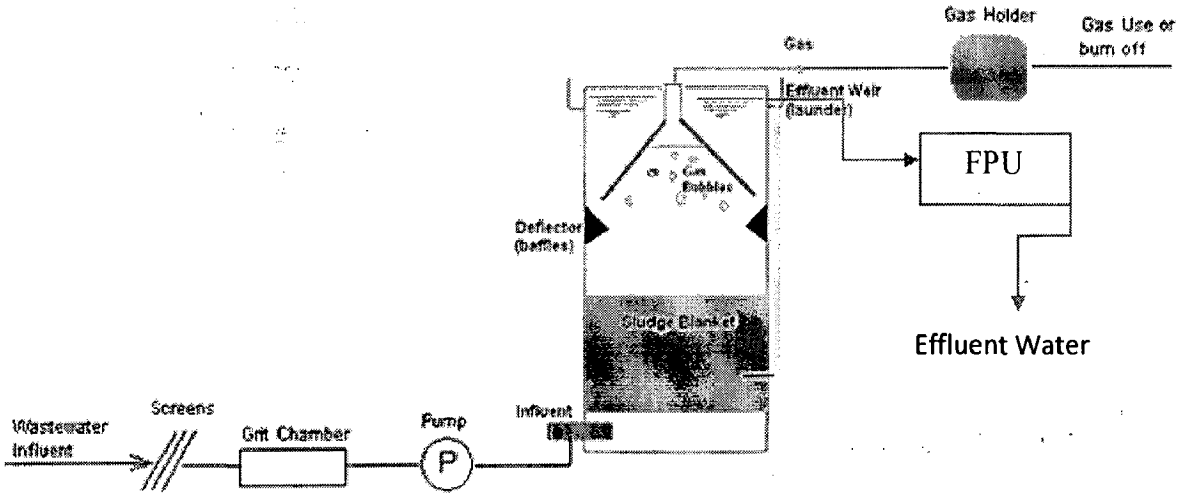


Fig. 6.2: Upward flow Anaerobic Sludge Blanket (UASB)

Presently, effluent is discharged into the river. This practice should be stopped with immediate effect. This must be ensured that treated effluent must comply the existing standards for the discharge into a stream or water body and must be discharged into the river. This will act as a replenishment of river with good water which will cause gradual dilution of pollution load inside the river.

6.2.4 Expected Sewage Quality after Treatment

The proposed alternative is based on already proven technologies and use in number of places. The plants as proposed and run according to design parameters shall conform to the pollution control board norms. The treated effluent characteristics shall be as follows [8]:

pH	:	6 - 7.5
BOD	:	30 mg/l
COD	:	250 mg/l
TSS	:	100 mg/l
Oil & Grease	:	5 mg/l

6.2.5 Cost of Treatment Alternatives

The approximate cost for each alternative proposed have been worked out and shown in **Table 6.5-6.6**. The cost figure and other details given will be useful to decide upon the treatment facility. The given cots figures has been referenced from dissertation of Sanjeev Kumar, 2008 [9]. The costs shown do not include either the initial or final pumping, if required due to difference in ground levels. The construction does not include the cost of land required for the plant. The cost figures and other detail given will be useful to decide upon the treatment system.

Table 6.5: Cost Estimation of Treatment Alternative I

S.No.	Description	Units	Activated Sludge Process			
			Dengur	Ahiran	Korba	Champa
1	Design Flow	MLD	4	5	2x50	9
2.	Unit Cost of Construction of STP	Rs. in lacs./MLD	48	48	48	48
3.	Unit Cost of Annual O & M of STP	Rs. in lacs./MLD	7.48	7.48	7.48	7.48
4.	Cost of Construction of STP	Rs. in lacs.	192	240	4800	432
5.	Total Cost of Annual O & M STP	Rs. in lacs.	29.92	37.4	748	67.32
6.	Unit Annual Revenue Generation of STP	Rs. in lacs./MLD	1.69	1.69	1.69	1.69
7.	Annual Revenue Generation of STP	Rs. in lacs./MLD	6.76	37.4	169	15.21
8.	Capitalized Cost of O & M For 20 year@ 10 % int.	Rs. in lacs.	254.73	318.42	6368.5	573.16
9.	LCC for 20 year	Rs. in lacs.	446.73	558.42	11168.5	1005.16

