CONSERVATION PLAN FOR HINDON 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

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CANDIDATE'S DECLARATION

I hereby declare that the work presented in this Dissertation entitled, "**CONSERVATION PLAN FOR HINDON RIVER**", submitted in partial fulfillment of the requirement for the award of the degree of Master of Technology in "**Conservation of River & Lakes**" in **Alternate Hydro Energy Centre, Indian Institute of Technology Roorkee,** is an authentic record of my own work carried out under the supervision and guidance of **Shri. M.K. Singhal,** Senior Scientific Officer, Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee (India).

I certify that I have not submitted the matter embedded in this dissertation for award of any other degree or diploma.

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ACKNOWLEDGEMENT

It is my proud privilege to express my sincere gratitude to **Shri Mukesh Kumar Singhal**, Senior Scientific Officer, Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee, for their invaluable guidance and constant inspiration throughout the dissertation work.

I wish to express my profound gratitude to **Dr. Arun Kumar**, Chief Senior Scientific Officer, Alternate Hydro Energy Centre, Indian Institute of Technology Roorkee, for his support and providing all the facilities, which would have made it possible for me to complete the dissertation work. The cooperation he gave is greatly appreciated.

I also express my sincere regards to **Dr. R. P. Saini**, Head, Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee, for providing me all the facilities during my course tenure. I am also grateful to all faculty members and staff of Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee.

I am also very thankful to my parents, and all of my friends for their never ending encouragement in bringing out this dissertation report to the form which it is now.

Date: 15th June, 2012

(ASHISH RANJAN)

ABSTRACT

The Hindon River and its tributaries, Kali and Krishna which flows through six districts of Uttar Pradesh (Saharanpur, Muzaffarnagar, Meerut, Baghpat, Ghaziabad, and Gautambudh Nagar) and predominantly through rural population of western Uttar Pradesh. It drains a catchment area of about 7, 083 km^2 of farmland while also flowing through a number of substantial sized towns and villages. A detailed survey of the river Hindon was carried out to understand the nature of waste effluents and their impact on the water quality of river Hindon. From the study conducted, it is found that the water of the river is subjected to varying degree of pollution, caused by numerous untreated waste outfalls of municipal and industrial effluents. The main sources, which create pollution in river Hindon include municipal waste of Saharanpur, Muzaffarnagar and Ghaziabad districts and industrial effluents of sugar, pulp and paper, distilleries and other miscellaneous industries through tributaries as well as direct outfalls. In non-monsoon months, the river is completely dry from its origin up to Saharanpur town. The effluents of Nagdev nala and Star Paper Mill at Saharanpur generate the flow of water in the river.

The dissolved oxygen content in the upstream section of the river was found to be quite unsatisfactory and a worst situation was observed after the confluence of paper mill and distillery effluents. The effluent of pulp and paper mill and distillery added high concentration of organic matter to the river, which is responsible for the decrease in dissolved oxygen along with increase in BOD, COD and TDS along with other factors. The maximum concentration of ammonia was found after the confluence of Dhamola nala, which is carrying the municipal waste of Saharanpur town and has significant flow throughout the year.

To conserve the water quality of Hindon River, all conservation related works like installation of STPs with appropriate technology, installation of CETPs, Solid waste management plan, public awareness and participation program, Cost estimation and institutional arrangement for all these works were suggested.

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CHAPTER 1

INTRODUCTION & LITERATURE REVIEW

1.1 GENERAL

The human activities combined with changes in land use pattern like urbanization, deforestation, agricultural and mining practices greatly influence the quality of river water. The influence of urbanization on the water quality depends mainly on the nature of generated industrial effluents, domestic sewage and surface runoff from urban areas.

Urban settlements and growing industrial development, combined with rapidly increasing demand for water, are causing water management problems. Ninety six percent of water pollution problems in India are due to indiscriminate discharge of municipal wastes (Chaudhary, 1981). These wastes being biodegradable produce a series of directional but predictable changes in water bodies. Industrial effluents are responsible for pollution to a lesser extent but the effects produced by them may be more serious as nature is often unable to assimilate them. Agriculture is also responsible for degrading the river water quality by generating runoff from animal husbandry units, which contain predominantly organic compounds from the use of mineral fertilizers and chemical pesticides.

1.2 RIVERS

Rivers are the most important freshwater resource for man. Social, economic and political development has, in the past, been largely related to the availability and distribution of fresh waters contained in riverine systems. A simple evaluation of surface waters available for regional, national or Tran's boundary can be based on the total river water discharge (Sethi, 2006).

The flow has been almost completely extracted and distribution in to nearby states. Any increase in extraction and use would require diversion of a similar water quantity to guarantee the minimum flow required to meet all the water demands of the region (Sethi, 2006). Upstream use of water must only be undertaken in such a way that it does not affect water quantity, or quality, for downstream users. Use of river water is, therefore, the subject of major political negotiations at all levels. Consequently, the

river water managers require high quality scientific information on the quantity and quality of the waters under their control. Provision of this information requires a network of river monitoring stations in order:

- To establish short- and long-term fluctuations in water quantity in relation to basin characteristics and climate.
- To determine the water quality criteria required to optimize and maintain water uses, and
- To determine seasonal, short-and long-term trends in water quantity and quality in relation to demographic changes, water use changes and management interventions for the purposes of water quality protection (Murugesan et al., 1999).

1.3 RIVER CLASSIFICATION

Rivers are complex systems of flowing waters draining specific land surfaces which are defined as river basins or watersheds. The characteristics of the river, or rivers, within the total basin system are related to a number of features. These features include the size, form and geological characteristics of the basin and the climatic conditions which determine the quantities of water to be drained by the river net work. Rivers can be classified according to the type of flow regime and magnitude of discharge. The flow regime may be subject to considerable modification by natural impoundments, lakes, and dams. Flow characteristics may also be changed by canalization, or requirements for water uses, such as withdrawal for irrigation or other water supply needs, or by changes in flood characteristics due to modifications of the soil infiltration as a result of agriculture and urbanization (Calow et al., 1994).

The classification of rivers according to their discharge is generally more satisfactory but has not, to date, been completely defined and accepted. However, there are certain specified discharge rates which are widely used to characterize river discharges and their annual variations. These include the average peak discharges, the monthly or annual average discharge and the average low discharge. A size classification based on discharge, drainage area and river width is given in Table (1.1) River discharge particularly in arid and sub-tropical regions, may range from zero in the dry season to high discharge rates in large rivers during the rainy seasons. Very

Mississippi and Nile rivers. River drain watersheds of varying dimensions, this area are directly related to the discharge and width. Efficient drainage is achieved by means of a dendritic network of streams and rivers. As these increases in size from small to large, and then to the main river channel, the order in which they appear is a function of the watershed size (Calow et al., 1994).

River systems represent the dynamic flow of drainage water, which is the final product of surface run-off, infiltration to ground water and groundwater discharge. The general relationships between these and the nomenclature for a river transect are summarized in Figure (1.1, 1.2).

Table 1.1: Classification of rivers based on discharge characteristics and the drainage area and river width

S. No.	River size	Average discharge (Cumecs)	Drainage area (Square km)	River width (m)	Stream order
1.	Very large rivers	>10000	>1000000	>1500	>10
2.	Large rivers	1000-10000	100000-1000000	800-1500	7 to11
3.	Rivers	100-1000	10000-100000	200-800	6to9
4.	Small rivers	10-100	1000-10000	40-200	4to7
5.	Streams	1.0-10	100-1000	8.0-40	3to6
6.	Small streams	0.1-1.0	10-100	1.0-8.0	2to5
7.	Brooks	<0.1	<10	<1.0	1to3

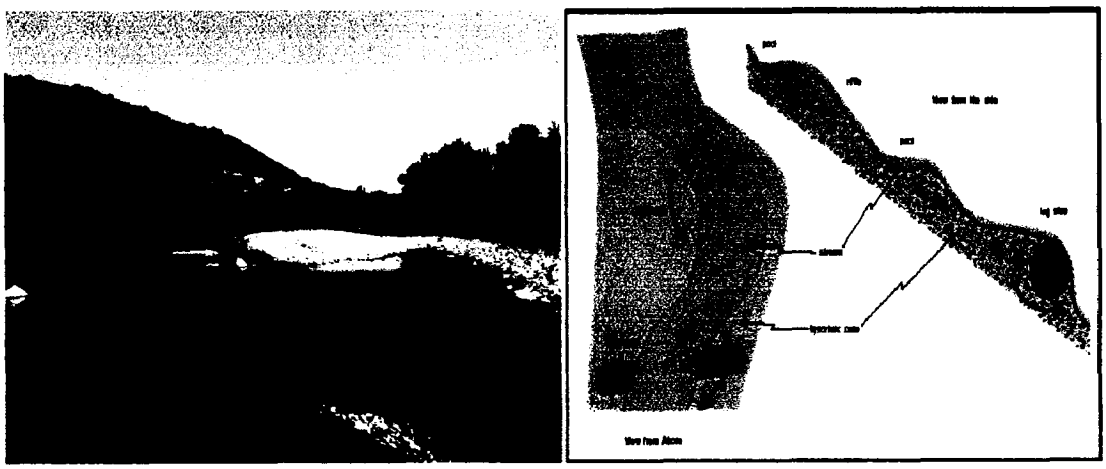

Figure 1.1: River Transect

1.4 INDIAN RIVER SYSTEM

India is a land of many rivers and mountains. Its geographical area of about 329 M.ha is crossed by a large number of small and big rivers, some of them figuring amongst the mighty rivers of the world. The rivers and mountains have a greater significance in the history of Indian cultural development, religious and spiritual life. It may not be an exaggeration to say that the rivers are the heart and soul of Indian life (Rao, 1979).

Most ancient civilizations grew along the banks of rivers. Even today, millions of people all over the world live on the banks of rivers and depend on them for their survival all of us have seen a river large or small, either flowing through our town, or somewhere else. Rivers are nothing more than surface water flowing down from a higher altitude to a lower altitude due to the pull of gravity. One river might have its source in a glacier, another in a spring or a lake. Rivers carry dissolved minerals, organic compounds, small grains of sand, gravel, and other material as they flow downstream. Rivers begin as small streams, which grow wider as smaller streams and rivers join them along their course across the land. Eventually they flow into seas or oceans. The flow in most rivers is not uniform, which means that sometimes there are floods and sometimes no water flows in them. Flood control projects attempt to reduce the variation in flow (Calow et al., 1994).

Rivers are the main source of water for drinking, agricultural and industrial purposes as they are available on the surface ready for use that is the reason for their importance. The entire river basin provides water for millions of people depending upon the length and flow of the river. Rivers are also useful for inland navigation, mass bathing purposes, propagation of wild life and fisheries. This reason the towns and cities along the riverbanks grow and develop at a faster rate.

The annual precipitation including snowfall, which is the main source of the water in the country, is estimated to be of the order of 4000 Km^3. For the purpose or rainfall country has been divided into 35 meteorological sub-divisions (Rao, 1979). The Resources potential of the country, which occurs as natural run off in the rivers is about 1869 Km^3 as per the basin wise latest estimates of Central Water Commission, considering both surface and ground water as one system. Ganga-Brahmaputra-Meghna

system is the major contributor to total water resources potential of the country. Its share is about 60 percent in total water resources potential of the various rivers. Based on 1991 census, the per capita availability of utilizable water comes around 220 Cubic metres (cu.m.).

Due to various constraints of topography, uneven distribution of resource over space and time, it has been estimated that only about 1122 Km^3 of total potential of 1869 Km^3can be put to beneficial use, 690 Km^3 being due to surface water resources. Again about 40 percent of utilizable surface water resources are presently in Ganga-Brahmaputra-Meghna system. In majority of river basins, present utilization is significantly high and is in the range of 50 percent to 95 percent of utilizable surface resources. But in the rivers such as Narmada and Mahanadi percentage utilization is quite low. The corresponding values for these basins are 23 percent and 34 percent respectively. (Ref. Ministry of Water Resource Govt. of India)

1.5 WATER SCENARIO OF INDIA

India is blessed with many rivers. In which 12 of them are classified as major rivers whose total catchment area comes around 252.8 Million hectare (M.ha). Of the major rivers, the Ganga - Brahmaputra system is the biggest with catchment area of about 110 M.ha which is more than 43 percent of the catchment area of all the major rivers in the country. The other major rivers with catchment area more than 10 M.ha are Indus (32.1 M.ha.), Godavari (31.3 M.ha.), Krishna, (25.9 M.ha.) and Mahanadi (14.2 M.ha). The catchment area of medium rivers is about 25 M.ha and Subernarekha with 1.9 M.ha. Catchment area is the largest river among the medium rivers in the country (Rao, 1979).

These rivers are categorized into four groups:

1) Rivers that flow down from the Himalayas and are supplied by melting snow and glaciers. This is why these are perennial, that is, they never dry up during the year.
2) The Deccan Plateau rivers, which depend on rainfall for their water
3) The coastal rivers, especially those on the west coast, which are short and do not retain water throughout the year

Rivers having several and variety of benefits to the common people are even considered as Gods and worshipped by the people in India. The major rivers in India are Ganga, Yamuna, Brahmaputra, Indus, Narmada, Mahanadi, Godavari, and Cauvery.

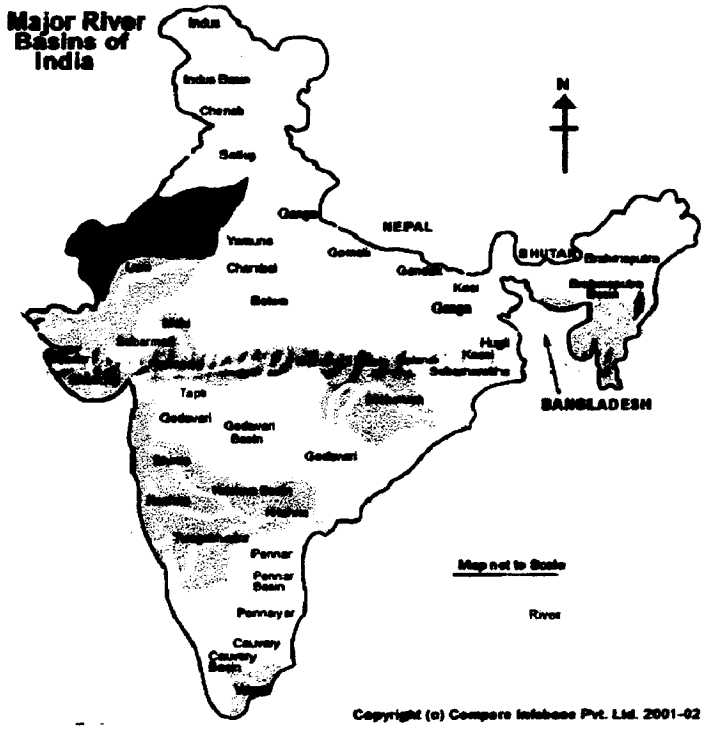

Figure 1.2: Indian River system (Rao, 1979).