Table 6.6: Cost Estimation of Treatment Alternative II

S.No.	Description	Units	UASB			
			Dengur	Ahiran	Korba	Champa
1	Design Flow	MLD	4	5	2x50	9
2.	Unit Cost of Construction of STP	Rs. in Lakh/MLD	44	44	44	44
3.	Unit Cost of Annual O & M of STP	Rs. in Lakh/MLD	5.47	5.47	5.47	5.47
4.	Cost of Construction of STP	Rs. in Lakhs	176	220	4400	396
5.	Total Cost of Annual O & M STP	Rs. in Lakhs	21.88	27.35	547	49.23
6..	Unit Annual Revenue Generation of STP	Rs. in Lakhs/MLD	1.69	1.69	1.69	1.69
7.	Annual Revenue Generation of STP	Rs. in Lakhs/MLD	6.76	8.45	169	15.21
8.	Capitalized Cost of O & M For 20 year@ 10 % int	Rs. in lacs.	186.29	232.85	4657.16	419.14
9.	LCC for 20 year	Rs. in lacs.	362.28	452.85	9057.16	815.14

Total estimated annual cost of suggested to alternatives are 6546.64 lacs and 5837.46 lacs. Total revenue generation from both treatment alternatives is same 1.69 lakhs per MLD. Including revenue generate from following activity such as power generation from methane, digested sludge cakes and treated effluent [10]. Total cost of treatment alternative II is less as compaired to treatment alternative I so that UASB technology is proposed for present conservation plan of Hasdeo River.

6.3 MUNICIPAL SOLID WASTE MANAGEMENT

Municipal Solid wastes damage Hasdeo river in a number of ways hence it is necessary to ensure that solid waste is managed in a proper manner. If solid wastes are not managed properly it has a number of adverse consequences. First it pollutes the river. Secondly the sediments deposit on the bed in the river. Thirdly it makes the town ugly. Hence management of solid wastes becomes an essential component of the conservation and management plan of any river

Municipal Corporation is responsible for the solid waste management for korba and champa city. Municipal laws governing the urban local bodies do not have adequate provisions to deal effectively with the ever growing problem of solid waste management. With rapid urbanization, industrialization the situation is becoming critical. **Table 6.7** summarizes the existing scenario relating to solid waste management in the municipal corporations of korba and Champa. There is no waste segregation in any of the cities either by residents or by the municipal corporations.

Table 6.7: Summarized Existing Scenario of MSW

Solid Waste Management			
S. No.	**Important Parameter**	**Korba**	**Champa**
1	Garbage(MT/day)	60-70	8
2	Equipment	2 Trucks, 1 Excavator,2 Dumper & 9 Trolley	2 Tractor, 1 Excavator, 1 & 5 Trolly
3	Waste Segregation	NO	NO
4	Primary Collection	NO	NO
5	Composting	NO	NO
6	Landfill Site	Yes	Yes

Source : Chhattisgarh Urban Development Report

6.3.1 Source and Quantity of MSW

The terms MSW describes the stream of solid waste ('trash' or 'garbage') generated by households, commercial establishments, industries and institutions. MSW consists of everyday items such as product packaging, grass clipping, furniture, clothing, bottles, food, scrap, newspapers, appliances, paint and batteries. We all generate wastes on daily basis. Municipal waste

generated by the surrounding catchment area of Hasdeo river is affecting the water of Hasdeo river and towns look ugly.

Assuming a standard rate of municipal waste generation according to waste generation per capita in Indian cities given in **Table 6.8**. Presently total municipal waste generation of generation of Dengur, Ahiran, Korba and Champa area estimated according to the population. Growth rate of area Dengur, Ahiran and korba for 1991 and 2001 census is 22.75 and 25.50 percent per 10 year bacause these three area come under same district (Source: http://censusindia.gov.in). Percentage increase in growth rate is 10% used for calculation of population in year 2010 and 2020.

Champa growth rate in census 1991 and 2001 is 14.67 and 18.55 percent per 10 year. Percentage increase in growth rate is 20% used for calculation of population in year 2010 and 2020 (Source: http://censusindia.gov.in). Estimation of MSW generation of korba and champa town shown in **Table 6.9 and 6.12.**

Table 6.8: Waste Generation per capita in Indian cities

S. No.	Population Range (in millions)	Average per capita waste generation gms /capita/day
1	0.1 to 0.5	210
2	0.5 to 1.0	250
3	1.0 to 2.0	270
4	2.0 to 5.0	350
5	5.0 plus	500

Source: NEERI (Environmental Engineering Research Institute, Nagpur, 1995)[10]

Table 6.9: Estimated MSW Generation of Dengur area

S. No.	Year	Population	MSW Generated
1.	1991	11661	2.5 MT/day
2.	2001	15,000	3.15 MT/day
3.	2010	19,790	4.2 MT/day
4.	2020	26,829	5.6 MT/day
5.	2030	37,448	7.9 MT/day