1.6 WATER BODIES

Inland Water resources of the country are classified as Rivers, Lakes, Ponds, Wet Lands, Canals, Reservoirs, Derelict Water and Brackish Water. Fig 1.3 shows the view of an Indian Lake and Reservoir. Other than Rivers and Canals, total water bodies cover all area of about 7 M.ha. Of the Rivers and Canals, Uttar Pradesh occupies the First place with the total length of rivers and canals as 31.2 thousand km, which is about 17 % of the total length of rivers and canals in the country. Other states following Uttar Pradesh are Jammu & Kashmir and Madhya Pradesh. Among the remaining forms of the inland water resources, tanks and ponds have maximum area (2.9 M.ha.) followed by reservoirs (2.1 M.ha).

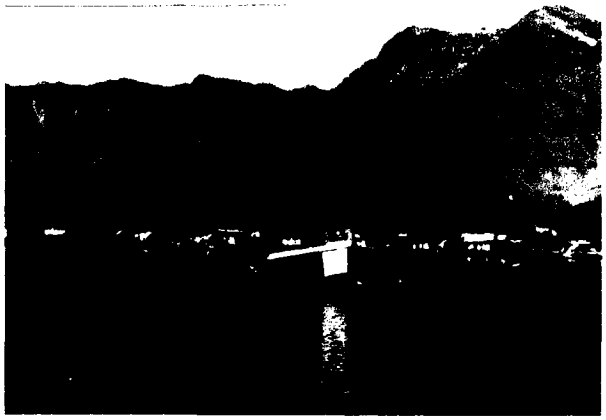

Fig 1.3: Views of an Indian Lake

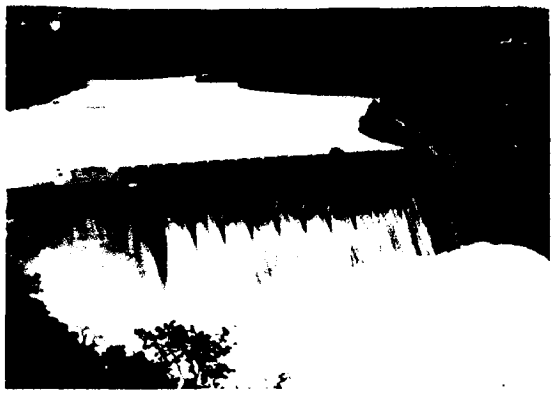

Fig 1.4: View of a Reservoir

Most of the area under tanks and ponds lies in Southern States of Andhra Pradesh, Karnataka and Tamil Nadu. These states along with West Bengal, Rajasthan and Uttar Pradesh, account for 62 percent of total area under tanks and ponds in the country. As far as reservoirs are concerned, major states like Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Rajasthan and Uttar Pradesh account for larger portion of area under reservoirs. More than 77 percent of area under beels, oxbow, lakes and derelict water lies in the states of Orissa, Uttar Pradesh and Assam. Orissa ranks first as regards the total area of brackish water and is followed by Gujarat, Kerala and West Bengal.

The total area of inland water resources is, thus, unevenly distributed over the country with five states namely Orissa, Andhra Pradesh, Gujarat, Karnataka and West Bengal accounting for more than half of the country's inland water bodies.

1.7 SOURCES OF RIVER POLLUTION

The sources of pollution may be classified into point sources and non-point sources. Generally, point sources of pollution are those sources emitted to a watershed at a specific point. They usually can be directly measured and their impact can be assessed. Common point sources include municipal and industrial pollutants discharged directly to a stream. The non-point (diffuse) sources are those sources discharged to a watershed in a way that they depend upon the vagaries of the hydrologic cycle to transport them to the stream system. Nutrients, pesticides, bacteria, heavy loads of organic matter, and sediments are considered non-point source pollutants.

In most cases the sources and concentrations of non-point source pollutants are the result of land use interactions with the transport system. It is a source transport problem in which the hydrologic cycle provides the transport processes to move pollutants from the source to ground water, a stream, or a reservoir. Non-point sources can be urban, industrial, or agricultural pollutants that are distributed over the surface. The mode of transport is the flow of water across the soil surface and in stream channels and reservoirs or the flow of water through the soil profile.

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. The chief sources of pollution are identified to be industrial pollution constituting 8-16% of the waste water and sewage comprises 84-92% (Chaudhuri, 1982). The sources of river pollution in India are tabulated in Table 1.2.

Table 1.2: Sources of river pollution in India

S. No.	Name of the river	Sources of pollution
1	Ganga	Industrial, urban and agricultural activities.
2	Yamuna, Delhi	Sewage, DDT factory and other industries and power plant
3	Kali, Meerut (UP)	Sugar mills, distilleries, paint, soap, silk, yarn, tin and glycerin industries
4	Bajora, Bareilly (UP)	Synthetic rubber factories
5	Ganga, Kanpur	Jute, chemical, metal, surgical, tanneries, and
6	Gomti, Lucknow (UP)	Paper and pulp mills and sewage
7	Suvaon, U.P	Sugar mills
8	Damodar, Bokaro	Fertilizers, steel mills, coal and paper plant
9	Sone, Bihar	Cement, pulp and paper mills
10	Hooghly, Kolkata	Paper & pulp, power plant, jute, textile, chemical, paint, varnishes, metal, steel, oil, rayon, soap and
11	Bhadra, Karnataka	Pulp, paper and steel industries
12	Cauvery, Tamil Nadu	Sewage, tanneries, distilleries, paper and rayon
13	Godavari	Paper mills
14	Kulu, Mumbai	Chemical, rayon and tanneries
15	Brahmaputra	Oil drilling, refineries, paper mills and sewage

Source: Central Pollution Control Board.

1.8 IMPACTS OF POLLUTION ON RIVER WATER

With the rapid industrialization and urbanization during the last 50 years, most of the Indian rivers are subjected to indiscriminate discharge of effluents affecting water quality and aquatic life (Verma and Shukla, 1969). Increasing pollution of rivers and other water bodies has become a matter of great concern in recent years (Ambasht, 1990; Dikshith et al., 1990). The industrial effluent, domestic and municipal sewage produces hazardous effects on aquatic life and ecosystem of the receiving water bodies (Ajmal et al., 1985; Neman and Lal, 1985).

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.

River systems have been dramatically altered by dams and reservoirs, canalization, and land use developments throughout their drainage basins. Some species of flora and fauna have disappeared; exotic species have invaded; the functional characteristics of the river systems have been disrupted; and there has been a reduction in landscape quality and loss of wilderness areas. The need to restore rivers and their water resources because of their existing needs for water supply, irrigation, industrial , for hydro-electric energy and the increasing needs of rapidly growing populations and their likely increase in per capita resource demands. However, there is arising a strong concern for ecosystem sustainability in the face of both socio-economic development and climate change. The restoration of rivers degraded by past urban, industrial and agricultural developments is now a priority for the developed nations (Calow et al., 1994).

1.9 NATIONAL RIVER CONSERVATION PLAN (NRCP)

The Ministry of Environment and Forests, Government of India, started a programme for cleaning up of rivers in the country with the implementation of the

Ganga Action Plan (GAP) in 1985. A Central Ganga Authority (CGA) was set up under the Prime Minister with the members being the Chief Ministers of the concerned states, Union Ministers and Secretaries of the concerned Central Ministries along with experts in the field of water quality. GAP was extended to GAP Phase – II in 1993 and then to NRCP in 1995. GAP Phase – II was merged into NRCP in 1996. The objective of the NRCP was to improve the water quality of major rivers as the major fresh water source in the country, through the implementation of pollution abatement schemes. Since then, a single scheme of NRCP is under implementation as a Centrally Sponsored Scheme. The CGA was renamed as National River Conservation Authority (NRCA) with a larger mandate to cover all the programmes supported by the National River Conservation Directorate (NRCD).

The functions of the NRCA are as follows:

(1) To lay down, promote and approve appropriate policies and programmes (long and short-term) to achieve the objectives.
(2) To examine and approve the priorities of the NRCP.
(3) To mobilize necessary financial resources.
(4) To review the progress of implementation of approved programmes and give necessary directions to the Steering Committee, and
(5) To make all such measures as may be necessary to achieve the objectives.

GAP Phase – I was started in 1985 as a 100% centrally funded scheme. The main objective was to improve the water quality of the River Ganga to acceptable standards by preventing the pollution load from reaching the river. Under GAP Phase–I pollution abatement works were taken up in 21 Class – I towns in Uttar Pradesh, Bihar and West Bengal. GAP Phase – I was extended to GAP Phase – II, approved in stages between 1993 and 1996. It covered the River Ganga and its major tributaries, viz. Yamuna, Gomati and Damodar. This plan covered pollution abatement works in 95 towns along the polluted stretches of these 4 rivers spread over 7 states. The total approved cost of this action plan was approved on 50:50 cost sharing basis between the Centre and the State Governments.

It was later felt that the river conservation activity needed to be extended to other rivers in the country as well. Accordingly, GAP was merged into a National River

Conservation Plan (NRCP) in 1995 on 50:50 cost sharing basis between Centre and State Governments. The Ganga Project Directorate was converted into the National River Conservation Directorate (NRCD) for servicing the National River Conservation Authority and the Steering Committee. It covered pollution abatement works in 46 towns along the polluted stretches of 18 rivers spread over 10 states. The GAP Phase – II was merged with NRCP in 1996.

NRCP was converted into a 100% centrally funded scheme in November 1998 with only the land cost to be borne by the States. However, in March 2001, it was decided to adopt an integrated approach for the river cleaning programme and that all future programmes will be shared on a 70:30 cost sharing basis between the Centre and State Governments respectively.

The activities covered under the NRCP include the following (Conservation of water bodies, 2004):

(1) Interception and Diversion works to capture the sewage flowing into the river through open drains and divert them for treatment.
(2) Sewage Treatment Plants for treating the diverted sewage.
(3) Low Cost Sanitation works to prevent open defecation on river banks.
(4) Electric Crematoria and Improved Wood Crematoria to conserve the use of wood and help in ensuring proper cremation of bodies brought to the burning ghats.
(5) River Front Development works such as improvement of bathing ghats.
(6) Public awareness and public participation.
(7) HRD, capacity building, training and research in the area of River Conservation.
(8) Other miscellaneous works depend upon location specific conditions including the interface with human population.

The criteria for funding of schemes under NRCP are as follows:

(1) NRCD/Government of India shall bear up to 70% of the Project cost.
(2) States and Local Bodies shall bear 30% of the Project cost of which the share of public would be a minimum of 10% to ensure public participation in the project.

1.10 WATER AVAILABILITY

Uttar Pradesh is endowed with bountiful water resources which were considered abundant but because of increasing demand for various purposes namely irrigation, drinking and domestic, power (thermal and hydro), industrial and other uses, its scarcity is becoming apparent which shall get more pronounced with increasing population. The Table 1.3 clearly shows that even though the rainfall in India is more than the world average the availability of water per person is less and in Uttar Pradesh it is still below the National availability. This is because of high population and apart from domestic purpose most of the water is utilized for Agricultural and Industrial purposes. Good water management practices will increase the water availability both in India and in Uttar Pradesh.

Table 1.3: Rainfall and the availability of water per person

Places	Normal Rainfall (in mm)	Availability of water per person per year in liters
World	800	7.5 lakhs
India	1150	2.2 lakhs
Uttar Pradesh	968	0.8 lakhs

(Source: Uttar Pradesh Water Supply and Drainage Board).

1.11 LITERATURE REVIEW

In western districts of Uttar Pradesh (U.P.), mainly Saharanpur, Muzaffarnagar, Meerut and Ghaziabad, large amount of water resources are present which are being used for irrigation, fishing, or to produce fish seeds and fingerlings. These water resources are also utilized for the disposal of industrial wastes of different industries. The main water resources of this region are river Hindon, Kali, Krishni, Ganga, and Yamuna with their respective tributaries and canals. Verma et al. studied the characteristics and disposal problems of various industrial effluents with reference to Indian standards. They also studied the pollution of stream Khala by the sugar factory effluent near Laksar and pollution of Kalinadi by industrial effluents near Mansurpur.

In western Uttar Pradesh rapid industrial and agricultural growth has taken place during last few decades. This is likely to become manifold in near future

particularly in areas like Saharanpur, Muzaffarnagar, Meerut and Ghaziabad where necessary industrial nucleus already exits. A variety of industries have already been set up hi this area such as paper and pulp, sugar, chemicals, rubber, plastics, food-processing, small scale industries and cottage industries etc. Most of these industries are discharging their wastes and effluents into the nearby water course without considering its consequences. In addition to this, the municipal waste of Saharanpur, Muzaffarnagar, Meerut and Ghaziabad districts are also being discharged to the nearby rivers. On account of these outfalls of municipal and industrial wastes into the rivers, the water is subjected to varying degree of pollution.

The river Hindon, an important tributary of river Yamuna, carries pollution load from industrial towns and agricultural areas of western Uttar Pradesh. The river originates from Upper Shivaliks (Lower Himalayas) and flows through four major districts namely Saharanpur, Muzaffarnagar, Meerut and Ghaziabad in western Uttar Pradesh and finally joins river Yamuna downstream of Delhi.

Verma et al., 1980 conducted detailed limnological studies of Hindon river in relation to *fish* and fisheries and reported that quality of the river water is not suitable for propagation of fish culture and related aquatic life. Singhal et al., 1987 studied the influence of industrial effluents on water quality of river Hindon. Seth, 1991 carried out studies on hydrological aspects of waste disposal in the Upper Hindon basin while Kumar, 1993 have investigated the bioaccumulation and concentration of toxic metals (Cd, Pb and Zn) in aquatic flora and fauna along with the impact of physico-chemical conditions in the river. Lokesh, 1996 studied the fate of heavy metals in water and sediments of the Hindon River.

Recently, detailed studies on water and sediments of river Kali, a tributary of river Hindon, have also been carried out in the Water Quality Laboratory of National Institute of Hydrology, Roorkee (Jain et al., 1997). It is reported that the river is highly polluted due to the numerous untreated municipal and industrial effluents of Muzaffarnagar district. The discharge of municipal and industrial wastes at regular intervals does not allow any self purification to occur. The important characteristic associated with the pollution of the river is the depletion of oxygen over a stretch of about 25 km. The mass balance conducted for some water quality constituents shows

that changes found in load along the river may be mainly due to the contribution of non-point sources of pollution.

In view of the above observations, it is of interest to study the detailed hydro-chemical characteristics of the waste effluents being discharged into Hindon River and their impact on the river water quality. For this purpose, various sampling stations in the waste effluents and selected river stretch were selected for water quality monitoring. The data was collected for pre monsoon period (2012) and the results are discussed in this report. In this dissertation preparation of necessary outline proposal for river restoration including Domestic and Industrial waste water management, Solid waste management, Construction of toilets, Public awareness institutional arrangements for Hindon River Restoration Programme are to be focused here.

1.12 GAPS IDENTIFIED

On the basis of review of literature, the following gap seems to be the long term sustainability of Conservation Measures:

1. Post and pre monsoon evaluation of various pollutants in a Saharanpur and Muzaffarnagar Hindon River stretch that is about 160 km.
2. The point and non-point sources of River pollution in a selected stretch.
3. Impact of the Human activities upon the quality of the water and sustainability for use.
4. Influence of Polluted and Unpolluted water on Distribution, Density and Community Structure of the biota.
5. Identification of Effluent Treatment Plants (ETPs) installed by all the industries discharging their effluents directly into the river.
6. Sewerage system in Saharanpur and Muzaffarnagar district.

1.13 OBJECTIVE OF THE STUDY

As mentioned above, the present dissertation is concerned about waste water quality management of Hindon River in two districts. The work included identification of pollution sources based on the survey of area around Hindon River contributing the discharge of sewage. Their pollution strength will be determined by performing tests from the samples from these polluted sources. The tests will be performed on the

samples for about two periods (post monsoon and pre monsoon) to study the variation in the pollution strength due to variation in flow condition and seasonal change.

The main parameters were carried out like pH, Total Suspended Solids, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrate, Phosphates, Electrical Conductivity, and Sulphates etc. These data was converted with National Sanitation Foundation Water Quality Index to achieve at a single value defining the water quality at selected locations.

In brief the objectives of present study are:

1. To find out point sources and non point sources for selected study stretch of Hindon River.
2. To assess the water quality of selected locations as a primary data for post monsoon and pre monsoon period.
3. To propose a feasible, comprehensive and cost-effective conservation plan for Hindon River in order to achieve the following goals:-

    - Conserve water quality of Hindon River.
    - Management of solid waste generated in the domestic & industries.
    - Conserve the basic natural resources like soil & water from degradation in catchment area.
    - Create the awareness among the local people activates about the conservation of River & its importance for them.
    - Control the effluent from industries by introducing recycling and reuse of waste water.

CHAPTER 2

ENVIRONMENTAL STATUS OF HINDON RIVER

2.1 STUDY AREA

The river Hindon is flowing through six districts (Saharanpur, Muzaffarnagar, Meerut, Baghpat, Ghaziabad and Gautambudh Nagar) before falling in river Yamuna and receives wastewater from municipal areas of these cities and industrial effluents of sugar, pulp and paper, distilleries and other miscellaneous industries through tributaries as well as direct outfalls.

Study area for the present work covers 160 km stretch of Hindon River starting from Purka Tanka village (Saharanpur) to Atali village (Muzaffarnagar). Fig 2.1 shows the profile of the Hindon River Stretch and Fig 2.2 shows the catchment area which is 3875 km^2 of Selected Stretch. Fig. 2.3 and Fig. 2.4 show the district boundary map of Saharanpur and Muzaffarnagar district respectively.

It has become dustbin for eventual disposal of all sorts of pollutants (waste water, debris etc.) due to the rapid and unplanned growth of human settlements along both sides of the river banks, insufficient sewage disposal and treatment facilitates, lack of bathing ghats, Dhobi Ghats (place for washing clothes), Place for washing of animals, vehicles etc. The study is to be concentrated on water quality assessment of the Hindon River to reduce the pollution in the Hindon River for study area.

The reason for selecting this stretch because upper part of the river basin in Saharanpur district has a large number of industries related to paper, milk products, distillery and many small scale cottage industries related to electroplating, paper board, chemicals, and rubber, etc. The waste effluents generated from these on lowlands and tributaries of the Hindon river system passing through the area. Much of these wastes apparently contaminate the receiving water as can be felt from the foul smell and anesthetic colour especially in the stretches to the downstream of the outfalls of waste effluents.