Table 6.10: Estimated MSW Generation of Ahiran area

S. No.	Year	Population	MSW Generated
1.	1991	14,408	3.03MT/day
2.	2001	18,534	3.9 MT/day
3.	2010	24,452	5.13 MT/day
4.	2020	33,153	7 MT/day
5.	2030	46,279	9.7 MT/day

Table 6.11: Estimated MSW Generation of Korba City

S. No.	Year	Population	MSW Generated
1.	1991	2,85,310	60 MT/day
2.	2001	3,67,006	77 MT/day
3.	2010	4,84,202	101.7MT/day
4.	2020	6,56,435	164 MT/day
5.	2030	9,16,349	229 MT/day

Table 6.12: Estimated MSW Generation of Champa City

S. No.	Year	Population	MSW Generated
1.	1991	32,053	6.7 MT/day
2.	2001	37,949	8.0 MT/day
3.	2010	47,294	10MT/day
4.	2020	61,551	13 MT/day
5.	2030	84,380	17.7 MT/day

6.3.2 Management Proposed for MSW

Composting of MSW is therefore, the most simple and cost effective technology for treating the organic fraction of MSW. Full-scale commercially viable composting technology is already demonstrated in India and is in use in several cities and towns. So that proposed MSW option taken as composting in starting because presently there is no correct facility is available in selected area.

Composting is the decomposition of organic matter by microorganism in warm, moist, aerobic and anaerobic environment. Farmers have been using compost made out from biodegradable MSW. The compost made out of urban heterogeneous waste is found to be of higher nutrient value as compared to the compost made out of cow dung and agro-waste. So that generated compost can be used as manure in agriculture field of study area.

6.3.3 Cost Estimation

Projected population of 2020 seems more realistic to develop sewage treatment facility for the population in the urban portion of the catchment. In year 2020 total generation of MSW are 5.6 MT/day, 7 MT/day, 164MT/day and 13 MT/day for Dengur, Ahiran, Korba and Champa area. Total Cost estimated for MSW management of study area is shown below in **Table 6.14.** For estimation of MSW management by using composting method has been done by using reference given in The Ministry of Urban Development of India [56] shown in **Table 6.13**:

Table 6.13: Cost of Vehicle, Tool, Equipment and Composting

City Population in Million	Cost of Vehicle, Tool, Equipment (Rs. in lacs)	Cost of Composting in lacs.
<0.1	50.97	50
0.1- < 0.5	295.00	150
0.5-<1	511.00	500
>2.0	948.00	1000

Source: The Ministry of Urban Development of India,2000

Table 6.14: Cost Estimation for SWM

S. No	Description	Unit	Dengur	Ahiran	Korba	Champa
1	Cost of Vehicles, Tools and Equipment	Rs. In lacs.	110.47	136.52	511	248.92
2	Cost of Composting	Rs. In lacs.	56.17	69.41	500	126.57
3.	Total Cost	Rs. In lacs.	166.64	205.93	1011	375.49

6.4 PUBLIC PARTICIPATION AND PUBLIC AWARENESS

Public participation and public awareness is proposed as the important key component in river management and has a great significance in making the project a success by involving the communities. People's participation and public awareness programs are basic need for successful and sustainable river management. This is a important tool for removing the in negative attitudes toward river. Participation of the public can only be possible when the people are aware about the project. The project shall be successful and completed only when their thinking in planning and execution of the project is positive.

It becomes essential to identify the stakeholders, discussing and exchanging information with stakeholders, regarding their requirement and interests with respect to project. Presenting the project in front of the people and choosing group for spreading awareness program regarding river and need of its conservation. It is also important to identify that how they are going to be affected. The stakeholders, who are going to be affected positively, must pay. But who of negatively affected group must be redressed by rehabilitation and resettlements, compensation and/or guarantee of certain benefits free of cost.

In case of Hasdeo River, the public participation and awareness is basic need for the successful completion of proposed conservation plan. Strong local and public support can result in effective implementation of the conservation schemes and programs. Working in coalition can result in active citizens in river basins being able to play leadership role in setting the actions.

6.4.1 OBJECTIVE OF PP/PA

In order to have more clarity on the significance of public Participation and Awareness, its major objectives may be outlined as follows and shown in [57] **Fig 6.3;**

- To create more awareness different segments of population about the pollution level of river Hasdeo, Various causes and preventive measure.
- To mobilized people towards active participation in various activities being undertaken in Hasdeo river conservation plan.
- To enhance the utilization level of various facilities created under conservation plan of Hasdeo River.

- To build /enhance the institutional capacity of Community Based Organization and NGOs enabling them to address the issues related with river pollution, environment and waste management etc. in order to ensure sustainable and long term impacts.