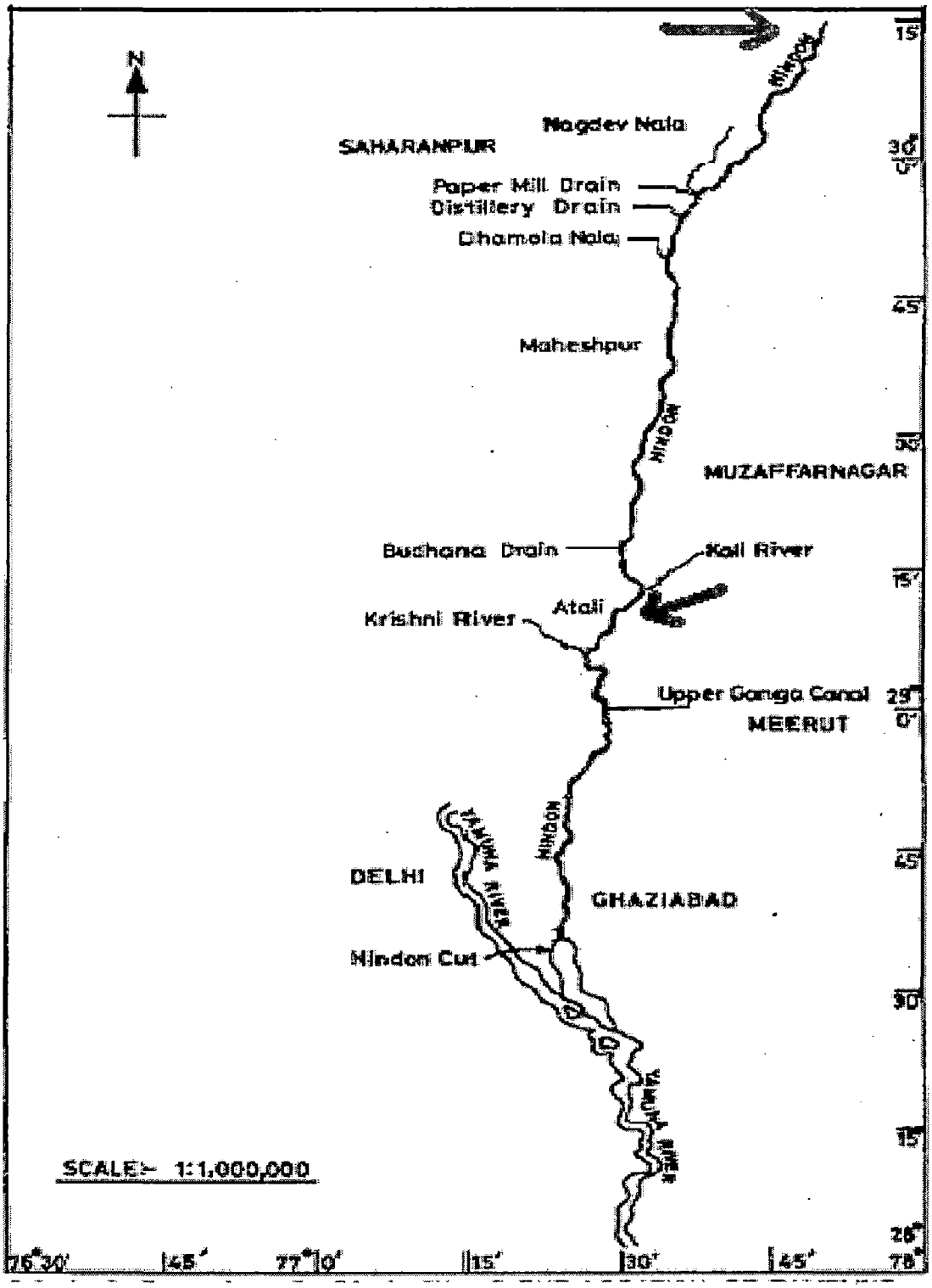

Fig 2.1: Profile of the Hindon River Stretch

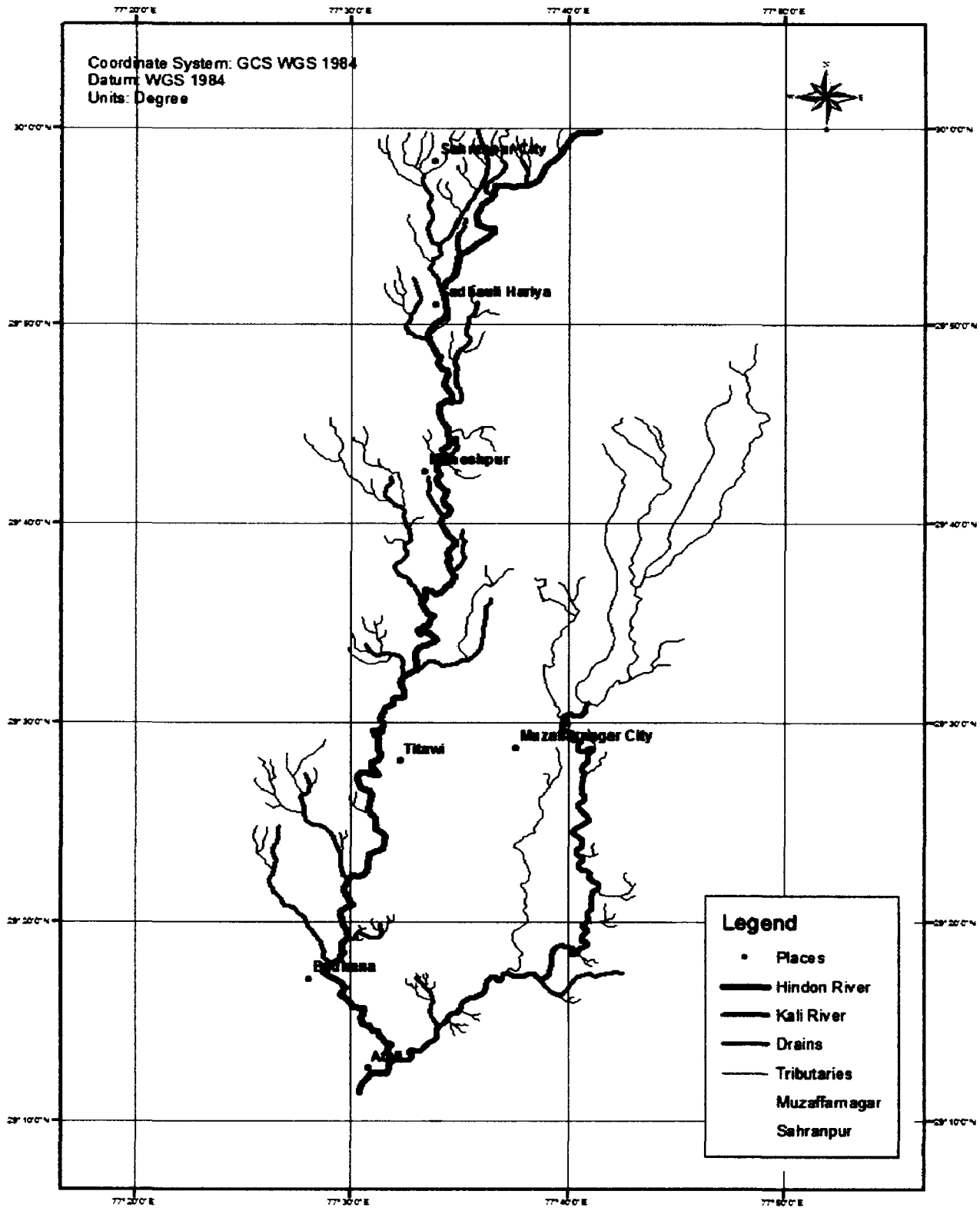

Fig 2.2: Catchment of Hindon River Stretch

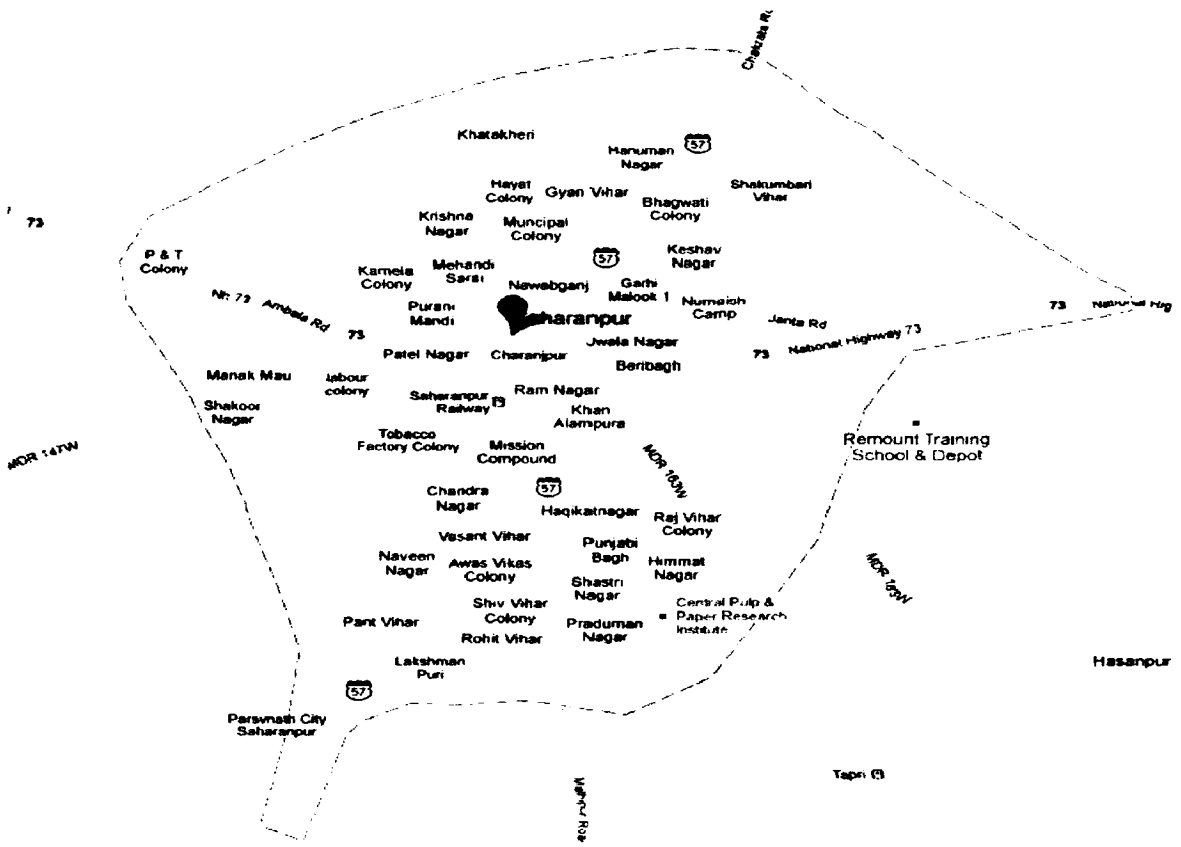

Fig 2.3: District boundary map of Saharanpur district

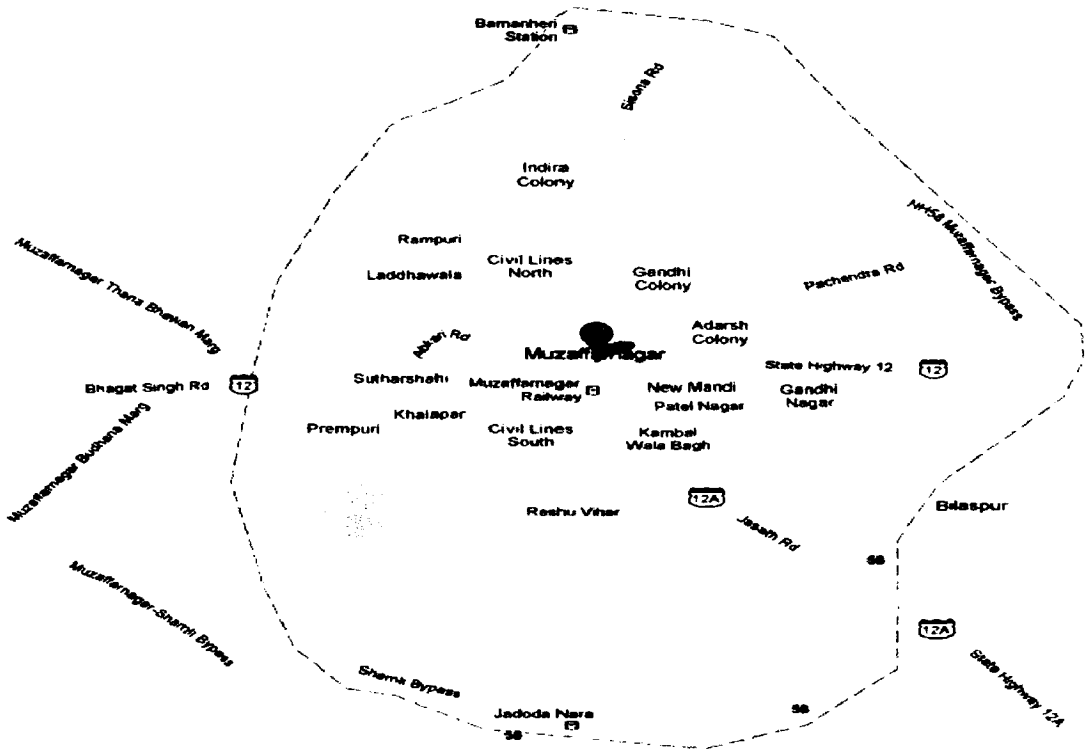

Fig 2.4: District boundary map of Muzaffarnagar district

The main effluent discharge in the upper part of the river system is from Star Paper Mill, Saharanpur, which is reported to be about 38 MLD. Beside this, the river has two drains in its upper portion, viz., Nagdev nala and Dhamola nala, which join the river Hindon near the village of Ghogreki and Sadhauli Haria, respectively. The municipal wastewater generated from the Saharanpur city is discharged to the Hindon River through Dhamola nala.

There is no wastewater collection and treatment system in the city. In addition, the wastes from several small units such as textile factory, sugar factory, cigarette factory, card board factory and laundries etc. also transfer their wastes to the Hindon River through Dhamola nala. The industrial effluent from Cooperative distillery also joins the river in this stretch.

In the mid portion of the basin, Kali River carrying the municipal and industrial effluents of Muzaffarnagar district joins the Hindon River near the village of Atali. River Krishni receiving wastes from sugar mill and distillery joins river Hindon near the village of Barnawa.

2.2 RIVER PROFILE

The Hindon Basin is a part of Indogangetic Plains, having a area of about 7000 km^2, composed of Pleistocene and sub recent alluvium and lies between latitude 28°30′ to 30°15′ N and longitude 77°20′ to 77°50′. The Hindon River originates from Upper Shivaliks (Lower Himalayas) at Purka Tanka village situated in the upper east area of Saharanpur district (Jain et al., 2001). The river flows for 260 kms through six districts until its confluence with the Yamuna River towards south of Tilwara village in Gautambudh Nagar district, downstream of Delhi In Ghaziabad district, the majority of the flow of the river is diverted to the Hindon cut canal at Mohan Nagar. Thereafter, the river flows downstream and joins the River Yamuna at the village of Tilwara (Jain et al., 2007) (Fig.2.5).

The Hindon River has two main tributaries, the Krishni River which originates at Kairi Village and joins the Hindon at Barnawa Village, and the Kali River (West) which originates at Dhanakpur Village and joins the Hindon River at Pithlokar. There are many others small tributaries and nallas which joins to the Hindon River (Heather, 2007). Length of Hindon River and its tributaries are given in Table 2.1.

Table 2.1: Lengths of Hindon River and its Tributaries

Name of the River	Total Length (km)
Hindon	260
Krishni	78
Kali (West)	75
Nagdevi	41
Dhamola	52
Paon Dhoin	20
Major Drains Related To The River	80
Total	**606**

Source: Hindon Ki Deh, an article by B.B.Singh (Former Principal of M.M.H. College, Ghaziabad)

2.3 HISTORY OF THE RIVER

The Hindon River formerly known as **Harnadi** (Jain et al., 2001), in particular, was the site of several skirmishes between Indian troops and British soldiers in 1857 including the Battle of Badli-ki-Serai and today, the graves of the British soldiers and officers can still be seen. Ghaziabad's place in Northern Indian history is assured by the birth of many freedom fighters who played a role in various revolutions all dedicated to the attainment of freedom for all who have lived – and are still living – there. An Indus Valley Civilization (3300–1300 BCE) site, Alamgirpur is located at the Hindon River, 28 km from Delhi (Ghosh, 1959). The Hindon Air Force Base of the Indian Air Force also lies on the bank of Hindon River in the Ghaziabad district on the outskirts Delhi.

2.4 HYDROMETEROLOGY OF THE CATCHMENT

The climate of the region is moderate subtropical monsoon type. The Hindon River is entirely rain fed and has a catchment area of 7, 083 sq.km. The average annual rainfall is about 1000 mm, the major part of which is received during the monsoon period. In non-monsoon months, the river is completely dry from its origin up to Saharanpur town. The basin is densely populated because of the rapid industrialization and agricultural growth during last few decades. The soil type of the basin is alluvial consisting of clay, silt and fine to coarse sand (Jain et al., 2001). On the basis of land use map the study area can be demarcated into five categories: agriculture (78.94%), urban area (6.63%), barren land (12.32%), forest cover (2.09%) and water bodies (0.02%) (Sharma et al., 2001).

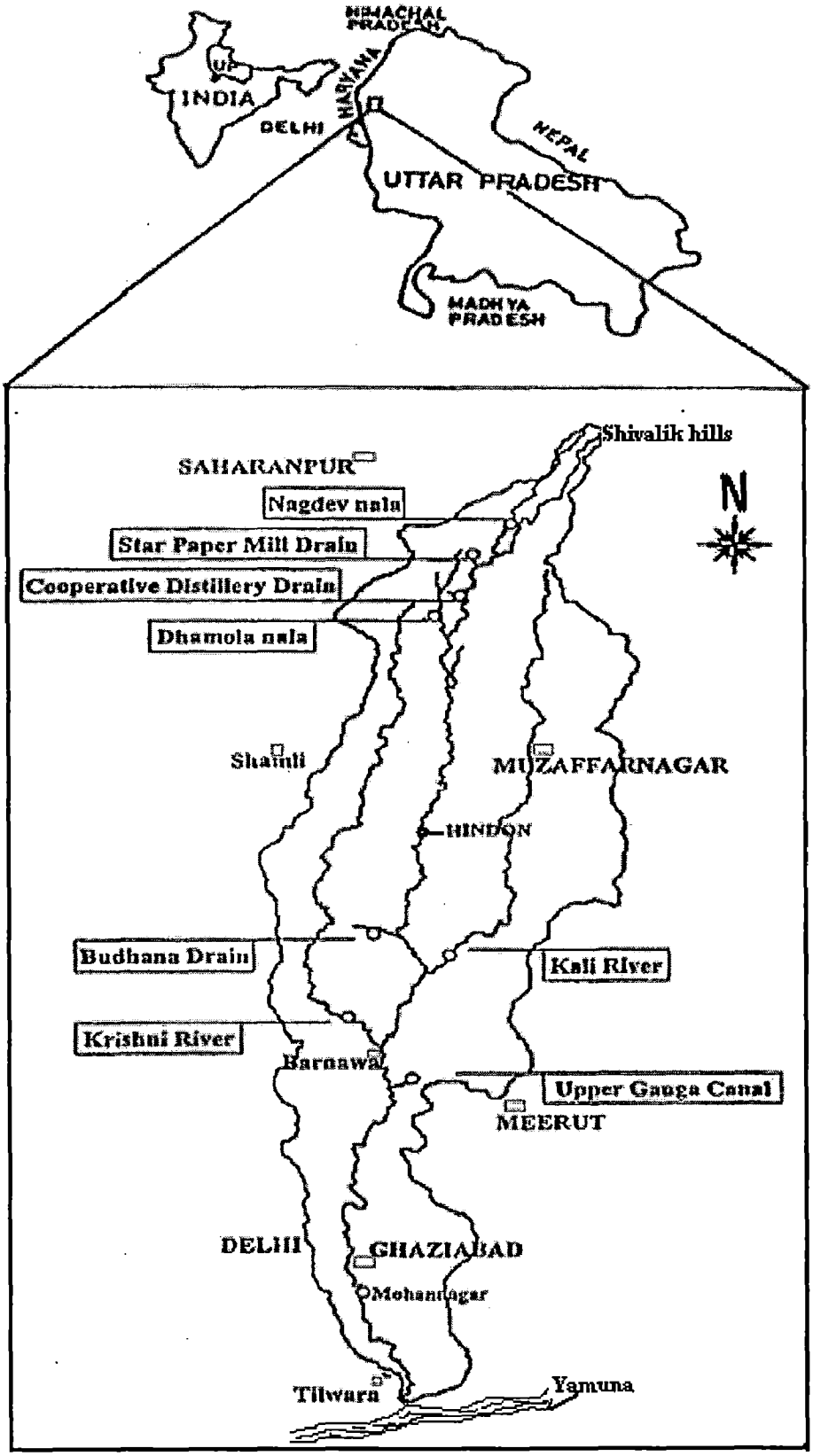

Fig 2.5: Hindon River Sub Basin (Jain et al., 2001)

2.5 SIGNIFICANCE OF THE RIVER

The Hindon River and its tributaries, Kali and Krishna is a major source of water to the highly populated and predominantly rural population of western Uttar Pradesh. It drains a catchment area of about 5,000 km^2 of farmland while also flowing through a number of substantial sized towns and villages.

Twelve villages in close proximity to the banks of the Hindon, with a total population of 6887, according to census 2011, are largely dependent on agriculture as a means of income. Residents of these villages lack clean water due to the pollution of Hindon River and contaminated ground water and have been forced to consume its water although it is unfit for domestic use and also use it for irrigation purposes (Heather, 2007).

2.6 PRESENT STATUS OF THE RIVER

The Hindon River water has been evaluated for physical and chemical characteristics, the presence of toxic contaminants and for biological diversity of river ecology. A once clean river has been reduced to a trunk sewer passing through urban towns, carrying a heavy load of pesticides released both from factories as well as agricultural runoff from the fields. Dissolved Oxygen levels are zero throughout the length of this river (Heather, 2007).

Untreated municipal wastes are known to contain a very high level of organic pollutants and suspended particulate matter, disease causing bacteria and other pathogens, as well as heavy metals which are not removed by conventional treatment are directly throw into the Hindon River. The river also receives a high loading of degradable and non-degradable domestic generated litter. Some of the pictures showing the pollution in Hindon River are given in Fig 2.6 to 2.9.

A wide range of highly toxic organochlorine and organophosphorus pesticides and heavy metals have been identified within rivers and groundwater throughout the catchment, at levels that exceed national and international standards for safe bathing and drinking water by several orders of magnitude. Concentrations of heavy metal in Hindon River and its tributaries are listed in Table 2.2 (Heather, 2007). Organochlorine and organophosphorus pesticides are shown to be entering water resources to toxic levels as a result of over-application of agricultural chemicals and heavy metals are

shown to be present as a direct result of discharge of large volumes of untreated industrial effluents.