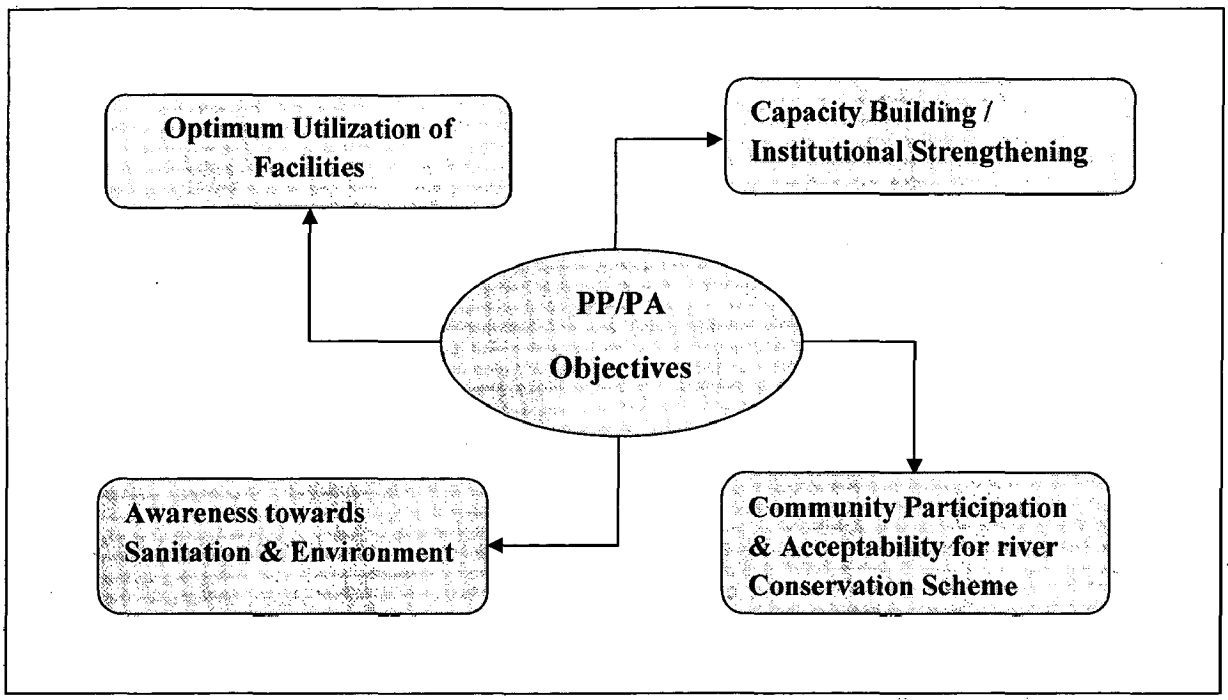


Fig 6.3: Objective of PP/PA

6.4.2 Identification of Stakeholders

First step towards achieving public awareness and its participation is to identify the target groups from the population which come in direct or indirect contact with the river to start communication with their representatives. Following are the stakeholders for the Hasdeo river, which can be broadly classified in three major groups:

(a) Public sector

1. Chief Secretary, Govt. of Chhattisgarh
2. Secretary, Drinking Water and Sanitation Department, Govt. of Chhattisgarh
3. Secretary, Department of Urban development, Govt. of Chhattisgarh
4. Secretary, Department of finance, Govt. of Chhattisgarh
5. Secretary, Department of Planning and Development, Govt. of Chhattisgarh
6. Secretary, Water Resource department, Govt. of Chhattisgarh

7. Secretary, Department of Forest and Environment, Govt. of Chhattisgarh
8. Secretary, Department of Fisheries, Govt. of Chhattisgarh
9. Secretary, Department of Agriculture, Govt. of Chhattisgarh
10. Secretary, Department of Rural Development, Chhattisgarh
11. Chairman, Ranchi Regional Development Authority, Govt. Chhattisgarh
12. Mayor, Municipal Corporation
13. Chairman, Jila Parishad (After election of Rural Local Bodies

(b) Private sector

1. Chairman, Chhattisgarh Chamber of Commerce
2. Chairman, Hotel and Restaurant Owners Association
3. Chairman, Truck Owners Association
4. Chairman, Bus Operators Association
5. Chairman, Garage and automobile body builders Association
6. Chairman, Shopkeepers Association

(c) Non-profit /Pressure sector

1. Senior and most respected person from fisherman community living in the catchment
2. Senior and most respected person from washer man community living in the catchment. Eminent personality/ Social worker living in the catchment

6.4.3 Proposed Activities for PP/PA

The aim of such activities is to draw attention to the fact that natural resources will not necessarily survive forever, and that there is a need for the sustainable and rational utilization of natural resources i.e. its conservation. To be able to achieve the goals of conservation, the attitude of the entire community towards the biosphere must be changed. Our goal, to further river protection has to become a common goal.