Table 2.2: Heavy Metal Concentrations in Hindon River and its Tributaries

RIVER	CONCENTRATION of HEAVY METALS (mg/l)		
	Lead	Chromium	Cadmium
Kali (West)	BDL – 1.12	1.88 – 5.80	BDL – 0.003
Krishni	0.04 – 0.16	3.25 – 4.58	BDL – 0.005
Hindon	BDL – 1.79	1.84 – 12.25	BDL – 0.017

2.7 SOURCE OF POLLUTION OF THE RIVER

The main sources, which create pollution in the River Hindon include municipal waste of Saharanpur, Muzaffarnagar and Ghaziabad districts and industrial effluents of sugar, pulp and paper, distilleries and other miscellaneous industries through tributaries as well as direct outfalls. (Heather, 2007).

Today however, the Hindon has become a trunk sewer of the urban towns, carrying a heavy load of toxins from paper mills, sugar mills, distilleries, slaughter houses, dyeing and chemical industries and from pesticides in agriculture runoffs. About 60 industrial manufacturing units are located along the Hindon and its two main tributaries, the Kali (West) and Krishni rivers. "These industries both abstract large volumes of water from the river for their manufacturing processes, and also discharge their industrial effluents, often with nominal or no treatment, directly to the river" (Heather, 2007). The discharge from municipal and industrial areas as well as runoff from agricultural areas affects the quantity and quality of the river water. The effluents of Nagdev nala and Star Paper Mill at Saharanpur generate the flow of water in the river. The List of major industries discharging their effluent into Hindon River and its tributaries are given in Table 2.3 (Heather, 2007).

The lower reaches of Hindon River catchments receives further heavy loading of municipal effluents of Ghaziabad district, through the three sewerage drains and the Indrapuram Sewage Treatment plant, the only such facility within the whole Hindon River catchment. However, this treatment plant does not have adequate volume capacity and is inadequate to efficiently treat all domestic and municipal wastes in the

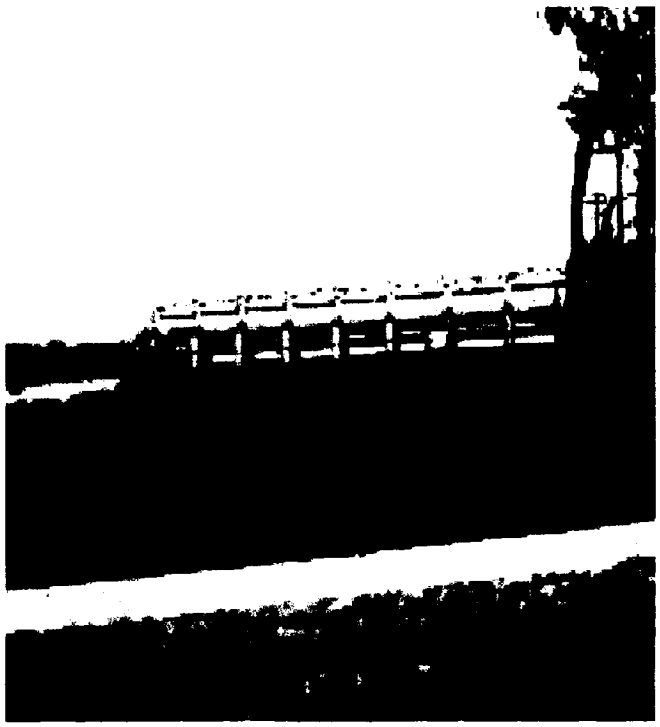

Fig 2.6: Floating Phytoplankton's (Ghaziabad)

Fig 2.7: Solid wastes and polythenes dumped by people in Hindon River (Muzaffarnagar)

Fig 2.8: Clothes washed on the Bank of Hindon River under the Hindon Bridge (Mohan Nagar)

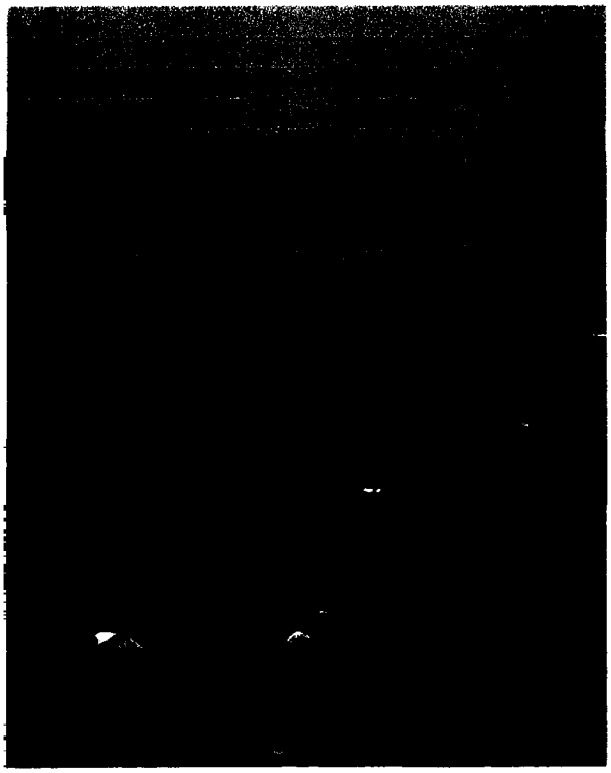

Fig 2.9: Garbage and remains of puja thrown into the Hindon River (Saharanpur)

catchment. There are no other formalized domestic waste water drainage systems along the course of the river which receives raw domestic waste directly from all the villages and towns through which it passes via open channels (Heather, 2007).The lower reaches of Hindon River catchments receives further heavy loading of municipal effluents of Ghaziabad district, through the three sewerage drains and the Indrapuram Sewage Treatment plant, the only such facility within the whole Hindon River catchment. However, this treatment plant does not have adequate volume capacity and is inadequate to efficiently treat all domestic and municipal wastes in the catchment. There are no other formalized domestic waste water drainage systems along the course of the river which receives raw domestic waste directly from all the villages and towns through which it passes via open channels (Heather, 2007).

The bridge over Hindon River also acts as an 'environmental disaster', because the artificial embankment erected for it could be damaged during the rainy season. The artificial embankment would not only pose a threat to the city and other surrounding areas but also disturb the ecological balance of the environment. The habitat of creatures and rare species would be disturbed by the construction of the bridge.

2.8 WATER QUALITY OF HINDON RIVER AND ITS TRIBUTARIES

Biochemical Oxygen Demand and levels of oxygen dissolved in the water column are good indicators of organic pollution levels. Organic pollutants such as sewage and food wastes have a high nutrient loading. These nutrients attract bacteria and other microbes. As these microbes digest the nutrients and proliferate, they consume oxygen within the water column. This reduces levels of oxygen available for the other aquatic organisms that form the populations of a healthy river, such as macro-invertebrates and fish. Under conditions of high BOD, a river suffocates and dies. A high BOD generally corresponds to low levels of dissolved oxygen within the water column.

The Central Pollution Control Board (CPCB) has set the standard for the levels of BOD acceptable for bathing water at 3 mg/l. Levels of BOD acceptable within a drinking water source without treatment is just 2 mg/l. A clean river with low organic pollution levels is also expected to have a BOD level of around 2 mg/l. The CPCB has also set minimum levels of dissolved oxygen required for bathing water at 5mg/l, and for drinking water before treatment at6 mg/l (CPCB). BOD levels found within the

Hindon River and the tributaries of the Kali River (West) and Krishni River are shown to massively exceed these BOD standards. Not one sample was suitable for drinking water or even bathing water purposes. Physical, Chemical, and Biochemical Parameters of Hindon River and its Tributaries are given in Table 2.4 (Heather, 2007).

From the Table 2.4, in the Krishni River BOD is above 1000 mg/l and dissolved oxygen level is zero throughout the length of this river. A river with no oxygen will be devoid of all aquatic life expected of a healthy river ecosystem. So, this river contributes the maximum amount of pollution in Hindon River.

Table 2.3: List of Major Industries Discharging to the Hindon River and Tributaries

DISTRICT	S.NO.	INDUSTRIES NAME
SAHARANPUR	1	Star Paper Mills Limited
	2	Daya Sugar Works
	3	Nagar Palika, Saharanpur
	4	The Cooperative Company Ltd., Tapri
MUZAFFARNAGAR	1	Titavi Sugar Mill, Titavi
	2	Bajaj Hindusthan Limited, Budhana
	3	Nagar Palika, Budhana
MEERUT	1	Kinauni Sugar Mill and Distillery
	2	Sardhana Paper Mill
	3	Dollar Sales Corporation, Sardhana
	4	Nagar Palika, Sardhana
GHAZIABAD	1	Ganga Paper Mill, Masoori Road
	2	Expliti Trading and Marketing, Masoori Road
	3	Triyesh Enterprises, Masoori Road
	4	Ved Pulp Tissues Pvt. Ltd., Masoori Road
	5	Vimal Organic, Bulandshahr Road
	6	Nagar Nigam, Ghaziabad
GAUTAMBUDH NAGAR	1	Sandeep Papers, Ph-I, Noida
	2	Kwatra Paper Mill, Noida
	3	Tristar Paper Mill, Noida

Table 2.4: Physical/Chemical/Biochemical Parameters of Hindon River and Tributaries

RIVER	PARAMETER					
	Transparency (cm), Top to Bottom	**pH**	**EC (µmhos)**	**DO (mg/l)**	**BOD (mg/l)**	**Cl (mg/l)**
Kali (West)	45 - 15	7.8 - 8.9	482 - 798	Nil - 13.6	3.2 - 320	12 - 60
Krishni	Nil - 10	4.8 - 7.9	1556 - 8290	Nil	800 - 9600	150 - 250
Hindon	Nil - 35	7.0 - 8.6	430 - 2525	Nil - 4.0	6 - 3600	22 - 270

2.9 IMPACT OF THE HINDON RIVER POLLUTION

The Hindon River in western Uttar Pradesh has become one of India's most polluted rivers due to callous industries as well as indifferent authorities and is causing serious diseases. The Hindon River contains toxic lead, cadmium, chromium, and traces of virulent pesticides. Not only has the surface water in the catchment area been contaminated, but contamination has also reached the groundwater level. This may affect millions of residents living in the catchment of the Hindon River and its tributaries who use the untreated ground water as their primary source of drinking water and irrigation.

A detailed health survey of the rural catchment population has identified alarming levels of serious debilitating illness such as, cancer, skin ailments, neurological disorders, and gastrointestinal problems which are directly attributable to the presence of dangerously high toxic pesticide and heavy metal contamination within the drinking water of these villagers. Women are most adversely affected because they perform domestic chores involving the use of water and often must walk long distances to fetch water from more adequate sources. Children are also especially susceptible to the water borne infections due to the contaminated waters, with negative impact on the enjoyment of the Right to adequate Food, in risk of developing malnutrition and even of death. Medical expenses incurred by villagers as a result of consuming contaminated drinking water are also shown to exert a heavy economic burden on a population already economically and socially marginalized. Results of heath survey done by Janhit foundation in the villages (Barnawa, Safipur, Momnathal, Simlana, Arthala, Markeda,

Nekpur, Sarabaad) situated near the bank of Hindon River are given in Table 2.5 (Heather, 2007).

Aquatic biodiversity of the Hindon River is entirely absent at almost all locations within the catchment due to a high loading of organic pollutants reducing oxygen levels and causing anoxic conditions in the river (Mahajan, 1988).

Table 2.5: Health Survey Results of villages on the bank of Hindon River

S. No.	Various ailments	No. of patients
1.	Cancer	90
2.	Skin related	3280
3.	Neurological Disorder	110
4.	Heart related	180
5.	Stomach ailments	2590
6.	Number of deaths in last five years due to serious ailments	490

Source: (Heather, 2007)

2.10 PRIOR CONSERVATION WORKS DONE BY GOVERNMENT

Rising pollution in the Hindon has been the biggest challenge for us. Over the years, domestic wastes, religious waste and untreated effluents from factories have raised pollution levels of Hindon River. The water quality of Hindon has not shown the desired improvement owing to large gap between the demand and availability of sewage treatment capacity and lack of fresh water in the river.

The Municipal Corporation of Ghaziabad (MCG) has launched its Yamuna Action Plan to clean up the Hindon River in 1998. This project has been launched as a part of the National River Conservation Programme for the six cities (Saharanpur, Muzaffarnagar, Meerut, Baghpat, Ghaziabad, and Gautambudh Nagar) of Uttar Pradesh. The projects taken up under YAP include all reforms like solid waste management of the city, maintaining sanitation levels around the river, interception and diversion of raw sewage, setting up of Sewage Treatment Plants, creation of low cost sanitation facilities, setting up of electric/improved wood crematoria etc.

In YAP-I, the drive was focused on 20 industries units in six districts to stop pumping industrial effluent into the river. During that period the industrial waste of 36 units flow into the Kali River and 14 units flow into Krishni River (the two tributaries of the Hindon River) also considered (Ghaziabad Nagar Nigam).

During YAP-I, it came out that the river water pollution cannot be lowered down without the active participation of the citizens. Therefore in YAP II a special component named as Public Participation & Awareness has been brought in wherein NGOs are partnering to work at the community level on different identified themes. In YAP-II there will be a mandatory launch of a project to treat waste before dumping it into the river and also a river conservation programme (Ghaziabad Nagar Nigam). Table 2.6 shows the various works done by government under different phases of YAP to protect Hindon River.

In another novel effort to prevent Hindon River from getting polluted from religious wastes, the Ghaziabad Municipal Corporation (GMC) has set up a huge prayer chamber filled with Ganga water along the banks. According to the survey done by Ghaziabad Municipal Corporation in 2010, Ghaziabad has 492 religious sites - 55 in Mohan Nagar, 123 in Vasundhara, 98 in Vijay Nagar, 112 in the city zone and 104 in Kavi Nagar (DPR Report for Ghaziabad, 2010). Even after putting up railings along the bridges and their peripheries (Fig. 2.8), people did not refrain from throwing waste into the river from vehicles and trains. The chamber, or ' Hawan Kund', will be used for immersing flowers and other objects used in religious rituals. Currently, these are thrown into the Hindon and are a major pollutant. To facilitate the transport of such ' religious' waste, the corporation has acquired special carrier vehicles for each of its five zones - Kavi Nagar, Vijay Nagar, Mohan Nagar, City and Vasundhara. They will be used for ferrying the waste from different parts of the city.

To protect Hindon River from pollution and encroachments, the government has decided to grow plants alongside the river banks (Fig.2.9 & Fig. 10) and clear the garbage and elephant grass from the banks. The plants grown alongside the river will virtually serve as a wall for Hindon which will help check encroachments made by the locals in addition to increasing the quantum of oxygen and green cover in the vicinity of the river. "Plants with deeper roots will protect sand erosion at the banks.

Table 2.6: Works done under different phases of YAP

S.No.	Scheme Name	Sanc. Cost Till Mar.10 (Lakhs)	Sanc. Date	Comp Date	Status
Yamuna Action Plan I, State: Uttar Pardesh, City: Ghaziabaad					
1.	Afforestation	2.19	08/12/1998	30/09/1999	C*
2.	Low Cost Sanitation	34.13	09/06/1994	30/11/1995	C
3.	STP(Cis-Hindon Area,70 mld)	112.73	14/02/1997	31/12/1997	C
4.	STP(Trans Hindon Area,56 mld)	1368.89	29/08/1997	31/08/1999	C
5.	Improved Wood Crematoria	13.83	09/06/1994	30/06/1995	C
Yamuna Action Plan II, State: Uttar Pardesh, City: Ghaziabaad					
1.	Low Cost Sanitation	252.29	27/06/2001	31/03/2002	C
2.	Public Participation	11.40	13/07/2001	31/03/2002	C
3.	Laboratory Equip. at Ghaziabad, Saharanpur & Noida	07.50	06/07/2001	31/12/2001	C
4.	Remedial Measures for Non-Sewage Facilities	00.64	06/07/2001	31/12/2001	C
Extended Yamuna Action Plan II, State: Uttar Pardesh, City: Ghaziabaad					
1.	Reform Action Plan	170.03	24/11/2006		C
2.	Consultancy Services for Master Plan	1193.58	29/11/2006	30/04/2009	C

Source: Ghaziabad Nagar Nigam

* Completed

2.11 NEED FOR CONSERVATION

Due to various sources of pollution as described above, the Hindon River stretch has been polluted and this pollution damages the conservation measures already taken by the Government with huge investment (Rs. 31.67 crores) in the downstream. Therefore it is necessary to formulate necessary conservation measures for the selected stretch of the Hindon River to preserve the whole River and also to reduce the pollution load to its main river, Yamuna.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Indiscriminate disposal of domestic waste water and industrial effluents into the Hindon River makes it to heavy damage in quality. To conserve the river, proper planning and execution of pollution abatement works in whole catchment of the river is essentially required. The present attempt is to formulate a long term conservation measures considering all physical, chemical and biological parameters.

3.2 QUALITY ASSESSMENT

For assessing the load of the river, samples were collected at Nineteen locations (6 industrial effluent or drain and 13 river water) during January and March 2012 by dip (or grab) sampling method. The discharge at all the sampling sites was also determined during each visit using a Seba current meter by the area velocity method.

3.2.1 Reconnaissance Survey

The reconnaissance survey has been performed before selecting the sampling station, sampling schedule and frequency of sampling. The following information's are collected / determined through the Reconnaissance Survey:

a) Following points observed:

1. Hindon River is much polluted and contributes a lot of pollution level into the Yamuna River.
2. The main sources of pollution are received through tributaries as well as direct outfalls from Nagdev nala and Star Paper Mill.
3. In the non-monsoon months, the river is completely dry, right from its origin up to Saharanpur town.
4. Confluence of Paper Mill and Distillery effluents, add high concentration of organic matter to the river, which decrease DO and an increase in BOD, COD and TDS.
5. Several crematoria's located on the bank of Hindon River also contributes pollution to the river.
6. River water is being utilized for agricultural purposes in various villages along the bank of the River.

7. Impact of the human activities upon the quality of the water and sustainability for use.

b) Following points were calculated:

1. Quantity of Domestic waste water being discharged into the river.
2. Quantity of Industrial effluents reaching the Hindon river water.
3. Quantity of Solid wastes dumping into the river.

3.2.2 Collection of Samples

The water and wastewater samples were collected from mid stream at about 15 cm depth using standard water sampler (Hydro Bios, Germany). The samples thus collected were stored in clean narrow mouth polyethylene bottles fitted with screw caps. Samples were preserved by adding an appropriate reagent. The samples thus preserved were stored at 4°C in sampling kits and brought to the laboratory for detailed chemical analysis. Physico-chemical analysis was conducted following standard methods.

All chemicals used in the study were obtained from AHEC biological lab and were of analytical grade. Double distilled water was used throughout the study. All glass wares and other containers were thoroughly cleaned and finally rinsed with double distilled water several times prior to use.

3.2.3 Parameters to be analyzed

Analyses of the following water quality parameters are to be carried out in order to detect pollution of a river. Samples are to be collected from the drainage outfall point, River as well as from the Sediments of the River.

1. Physical parameters like pH, Temperature (°C), Turbidity (NTU), TSS (mg/l), TDS (mg/l), Colour, Odor, Electrical conductivity (μ-mho/cm), & Radioactivity.
2. Chemical parameters like BOD(mg/l), COD (mg/l), DO (mg/l), Ca, Mg as $CaCO_3$, Oil & Grease (mg/l), Sulphates, and Chlorides.
3. Biological parameters like Total coliform (MPN/100ml), and Faecal coliform (MPN/100ml).

3.3 QUANTITY MEASUREMENT

The volume of wastewater generated by households is calculated with population forecasts and per capita water consumption. The population census 2011 is taken as the base population for forecasting the present, intermediate and ultimate populations. The minimum per capita water consumption of 135 lpcd as per CPHEEO manual for sewerage and sewage treatment plant is adopted. Generally sewer line is laid along roads so that the length of all kinds of roads (bitumen road, concrete road and cart track) and streets available in each town are collected to calculate the length of network system. According to the towns' requirements, suitable STP technology is proposed. For rural population low cost sanitation facilities (Community toilets or 50% financial assistance to individual toilets) are proposed. Total number of households in the rural catchment is 1, 80,495. A rapid survey shows 40 percent of households have individual toilet systems. Therefore, the number of households not having toilet facility is approximately 1, 08,297.

The volume of wastewater generated by the industries is calculated as per actual field surveys. In case the industrial effluent is let into the public collection system, it should be pre-treated to the required standards as per CPHEEO, by the industries themselves. If the industries have their own ETPs or CETPs then the treated effluent can be directly let into the river, provided the final effluent is as per the specified standards. According to the nature of industries, their location and effluent load suitable CETPs or ETPs are proposed.

As per report dated 10th January 2012, Sustainable solid waste management in India, 250g per capita for villages and 580g for towns in Uttar Pradesh state, are adopted for arriving the municipal solid waste generated in the villages and towns under the study areas. According to the solid waste load and availability of suitable disposal site, the numbers of solid waste processing units are fixed.

In all the above treatment processes, necessary resource recovery/recycling possibilities are to be analyzed for implementation.

3.4 RATE ANALYSIS

The unit rate for various items of work is as per the U.P. Jal Nigam Standard schedule of rates for the year 2011-2012 wherever possible. The unit rates have also

been derived for certain items of work based on U.P. PWD standard Data Book 1987. The land guideline values as per the U.P. Revenue Department are adopted for arriving land cost. For all electric energy related items, the current U.P. Electricity Board (UPEB) Rates are adopted. Wherever the rates are not feasible to arrive in above 3 ways, a lump sum rate as adopted by U.P. Jal Nigam as observed data on the basis of practical experience is adopted.

3.5 COST ESTIMATION

The cost estimation is made with the quantity estimated multiplied by the concerned item unit rate. For the miscellaneous items, suitable lump sum provisions have been made to arrive for the total conservation project cost. Price escalation at 5% , Insurance at 1.5%, Physical Contingency at 1%, Unforeseen Items at 2.5%, Supervision Charges at 5%, Service Charges for inter department payments at 1% are provided to account the total general cost estimation. The component wise cost analysis and estimation is given in Chapter 5, 6, 7 and 8. The general abstract estimate is given in Table 3.1.

Table 3.1: General Cost Estimation

S. No.	Description of Item	Amount Rs (in Crores)
1	Providing Sewerage Schemes to urban population and Sanitation facilities to rural population	732.03
2	Capital Investment Requirement for MSWM system in	
a)	Saharanpur Municipal Corporation	102.66
b)	Muzaffarnagar Municipal Corporation	113.51
3	Installation of CETPs for Industries	217.45
	Sub-Total	1165.65
	LUMP SUMP PROVISIONS	
1	Shifting of water, power or telephone lines	11.66
2	Public Awareness and Public Participation	3.95
3	Insurance at 1.5%	17.49

4	Physical Contingency at 1%	11.66
5	Unforeseen Items at 2.5%	29.14
6	Supervision Charges at 5%	58.28
7	Service Charges for inter department payments at 1%	11.65
8	Price Escalation for 3 years at 5% for each year	183.73
	Total	**1493.21**

3.6 WORK PLAN

In accordance with the volume of work load, value of works involved and the institutional arrangements, the work is planned to be executed in several phases in long term basis, from 5 to 10 years. Then the work schedule for each item of work is prepared. Finally the year wise funds requirement statement is prepared for projection of funds by the government for this conservation projects.

CHAPTER 4

RIVER WATER QUALITY ASSESSMENT

4.1 GENERAL

Anthropogenic interventions to the river and the catchment area are, ultimately, manifested by the change in physical, chemical and biological parameters of the river and its environment. These parameters indicate the status of the river with respect to its degradation and also relate qualitatively and quantitatively to the existing point and nonpoint sources of pollution load. This underlines the importance of sustained monitoring and analysis of water of the river for suggesting more accurate restoration and conservation measures for the river environment.

The Hindon River is utilized by a wide range of industrial uses along its length. Indeed, the Hindon River and its two main tributaries, the Kali (West) and the Krishni Rivers, together have 60 industrial manufacturing units. These industries both abstract large volumes of water from the river for their manufacturing processes, and also discharge their industrial effluents, often with nominal or no treatment, directly to the river.

Agricultural practices within the Hindon River catchment have an important effect on the quality of the river. The river is a primary source of water for irrigation of agricultural land in the locality. Abstraction for irrigation reduces natural freshwater flows within the Hindon River, reducing dilution potential of the river and concentrating the effects of other pollutants entering the river. Surface water runoff from agriculture carries with it a number of suspended pollutants particularly elevated suspended sediments due to soil erosion, and agricultural chemicals such as pesticides and fertilizers. Agricultural chemical fertilizers have also been demonstrated to contain heavy metals.

In this study, surface water quality of the Hindon River has been analyzed to know the status of the river in order to suggest the conservation plan. It has been tried to establish variation of various parameters of water quality of Hindon River with respect to distance.

4.2 SAMPLING POINTS

Samples of Hindon River water were taken in 19 locations, 6 locations at its tributaries indicated by Station A to Station F and 13 locations at different points in Hindon River indicated by Station R1 to Station R13 as mentioned in Fig 4.1. Each sampling station can be characterized as follows:

4.2.1 Waste Effluents/Tributaries

Station A (Nagdev Nala) is located in the Nagdev nala at village Beherki, through which industrial effluents of some of the industries located in Saharanpur is discharged into the Hindon River.

Station B (Star Paper Mill) is located in the Star Paper Mill effluent drain at village Paragpur.

Station C (Cooperative Distillery) is located in the Cooperative Distillery drain at village Yusufpur, through which distillery effluent is discharged into the river Hindon.

Station D (Dhamola Nala) is located in the Dhamola nala at village Nanandi, through which municipal waste of Saharanpur city is discharged into the Hindon river.

Station E (Budhana Drain) is located in the Budhana drain near Bus Stand, through which municipal waste of the Budhana town is discharged into the river Hindon.

Station F (Kali River) is located in the Kali River at village Ratanpuri downstream of the bridge over the Budhana-Khatauli road through which municipal and industrial waste effluents of Muzaffarnagar city is discharged into the Hindon River.

4.2.2 River Water

Station R-I (Gagalheri) is located in the unpolluted zone at village Khajnawar, where the water is available only in monsoon period. The water at this point is very clean. The banks are high with sandy soil.

Station R-2 (Ghogreki) is located downstream of Nagdev nala at village Ghogreki. At this water is light brown in colour.

Station R-3 (Santagarh), is located downstream of Star Paper Mill at village Santagarh. The water is brown with oozing substratum. The pulp fibers are found lying in the bed and on the bank of the river.

Station R-4 (Nanandi) is located near village Nanandi before the confluence of Dhamola nala. The river banks are sleepy with black muddy and oozing substratum which is full of pulp fibers.

Fig 4.1: Hindon River Map showing Sampling Points

Station R-5 (Sadhauli Hariya) is located near cremation ghat at village Sadhauli Hariya. The substratum is oozing and muddy. The colour of the water is brown black. The banks on both the sides are plain.

Station R-6 (Bhagwanpur) is located near the village of Bhagwanpur. The water is light brown in colour and the banks are high with sandy soil.

Station R-7 (Maheshpur) is located near the village of Maheshpur downstream of the bridge on Deoband road.

Station R-8 (Kanheri) is located near the village of Kanheri. Lot of phytoplankton's is grown at this place.

Station R-9 (Titawi) is located downstream of Titawi sugar mill drain at village titawi. The water is brown in colour.

Station R-10 (Dulhara) is located near the village of Dulhara downstream of the bridge. The water is clear with sandy and stony bed.

Station R-11 (Budhana) is located near the village of Budhana. The banks are high with sandy soil.

Station R-12 (Chandheri) is located downstream of Budhana drain at village Chandheri. The banks are high with sandy soil.

Station R-13 (Atali), is located near the village of Atali, just after the confluence of river Kali, The River is wide with high banks. The water is light brown in colour. The soil is sandy mixed with clay. A large quantity of water from Upper Ganga Canal is released into the river Kali through Khatauli escape.