Through education and participatory activities there are opportunities for compatible wise-use projects in river areas. For example, those who live and work in river areas are not aware of their public benefits and therefore they may resist efforts to bring about developmental changes in the area. Through education they can be made to see how tourism development is linked to the needs of local economy? A comprehensive public awareness and participation plan

for three years under the conservation plan of Hasdeo river with an estimated cost of Rs.152 lacs. has been formulated which is 2% of total cost of sewage treatment and MSW management. The idea about Public Participation and Public Awareness has been referenced from dissertation of Arshad Ali, 2009 [11]. This can be seen in **Table 6.15.**

Table 6.15: Cost Estimated for Public Awareness and Public Participation Plan

S.No.	Activity	Numbers	Unit Cost in Rs.	Amount in lacs.
1	Audi-visual films	8 nos. of 15 minutes duration each	1000000/-	80.00
2	Group Meetings with slide shows, screening of audio-visual films and interactive work shops	15 each year for a period of 3 years	25000/pm	11.25
3	Children workshops with Nature Trails/games; Eco-rallies			15.00
4	Support to NGOs	2 NGO to Support for 3 Year	40000/-	28.8
5	Training programmes	5 workshops each year for 3 yrs.	47000/-	7.05
6	Printing pamphlets & Brochures & Awareness kits			10.00
	Total			152.10

6.5 SUMMARY

Since the pollution of Hasdeo river is due to point sources and non-point sources of pollution include domestic sewage and municipal solid waste. For making Hasdeo river pollution free clean river these two pollution sources must be managed before influence the river. Option of Sewage and Municipal Solid Waste management is proposed with detail cost estimated. Without Public Participation and Public Awareness these proposed management plans cannot work successfully so the PP/PA options are also proposed.

Due to application of these proposed conservation measures on Hasdeo river. River quality will be improved for future use and water can be used for irrigation, domestic, industrial activity in catchment area.

CHAPTER-7

CONCLUSION AND SCOPE OF FUTURE WORK

7.1 CONCLUSION

Waste generated from domestic, industrial and urban activity basically, affects the water quality of neighboring water resources. Similar result also been observed in the case of Hasdeo River. The effluents from industries like power plants, Paper mill and sewage water from various sources affect the water quality, aquatic life (flora and fauna), in the Hasdeo River eco-system. Therefore the following important conclusions are given after studying the current status and problems of Hasdeo River in present dissertation work.

1. Hasdeo River is facing moderate pollution as per water quality assessment. The value of Water quality index (NSFWQI) at location S1, S2, S3 and S6 were determined to be 40 to 49 show in that the water quality is bad at these locations.. The index value at locations S3 and S4 index value were calculated 50 to 62. This indicates the quality of water which is near to the lowest value 50 which shows the water quality is near to medium quality.
2. As per CPCB norms, the Water quality of Hasdeo river is of class B at location and class D at location S1, S2, S3 and S6. This indicates that at all location can be used for irrigation, industrial cooling and controlled waste disposal. However at location S4 and S5 water can be used for drinking with conventional treatment .However disinfection to be carried at locations S1, S2, S3 and S6 before using for drinking purpose.
3. Temperature is one the most important parameter for aquatic environment because almost all the physical, chemical and biological properties are governed by it. Temperature of water of Hasdeo River is high at Location S1, S2 and S3 due to the discharge of industrial effluent. This is unfavorable for the aquatic life present in water.
4. The BOD of Hasdeo river shows that the Hasdeo river water medium organic polluted. But the assessments show the value of BOD is increasing year by year. Basically due to presently there is no proper sewage and solid waste management. In future the organic loading will increase up to high level if conservation measure ar not taken in catchment area of Hasdeo River.

5. The water quality index of Hasdeo river Shows river quality getting bad in winter and pre monsoon season due to less water flow in along the flow path of Hasdeo River and moderate at monsoon, post monsoon season.
6. Water quality parameter nitrate present in Hasdeo river water. Presence of nitrate of about 0.30 mg/l of nitrate nitrogen initiates to excessive growth of algae bloom and aquatic weeds. Hasdeo river Nitrate varies from 0.03 to 2.3 mg/l shows pollution due to nitrate. Sources of nitrate are basically sewage and industrial waste.
7. The DO and Faecal Coliform are also most important parameter for assessment of water quality of any river. Hasdeo river DO and Faecal Coliform value are showing alarming value as per CPCB norms. This shows the locations S1, S2, S3 and S6 are polluted and location S4 and S5 are in moderate polluted.
8. Conservation measures proposed in present study are Sewage treatment, Solid Waste Management, Public Participation and Public Awareness as per objective. For sewage treatment and SWM selected locations are S1, S2, S3 and S5 because they are densely populated. Large sewage and municipal waste are generating because population is dense so there is need of STP and SWM at this location. Two alternatives of sewage treatment are proposed are Activated Sludge Process, UASB and composting for SWM. In which UASB is finally proposed for sewage treatment at LCC cost of 10687.49 lacs. Composting at the cost of 1759.06 lacs.
9. Public participation and Public Awareness is proposed for better result of this conservation plan of Hasdeo river because without help of local stakeholder Conservation plan cannot successfully run so that PP/PA activity and cost are proposed in present study. Estimated cost for PP/PA is 152.10 lacs.

In view of above statement shows, the water quality of Hasdeo River is gradually deteriorated due to industrialization and urbanization of Catchment area.

The Hasdeo River water is one of major source of water for neighboring area. For domestic, Industrial and agricultural uses. Due the pollution of Hasdeo River live hood of catchment area will be affected so that it is our first priority to conservation measure for Hasdeo River so that in future the quality of Hasdeo River will improve not to become more polluted.

All activity which deteriorates the water quality of Hasdeo River also can be minimized. After taking proper conservation plan for Hasdeo River. Public participation and public awareness should be started for better result of Conservation plan of Hasdeo River.

7.2 SCOPE OF FUTURE WORK

The scope of the future study may be as follows:

1. The affect of pollution due to agricultural land runoff can be done detailed in future.
2. The river can be studied more clearly if numbers of sampling point will increase.
3. The affect on macro invertebrate and micro invertebrates may be studied due to receiving of effluents from sewage.
4. The study may be carried out by collecting samples on the drains before confluence with the river to ascertain the pollution level by drain.

REFERENCES

1. http//: cpcb.nic.in
2. Murugesan, A.G. and N. Sukumaran; (1999), "Impact of urbanization and Industrialization on the river Tamirabarani, the life line of Tirunelveli and Thoothukdi districts, Proc, Sem- Env. Prob. 1-6.
3. Kumar, A; (2002), "Ecology of Polluted Waters", (vol-II) 1st Edition, A.P.H. Publishing Corporation, New Delhi- 2.
4. Chaudhari, N., (1982), "Water and Air Quality Control", The Indian context central board for the prevention and control of water pollution, New Delhi, India.
5. Dikshit, et al., (1990), "Residues of DDT and HCH in major Sources of drinking water in Bhopal", India Bull., Environ. Contam, Toxicol.45:389-393.
6. Meybeck, M. and Helmer, R., (1989), "The quality of rivers: from pristine state to global pollution", Paleogeog. Paleoclimat. Paleoecol. (Global Planet. Change Sect.), **75**, p., 283-309
7. Arshad Ali, (2009), " Conservation plan For Kanke Lake ,M-tech Dissertation, AHEC,IIT, Roorkee
8. Krishnamoorthy, M. and Barua, D., "Waste Water Treatment: Need of The Hour (A Case Study of Proposed Waste Water Treatment Plant At Omkareshwar, M.P), Allied Publishers Pvt. LTD, p. 239-244.
9. Sanjeev Kumar, (2008), "Techno Echonomic evaluation of various waste water treatment Plant,M-tech Dissertation, AHEC,IIT, Roorkee
10. NEERI, (1995)," Environmental Engineering Reasearch Institute, Nagpur, 1995
11. NEERI, (1995), "Strategy Paper on SWM in India", National Environmental Engineering Institute, Nagpur.
12. Citizen report, (1982), "The state of Indian's environmental centre for science and environment ", New Delhi, India
13. Verma, S.R. and Sukla, G.B., (1969)., " Pollution in a perennial stream khala by the sugar factory effluent near Lakshar", district Saharanpur, UP, Indian J. Env. III, 11:135.