The river water was evaluated for physical and chemical characteristics, the presence of toxic contaminants (heavy metals and pesticides) and for biological diversity of river ecology. Physical, chemical and biochemical parameters where chosen for analysis for each sample taken, including Dissolved Oxygen and Biochemical Oxygen Demand (BOD). These parameters where chosen for assessment as they give a good overview of general water quality. Fig 4.2 to Fig 4.7 shows the different locations of Hindon River & its tributaries.

Fig 4.2: River showing no flow in Hindon River near Gagalheri

Fig 4.3: Drainage from Star paper mill

Fig 4.4: Nagdev Nala, a tributary of Hindon River

Fig 4.5: Confluence of Nagdev Nala to Hindon River

Fig 4.6: Hindon River near Maheshpur village sampling point village

Fig 4.7: Dhamola Nala, a tributary of Hindon River

River water samples were collected using a Hydro-Bios standard water sampler in February 2012. At each station three samples were collected from 1/3, 1/2 and 2/3 width of the river along transect and mixed together to obtain a composite sample. All the samples were collected from the upper 15 cm of the water surface and stored in polyethylene bottles fitted with screw caps. Samples were preserved by adding an appropriate reagent and brought to the laboratory in sampling kits maintained at 4°C for detailed chemical analysis. The physico-chemical analysis was performed following standard methods (APHA, 1985, Jain and Bhatia, 1987). The accuracy of the methods is greater than ± 10%. The discharge at all the sampling sites was also determined during each visit using a Seba current meter by the area-velocity method.

4.3 TYPES OF SAMPLES

The samples must be representative in nature. The samples are generally of three types (Mark, 2006):

1. **Grab sample:** It is a sample taken at a sampling point and time. The sample is collected from the main current and 20 to 30 cm below the surface to avoid collection of scum. This sample may be taken to represent the water quality of the source.
2. **Composite sample:** It is a combination of equal volumes of a number of grab samples collected at the same location at different times. Composite samples may be required only in special cases for calculation of mass flux in rivers when the quality of water is suspected to change over short periods of time.
3. **Integrated sample:** It is a mixture of grab samples collected simultaneously at different locations across the width of the river or at different depth. The need for an integrated sample may occur for very wide and deep rivers where the quality of water may vary across its width and depth.

   For our study Grab sample was collected.

4.4 METHOD OF WATER AND WASTE WATER SAMPLING

The method of water and wastewater sampling mainly depends on the nature of analysis to be carried out. Analysis may be broadly divided into physiochemical, bacteriological and biological categories (Mark, 2006).

1. **Water samples for Chemical analysis:** The water samples are collected from a depth of 20-30 cm from the river by the plastic containers of minimum 5 liter of capacity, provided with double cap device. The samples are collected up to the top, without leaving any space so as to prevent the premature release of dissolved gases during the transit period.
2. **Water samples of Bacteriological analysis:** The water samples are collected from 30 cm depth of the river in properly sterilized neutral glass bottles of 120 ml capacity. The water sample is not collected up to the top of the glass bottles due to the survival of bacteria. The water samples are analyzed within 24 hours of collection.
3. **Water samples of Biological analysis:** The river water up to a depth of 10 cm are collected in wide mouth glass bottles of 1 liter capacity and preserved by using 1ml of Lugol's solution. The collection of samples was done in the morning time. All the samples were brought to the laboratory and stored at 4°C in a refrigerator till the analysis was completed.

4.5 PERIOD OF SAMPLING

The samples were collected in January and March, 2012 from thirteen sampling points. The sampling schedule for both the seasons is shown in Table 4.1.

4.6 EXPERIMENTAL WORKS

Physicochemical and bacteriological parameters were evaluated identification and tests are performed according to the methods specified in "Standard Methods for the Examination of Water and Wastewater" (APHA-AWWA-WPCF-1995). The techniques, instruments and principles involved in arriving at different water quality parameters are tabulated in Table 4.2

Table 4.1: Sampling Schedule

January, 2012			March, 2012		
Sampling Points	Date of Sampling	Time of Sampling	Sampling Points	Date of Sampling	Time of Sampling
1	11.01.12	10.05AM	1	11.03.12	10.30AM
2	11.01.12	11.40AM	2	11.03.12	11.34AM
3	11.01.12	01.10PM	3	11.03.12	12.30PM
4	11.01.12	02.18PM	4	11.03.12	01.18PM
5	14.01.12	10.40AM	5	14.03.12	10.10AM
6	14.01.12	11.17AM	6	14.03.12	11.26AM
7	14.01.12	12.21PM	7	14.03.12	12.48PM
8	14.01.12	01.35PM	8	14.03.12	01.55PM
9	14.01.12	02.48PM	9	14.03.12	02.55PM
10	18.01.12	10.15AM	10	18.03.12	10.45AM
11	18.01.12	11.27AM	11	18.03.12	11.47AM
12	18.01.12	12.38PM	12	18.03.12	12.58PM
13	18.01.12	01.55PM	13	18.03.12	02.15PM

Table 4.2: Summary of principles and methods

Sl. No.	Parameters	Principles	Instrument / Technique used
1.	Temperature	Metric	Thermometer.
2.	pH	Electrometric	Digital pH meter
3.	Total Dissolved solids	Gravimetric	Evaporation of filtrate (Whatman paper no. 44) at 103^0-105^0C
4.	Specific conductance	Electrometric	Digital conductivity meters
5.	Dissolved oxygen	Electrometric	Digital D. O. meters
6.	Hardness	Volumetric	Titrimetric method using EDTA soln. (0.01 M).
7.	Alkalinity	Volumetric	Titrimetric method using 0.02 N H_2SO_4
8.	BOD	Volumetric	Dilution technique and keeping the sample at 20°C for 5-days followed by winkers method.
9.	COD	Electrometric	Digital COD meter
10.	Nitrate	Colorimetric	Hach make Spectrophotometer
11.	Sulphates	Volumetric	Precipitate as $BaSo_4$
12.	Phosphate	Colorimetric	Hach make Spectrophotometer
13.	Chloride	Volumetric	Titrimetric method using $AgNo_3$
14.	Total coliform	MPN-index	Mc. Concey's browth at 35°C for 48 hrs

4.7 RESULTS AND DISCUSSIONS

The physico-chemical characteristics of the various waste effluents/tributaries discharged into river Hindon are given in Table 4.3 and Table 4.4 to assess the deterioration of river water quality.

4.7.1 Characteristics of Wastewater of Nagdev Nala, Saharanpur

The Nagdev nala receive municipal waste water of the adjoining villages and industrial wastes from some industrial unit's e.g. paper and board mill, leather board and tannery, steel rolling mills, dairy and food mills etc. The pH of the waste effluent of the Nagdev nala varies from 7.4 to 7.6 indicating alkaline nature of the waste water. High values of BOD and COD indicates organic contamination of the waste water.

4.7.2 Characteristics of Star Paper Mill Effluent, Saharanpur

The Star Paper Mill is located on the north-east of the Saharanpur railway station and manufactures all varieties of writing, printing, craft wrapping and wall papers. The raw materials used in the factory include wood, bamboo, jute sticks, straw, hemp, sawai, and sabal grass. The important chemicals used by most of the paper and pulp mills are sodium sulphate, sodium hydroxide, sodium sulphide, sodium carbonate, calcium hypochlorite and magnesium bisulphite.

Obviously, wastewater containing various amounts of these chemicals may be hazardous to the aquatic life. The wastes from different other small units flow separately for some distance but finally join at one point and form the combined waste of pulp and paper mill.

The combined effluent from the factory is discharged into the river through an open channel. The channel is about 3 km in length and opens on the right bank of river Hindon near the village of Paragpur, the waste is discharged with a considerable force. Due to the presence of caustic soda and other alkaline mixtures, a soapy and fibrous froth is continuously generated at the point of discharge. A characteristics smell of sulfate mercaptan and sulphide is very strong in this area. The effluent imparts a dark brown colour to the river water.

Table 4.3: Physico-chemical characteristic of tributaries of Hindon River (January 2012)

S.No.	Parameters	Sampling Locations					
		Nagdev Nala (A)	Star Paper Mill (B)	Cooperative Distillery (C)	Dhamola Nala (D)	Budhana Drain (E)	Kali River (F)
1	pH	7.4	8.4	5.5	7.6	7.2	7.8
2	DO, mg/l	0.4	0.8	1	0.8	1.9	1.4
3	BOD, mg/l	185	253	234	208	236	250
4	COD, mg/l	264	348	313	292	320	355
5	Conductance, µS/cm	920	1320	1400	902	1820	987
6	TDS, mg/l	570	1110	1218	676	1293	890
7	Alkalinity, mg/l	208	260	280	302	443	466
8	Hardness, mg/l	285	437	392	264	423	290
9	Sulphate, mg/l	65	290	145	96	128	105
10	Phosphate, mg/l	1.2	1.42	0.79	2.07	4.8	1.2
11	Nitrate, mg/l	4.1	4.5	6.9	3.2	4.4	5.8
12	Chloride, mg/l	145	350	95	54	105	83
13	Discharge, m^3/s	0.32	0.47	0.38	1.4	1.1	2.4

Table 4.4: Physico-chemical characteristic of tributaries of Hindon River (March 2012)

S.No.	Parameters	Sampling Locations					
		Nagdev Nala (A)	Star Paper Mill (B)	Cooperative Distillery (C)	Dhamola Nala (D)	Budhana Drain (E)	Kali River (F)
1	pH	7.6	8.2	5.9	7.8	7.4	8.1
2	DO, mg/l	0.2	0.3	0.8	0.5	1.6	1.2
3	BOD, mg/l	210	286	256	227	238	288
4	COD, mg/l	292	368	348	334	340	385
5	Conductance, µS/cm	1050	1565	2130	916	2065	1655
6	TDS, mg/l	680	1260	1586	1086	1390	947
7	Alkalinity, mg/l	223	296	320	310	476	420
8	Hardness, mg/l	385	455	405	280	487	358
9	Sulphate, mg/l	72	305	165	84	136	102
10	Phosphate, mg/l	0.9	1.52	0.89	2.67	4.5	1.4
11	Nitrate, mg/l	3.8	4.9	6.4	3.8	5	5.4
12	Chloride, mg/l	152	255	105	66	120	95
13	Discharge, m^3/s	0.27	0.41	0.32	1.3	0.95	1.98

4.7.3 Characteristics of Effluent of Cooperative Distillery, Saharanpur

The physico-chemical characteristics of the waste effluent of Cooperative distillery are given in Table 4.4. The distillery effluent resulting from cane molasses based alcohol industry is one of the highly polluting industrial effluents. The pH of the distillery effluents vary from 5.1 to 5.8 indicating acidic nature of the effluent. The BOD and COD of the distillery effluent were found to be very high indicating very high pollution potential of distillery effluent on the river water quality.

4.7.4 Characteristics of Wastewater of Dhamola Nala, Saharanpur

Other sources of pollution in Hindon River are the city sewage of Saharanpur and several other wastes from textile mill, sugar mill, cigarette factory, card board factory, laundry and other small industrial units which discharge their waste effluents in Dhamola nala which in turn opens into Hindon River. The water samples from the Dhamola nala were collected from the village of Nanandi. At this point domestic animals (cows and buffaloes) take bath in the wastewater.

It is clear from the results, that the wastewater of Dhamola nala contains large amount of solids, moderate BOD and COD. It also contains toxic substances like ammonia and suspended solids. The pH of the wastewater varies from 7.1 to 8.4 indicating alkaline character of the wastewater. The dissolved oxygen content in the wastewater is almost nil throughout the year.

4.7.5 Characteristics of Wastewater of Budhana Drain, Budhana

The municipal wastewater of Budhana drain is discharged into river Hindon near Budhana bus stand. The contents of dissolved solids are much higher in the Budhana drain as compared to Dhamola nala. The pH of the wastewater is alkaline in nature and the flow in the drain is negligible as compared to Dhamola nala but the organic load is higher than that of Dhamola nala. These observations indicate that the Budhana drain contains concentrated wastes and there is not much dilution of the waste water.

4.7.6 Characteristics of Wastewater of Kali River

The Muzaffarnagar portion of the catchment is not directly contributing municipal and industrial effluents into the Hindon River. Muzaffarnagar are discharging their wastes in Kali River which is subjected to varying degree of pollution

caused by numerous untreated outfalls of municipal and industrial effluents. The waste effluents stagnate in the river for a long time because of which the biological action starts and obnoxious condition soon develop in the region. This septic condition results in the production of hydrogen sulphide gas imparting black colour to the river water. It can be observed from the results that the discharge of the Kali River in the Hindon River is hazardous due to high values of BOD, COD and other constituents.

4.7.7 Characteristics of Wastewater of Hindon River

The upper part of the river basin falls in the Saharanpur district, and has a large number of industries related to paper, milk products, distillery and small scale cottage industries pertaining to electroplating, paper board, chemicals, and rubber, etc. The waste effluents generated from these industries are released either directly on the lowlands or into the tributaries of the Hindon River in their vicinity. Much of these wastes contaminate the receiving water, especially in the stretches immediately downstream of their outfalls.

The main effluent discharge into the upper part of the river system is from the Star Paper Mill, Nagdev nala and Dhamola nala, which join the Hindon near the village of Paragpur, Ghogreki, and Sadhauli Hariya respectively. The municipal wastewater generated from the Saharanpur city is discharged to Hindon River through Dhamola nala. There is no wastewater collection and treatment system in the city. In addition, the wastes from several small units such as textile factory, sugar factory, cigarette factory, cardboard factory and laundries etc. also transfer their wastes to the Hindon through the Dhamola nala. The industrial effluent from the Cooperative Distillery also joins the river in this stretch.

In the mid portion of the basin, the Kali River carries the municipal and industrial effluents of Muzaffarnagar district and joins the Hindon near the village of Atali. In addition, some local drains from villages and towns also join the river. There are no notable waste outfalls in the lower portion of the study area.

The Hindon River has not been used at any place in its course of flow for organized water supply. The local fishermen use the river water for fishing, fish-seeds and fingerlings of several crops. The river is also utilized to flush the water of the Yamuna through the Hindon cut canal in Delhi. The water quality of the river has been monitored at 13 locations (Figure 4.1) on the basis of contribution of pollution load by

point sources to assess the impact of waste effluents. The longitudinal variations of various constituents are shown in Figure 4.8 to Figure 4.19.