14. Ambasht, R.S., (1990), "Environmental and Pollution", Student Friends and Co.", Varanasi, U.P., p.230.
15. Ajmal, et al., (1985), "Physico chemical aspects of Pollution in Kalindi", IAWPC Tech. Annual 12 : 106-114.
IAWPC Tech. Annual .
16. Anjaneyulu, Y., (2002), "Environmental Impact Assessment Methodologies", 1st Edition, BSP BS Publications, Hyderabad. P. 63-68.
17. Adhikary, S.P. and Saha, J., (1986), "Effects of distillery effluents and the blue green algae Anabaena on growth and development of rice seedlings ", Environ. Ecol., 4: 36-43.
18. Ford, D.L., (1976), Water Pollution Control in the Petroleum Industry", Industrial Waste water management hand book, H.S. Azad, 1st Edition Mc Graw-Hill book Co, New Work. : 1- 75.
19. Sengupta, D. and Mandal, A., (2006), "An assessment of soil contamination due to heavy metals around a coal fired thermal power plant in India". Environ Geol (2006) 51: 409–420.
20. Haslam, S.M., (1991), "River Pollution: An Ecological Perspective" 1st Edition, CBS Publishers & Distributors, Delhi-32.
21. Hynes, H.B.N., (1963), "The Biology of Polluted Waters", Liverpool university press, Liverpool, England. p. 201.
22. Jhingran, A.G., (1991), " Impact of Environmental stress on freshwater fisheries resources",J. Inland Fish Soc. India.
23. Thompson, D.H., (1928), "The kunthead crop of the llions river", III Nat. History, Survey Bulle. 17 : 285-290.
24. Pandey, et al., (2000), "Pollution and fish physiology, a review aquacult". 1: 1-8. Fish and Fishes in relation to aquatic pollution. Environmental issues and management. Nature conservators Publication. 6: 87-112.
25. Thieneman, A., (1954),"Ein drittes biozoatisches Grundprinzip", Arch Hydrobiol. 49, 421-2
26. Chopra, A.K. et al., (2010), "Bioaccumulation of organo chlorine in aquatic system", Environmental Monitoring Assessment: p. 105-120.

27. Winner, J.M., (1975)," Zooplankton, In BA whitton (Ed.), River ecology", Oxford: Backwell Scientific Publications. 155-69.
28. Herzing, A., (1987), "The analysis of Plank tonic rotifer population", Hydrobiolgia, 147: 163-180.
29. Kumar, A; (2002), "Ecology of Polluted Waters", (vol-II)1st Edition, A.P.H publishing Corporation , New Delhi-2.
30. Patrick, R., (1949), "A proposed biological measure of stream condition based on a survey of the conostoga basin ", Lancaster country, Pennsylvania, Nat. Sci Phil. 101: 277-341.
31. Lund, J.W.J., (1945), "Observation on soil algae. The ecology, size & taxonomy of British soil diatms", New phytol. 44 : 196-219.
32. Mitra, A.K., (1961), " The algal flora of certain Indian soils"' Ind. J. Agri. Sc. 21:357-373.
33. Verma, J.P. & Mahanty, R.C., (1995), "Phytoplankton of Malyanto pond of Laxmisagar & its correlation with certain physic chemical parameters" poll. Res.14 (2), 242-252.
34. Seven, O.K. and Walter, R. (1989), "Man and the Biosphere series, vol. 1.
35. Schindler, D.W., (1971), "Carbon, nitrogen and phosphorous and eutrophication of fresh water lakes" J. Phycol. 7: 321:329.
36. Shukla, et al., (1992), "Physico chemical and bacteriological properties of the water of the river Ganges at Ghazipur. Comp. Physiol. Ecol 17-72-96.
37. Gaur, et al., (1997), "Bacteriological quality of river Ganga from Narova to Kannauj": a comparative study "Indian J. Enverion Protection,20: 165-169.
38. Garg, S.K. and Garg, R., (2004), "Sewage Disposal and Air Pollution Engineering", 15th Edition, Khanna Publishers, Delhi-6, p. 228-45.
39. Tiwary, R.K. and Dhar B.B., (1994), "Environmental Pollution from Coal Mining Activities in Damodar River Basin, India" Mine Water and Environment vol,13 pp 1-10.
40. Brown, R.M. et al., (1970), "A Water Quality Index- do we Dare ? ",Water sewage works, 11,339-343.
41. Nath, H. and Gupta, A; (1993), "Status of Environmental Pollution in Shillong (1981-1991), an overview, In Dynamics of a tribal society. p. 41-64, Uppal Publishing House. New Delhi.

42. Gupta, A., (1984), "Observations on human interference in some running water system of Meghalaya", In status of Ecology, p. 61-68. Punjab publishing house, Patiala.
43. Dutta, D., (1983), "Volume published on the occasion of the centenary of Sichar municipality", Silchar Paurasabha Udjapan Samiti, Silchar.
44. NRCD Guidelines for DPR.
45. CAMPA Project Report,.(2009)," Compensatory Forestation in the State of Chhattisgarh".
46. Guha, A., Kumar Vinod, K. and Lesslie, A. (2009) ," Satellite-Based Geomorphological Mapping for Urban Planning and Development- A case study for Korba city, Chhattishgrh. Current science, vol. 97, no. 12, p. 1761-1763.
47. Bouza-Dean˜o, R. et al., (2008), "Trend study and assessment of surface water quality in the Ebro River (Spain)", Journal of Hydrology (2008) 361, p. 227– 239.
48. Suthar, S. et al.(2009)," Assessment of metals in water and sediments of Hindon river, India Impact of Industrial and urban discharges", Journal of Hazardeous Material 171, p. 1088-1095.
49. Bhardwaj, R.M., (2005),"Water Quality Monitoring in India Achievements and Constraints" C.P.C.B, India.
50. Chavan, D. Ajay, Sharma, M.P. and Bhargava, Renu, (2009), "Water Quality Assessment of the Godavari River.
51. Brown, R.M. et al., (1970), "A Water Quality Index – do we dare? ", water sewage works, 11, 393-343.
52. Central Pollution Control Board, (2000), The Brahmaputra Basin", Basin sun inventory of water pollution, Ministry of Environment and Forest, P. 31-39.
53. Dhawajendra Nath Das, (2006), "The Effect on Water of Tunia River Due to Pollution of the Industrialization and Urbanization". M. Tech Dissertation, AHEC, IIT Roorkee.
54. Shukla, S.K., (2009), "Natural Resource Management and Police, Water Pollution", Journal of Environmental Health, p. 1-4.
55. Central Water Commission, (2007)," Hydrological Data Report".
56. CPCB (2000). Status of Municipal Solid Waste Generation, Collection Treatment, and Disposal in Class 1 Cities, Central Pollution Control Board, Ministry of Environment and Forests, Government of India, New Delhi.

57. Technical Proposal for Project Management Consultant of Yamuna Action Plan-II, p 4-92-102.
58. Dikshit, A.K., (2005), "Global Water Scenario: The Changing Statistics. p. 2-5.
59. Avinash, K., et al., (2009) "Pollution urban and suburban area", The Encyclopedia of Earth. P. 1-2.
60. Draggan, S., (2009) "Non Point Source Pollution: Urban and Suburban Area", National Ocean Service Education.
61. Tiwary, K.R., (2000) "Environmental Impact of Coal Mining on Water Regime and Its Management" p. 1- 4.
62. Rajaram, T., et al., (2007), "Water pollution by industrial effluents in India: Discharge scenarios and case for participatory ecosystem specific local regulation. p. 1-4
63. Tiku, D.K., (2007) "Effectiveness of Treatment Technologies for Waste water generated by Indian Pulp Mills". Environ Monit Assess. p. 453-466.
64. Pandey, M., & Sundaram, S. M. (2002)., "Trend of water quality of river Ganga at Varanasi using WQI approach". International Journal of Ecology and Environmental Science (28, 139–142). New Delhi: International Scientific Publications.
65. Chetana Suvarna, A., & Somashekar, R. K. (1997). "Evaluation of water quality index of the river Cauvery and its tributaries". Current science (Current Science Association and Indian Academy of Science, Bangalore), 72(9). p. 640-646.
66. Ram, R. S., & Anandh, H. (1996). "Water quality index of some Indian rivers". Indian Journal of Environmental Health, NEERI, Nagpur, 38(1), p. 21–34.
67. Bhargava, D. S. (1983). "Use of a water quality index for river classification and zoning of the Ganga river". Environmental Pollution, B6, p. 51–67.
68. Dwivedi, S., Tiwari, I. C., & Bhargava, D. S. (1997). "Water quality of the river Ganga at Varanasi". Institute of Engineers, Kolkata, 78, p. 1–4.
69. Kunwar P. Singh, (2005) "Water quality Assessment and Apportionment of Pollution Sources of Gomti river (India) using Multivariate Statistical Techniques" Analytica Chimica Acta 538, p. 355–374.
70. Singh, S. et al. (2004), "Water Quality Assessment of an Untreated Effluent Impact Urban Stream: The Bharalu Tributary of Brahamputra River, India. Environ Monit Assess (2007) 130: p. 221–236

71. Stroomberg, S. et al. (1995), "Water Pollution Sources Assessment by Multivariate Statistical Methods in the Tahtali Basin, Turkey. Environ Geol (2008) 54: p.275–282.
72. Carpenter, S.R. and Jaravie, H. P., (2009), "Water Pollution Sources Deatil Study in Italy", Environ Monit Assess 135: p. 202–212.
73. EPA, (1998), "U.S. Environmental Protection Agency, Water Conservation Plan Guidelines Recommend for water systems.
74. Khalil, N. et al. (2006), "UASB Technology for Sewage Treatment in India", 20 Year Experience Environmental Management 80, p. 198-207.
75. Asnani, P.U., (2004). "United States Asia Environmental Partnership Report", United States Agency for International Development, Centre for Environmental Planning and Technology, Ahmedabad.