The results of the analysis have been shown in Table 4.5 and Table 4.6. The river water has a foul and pungent organic odor at station R-2 to R-5 due to the discharge of pulp and paper mill effluent. The odor becomes much more pronounced in the summer months. In addition to the floating froth and foam, the river water also becomes brown in color owing to the discharge of pulp and paper factory effluent. The water is dark brown at stations R-2 and R-3, and becomes light brown with a black tinge at stations R-4 and R-5. The brown color of the water decreases the penetration of light and affects the spectrum of the light wavelengths which penetrate into the river water. The change in the wavelength and its reduction in intensity limits the growth of phytoplankton and other aquatic plants which are of great importance, not only because they form an important link in the food chain cycle of aquatic habitats, but also because they produce oxygen by photosynthetic activity which plays an important role in re-aeration of streams and in natural self-purification processes.

The pH of the river water was always found towards the alkaline side except at station R-4, where the river water is acidic in nature. At station R-4, the pH value gets reduced due to the mixing of distillery effluent and then slightly increased from station R-5 to R-8 after the discharge of wastewater from Dhamola nala. The values of pH show almost the same trend in the downstream section between stations R-9 to R-13. The variation in pH at different sampling stations is well within the range of tolerance by fish.

The contents of total dissolved solids vary from 885 to 1022 and 1030 to 1305 mg/L at station R-3 and R-4 respectively, mainly due to the mixing of effluent from the Star Paper Mill and Cooperative Distillery. The excess dissolved solids create an imbalance due to increased turbidity and causes suffocation of fish even in the presence of high dissolved oxygen. The dissolved solids decreased considerably at station R-5, R-6 and R-7 due to the dilution effect of the Dhamola nala, which has significant flow throughout the year. A slight increase in dissolved solids was observed at station R-8 due to the discharge of wastewater from the Budhana drain, which then indicated a slight decreasing trend in the downstream section of the river.

The critical situation as observed for dissolved oxygen at stations R-2 and R-3. The sudden fall in dissolved oxygen at stations R-2 and R-3 is attributed to the discharge of untreated municipal and industrial wastes from Nagdev nala, Star Paper Mill and Cooperative Distillery. However, the distribution of dissolved oxygen at all the stations is not the same. The dissolved oxygen content gets reduced to zero at station R-2 and R-3 during summer months so that a complete anaerobic condition is developed. This indicates that the river flow is mainly composed of the wastewater generated from industries. The DO values gradually improve from station R-4 to R-8 due to re-aeration and photosynthesis.

The Kali River, carrying wastewater of municipal and industrial establishments of Muzaffarnagar district, meets the Hindon at Atali village (Station R-13), thus augments the flow of the Hindon. A substantial amount of water is discharged in the Kali from the Upper Ganga Canal at Khatauli. The level of dissolved oxygen in the Hindon after the confluence with the Kali deteriorates further, and is observed to be nil during summer months.

BOD levels found within the Hindon River and the tributaries of the Kali River (West) are shown to massively exceed these BOD standards. Not one sample was suitable for drinking water or even bathing water purposes. As expected, dissolved oxygen levels are zero throughout the length of this river. A river with no oxygen will be devoid of all aquatic life expected of a healthy river ecosystem. The high values of BOD were observed at stations R-3 and R-4 due to the discharge of paper mill and distillery effluents. The higher values of BOD observed at these stations indicate a high degree of organic pollution in this stretch of the river. The effluent of pulp and paper mill and distillery adds to the high concentration of organic matter in the river, which is responsible for a remarkable decrease in DO, along with increase in BOD, COD and TDS. From station R-5 to R-8, the oxygen condition improves significantly with the lowering of BOD values but at station R-9 BOD value again increased due to effluent coming from Titawi drain. Upstream of Atali village, the Hindon has little flow due to significant abstraction for irrigation by the farmers along its course. At Atali village (Station R-13), the Kali joins the Hindon and the water quality of the Hindon is controlled by the inputs from the Kali.

Table 4.5: Average Value of Water Quality Parameters Tested (January 2012)

S.No.	Parameters	Sampling Locations												
		R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13
1	pH	_	7.4	7.6	6.6	7.2	7.3	7.4	7.2	7.6	7.4	7.2	7.4	7.6
2	DO, mg/l	_	0.4	0.2	0.4	0.3	0.8	1.3	1.8	0.6	1.6	1.9	0.8	1.2
3	BOD, mg/l	_	185	205	207	218	198	184	166	194	174	162	215	235
4	COD, mg/l	_	264	295	314	334	290	276	262	285	268	245	298	320
5	Conductance, µS/cm	_	920	1020	1325	1110	964	885	85	1255	1185	976	1790	1490
6	TDS, mg/l	_	570	885	1030	922	880	845	824	1155	920	860	1122	925
7	Alkalinity, mg/l	_	208	220	257	263	257	248	220	270	255	220	320	345
8	Hardness, mg/l	_	285	315	343	287	256	242	212	350	332	298	343	310
9	Sulphate, mg/l	_	65	247	217	180	165	140	115	124	105	97	116	86
10	Phosphate, mg/l	_	1.2	1.34	1.14	1.92	1.81	1.55	1.66	1.98	1.55	0.9	3.4	2.2
11	Nitrate, mg/l	_	4.1	4.3	5.4	4.4	3.9	3.5	3.2	3.8	3.3	3.1	3.9	4.3
12	Chloride, mg/l	_	145	205	165	98	85	56	42	98	80	74	98	82
13	Discharge, m^3/s	_	0.27	0.53	0.97	1.8	1.27	0.92	0.76	1.2	0.98	0.56	1.83	3.12

Table 4.6: Average Value of Water Quality Parameters Tested (March 2012)

S.No.	Parameters	Sampling Locations												
		R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13
1	pH	_	7.6	7.8	6.9	7.5	7.4	7.7	7.6	8.2	8.1	7.8	7.6	7.8
2	DO, mg/l	_	0.2	0.1	0.2	0.4	0.6	0.2	1.4	0.2	1.2	1.4	0.8	0.3
3	BOD, mg/l	_	210	245	234	225	205	192	168	222	162	154	215	247
4	COD, mg/l	_	292	344	325	356	317	296	275	322	286	268	317	334
5	Conductance, µS/cm	_	1050	1230	1760	1726	1334	1110	980	1300	1292	974	1880	1730
6	TDS, mg/l	_	680	1022	1305	975	895	868	843	1225	980	825	1260	1110
7	Alkalinity, mg/l	_	223	248	288	275	262	255	235	295	267	245	364	385
8	Hardness, mg/l	_	385	418	437	360	342	327	302	385	357	344	397	420
9	Sulphate, mg/l	_	72	270	182	168	145	135	125	144	95	86	106	92
10	Phosphate, mg/l	_	0.9	1.38	1.07	2.2	1.95	1.7	1.55	1.92	1.68	1.57	4.2	2.02
11	Nitrate, mg/l	_	3.8	4.6	5.8	4.5	3.6	3.4	2.9	3.9	3.6	2.6	3.8	4.8
12	Chloride, mg/l	_	152	210	118	80	77	65	56	115	95	76	106	96
13	Discharge, m^3/s	_	0.32	0.73	0.97	2.5	1.42	1.28	0.8	1.8	1.2	0.7	2.52	3.9

Table 4.7: Calculation of NSFW Quality Index in Hindon River (Jan. 2012)

S. No.	Sample	pH		DO		BOD		Phosphate		Nitrate		NSFW Q Index	
	points	Data	Q Value	Data	Q Value	Data	Q Value	Data	Q Value	Data	Q Value		
1	Ghagreki (R2)	7.4	93	0.4	4	185	2	1.2	36	4.1	70	32	Bad
2	Santagarh (R3)	7.6	92	0.2	3	205	2	1.34	33	4.3	69	36	Bad
3	Nanandi (R4)	6.6	75	0.4	4	207	2	1.14	37	5.4	63	32	Bad
4	Sadhauli Hariya (R5)	7.2	92	0.3	4	218	2	1.92	28	4.4	68	35	Bad
5	Bhagwanpur (R6)	7.3	93	0.8	7	198	2	1.81	28	3.9	72	37	Bad
6	Mahespur (R7)	7.4	93	1.3	10	184	2	1.55	31	3.5	80	39	Bad
7	Kanheri (R8)	7.2	92	1.8	13	166	2	1.66	30	3.2	86	41	Bad
8	Titawi (R9)	7.6	92	0.6	6	194	2	1.98	27	3.8	74	36	Bad
9	Dulhra (R10)	7.4	93	1.6	11	174	2	1.55	31	3.3	84	40	Bad
10	Budhana (R11)	7.2	92	1.9	13	162	2	0.9	43	3.1	88	43	Bad
11	Chandheri (R12)	7.4	93	0.8	7	215	2	3.4	19	3.9	72	35	Bad
12	Atali (R13)	7.6	92	1.2	9	235	2	2.2	26	4.3	69	36	Bad

Table 4.8: Calculation of NSFW Quality Index in Hindon River (March 2012)

S. No.	Sample	pH		DO		BOD		Phosphate		Nitrate		NSFWQ Index	
	points	Data	Q Value	Data	Q Value	Data	Q Value	Data	Q Value	Data	Q Value		
1	Ghagreki (R2)	7.6	92	0.2	3	210	2	0.9	43	3.8	74	38	Bad
2	Santagarh (R3)	7.8	90	0.1	3	245	2	1.38	33	4.6	67	35	Bad
3	Nanandi (R4)	6.9	86	0.4	3	234	2	1.07	39	5.8	61	34	Bad
4	Sadhauli Hariya (R5)	7.5	93	0.6	5	225	2	2.2	26	4.5	68	35	Bad
5	Bhagwanpur (R6)	7.4	93	0.2	6	205	2	1.95	27	3.6	78	37	Bad
6	Mahespur (R7)	7.7	91	0.4	3	192	2	1.7	29	3.4	82	37	Bad
7	Kanheri (R8)	7.6	92	1.4	11	174	2	1.55	31	2.9	91	41	Bad
8	Titawi (R9)	8.2	77	0.2	3	222	2	1.92	28	3.9	72	35	Bad
9	Dulhra (R10)	8.1	80	1.2	9	189	2	1.68	29	3.6	78	36	Bad
10	Budhana (R11)	7.8	90	1.4	10	176	2	1.57	30	2.6	92	41	Bad
11	Chandheri (R12)	7.6	92	0.8	7	235	2	4.2	16	3.8	74	35	Bad
12	Atali (R13)	7.8	90	0.3	4	247	2	2.02	27	4.8	66	34	Bad

Effluents from the manufacture of sugar from sugarcane, is characteristically very high in organic pollutants. Untreated sugarcane processing effluent is known to have a Biological Oxygen Demand (BOD) in the range of 1,700 to 6,600 mg/l. It is due to such extraordinarily high organic pollutant loading, that the Central Pollution Control Board lists sugarcane processing within the top 17 most polluting industries in India. The Hindon River system also receives effluent from the distillation of ethanol from sugarcane molasses. This corrosive effluent, known as 'vinasse', also contains high levels of organic pollutants, and adds to the high BOD / low oxygen level suffocation of the rivers. Paper mill effluent is also notoriously high in organic pollutants, and is again listed within the top 17 most polluting industries in India. The Hindon River and its tributaries receive effluent from numerous sugar and paper mills which are a primary contributor to the anaerobic conditions within the river.

The high value of COD values was observed at stations R-3 and R-4 due to the discharge of paper mill and distillery effluents. The COD values at the two stations vary from 295 to 344 and 314 to 325 mg/L respectively. The high values of COD observed at stations R-3 and R-4 indicate a certain degree of organic pollution in this stretch of the river. The effluent of the pulp and paper mill and the distillery add a high concentration of organic matter to the river, which is responsible for a remarkable decrease in DO, along with an increase in COD values. From station R-4 to R-8, the oxygen condition improves significantly due to re-aeration, resulting in the lowering of COD values. At stations R-9 and R-13 again, the values of COD rise while DO decreases due to the confluence of the Titawi drain and Kali into the Hindon.

The maximum concentration of sulfate was found to be 270 mg/L at Station R-3 after the confluence of paper mill waste. The highest concentration of sulfate at Station R-3 is due the discharge of paper mill waste, which uses sodium sulfate as raw material in the manufacture of pulp and paper. The maximum concentration of phosphate was found to be 4.2 mg/L at Station R-12 after the confluence of wastewater from Budhana drain. This is due to the presence of soapy mixtures in the wastewater, which contain phosphate as one of the important constituents.

The river is sluggish except during the high flow period. It is evident that during a high flow period, there is no significant effect of pollution owing to a very high

dilution of the effluent, but once the flow decreases, there is visible sign of pollution, specifically during summer months. From the above discussion it is evident that the pollution load generated from Saharanpur town and industrial establishments of this region, viz. Star Paper Mill, Cooperative Distillery, Nagdev nala etc., is mainly responsible for the water quality degradation in the upper stretch of the Hindon River. In the intermediate stretches, water quality shows a steady improvement due to re-aeration and photosynthesis. Improvement in the river water quality downstream of the confluence of Dhamola nala indicates a relatively better quality of water in Dhamola nala compared to the river water. The river water before the confluence of Dhamola nala is mainly the mixture of wastewater of Nagdev nala and effluent from pulp and paper factory and distillery waste. A further improvement in the river water quality was noticed downstream due to re-aeration. In the lower stretch, degradation of water quality is observed due to the discharge of wastewater from Budhana drain, and the Kali River.

Table 4.6 and Fig 4.20 shows the Comparison of Hindon River water quality at three sampling points for three consecutive years 2010, 2011, 2012. It clearly shows that the pollution level increases by year by year in Hindon River due to increase in population and no. of industries.

It is recommended that the wastewater generated by the municipal areas of Saharanpur and Muzaffarnagar be treated and utilized for irrigation through an organized network. The industrial units discharging their effluents directly into the river without any treatment should install effluent treatment plants.

Table 4.9: Comparison of Hindon River water quality at three sampling points for three consecutive years 2010*, 2011*, 2012**

Parametrs	Maheshpur (R7)	Dulhara (R10)	Budhana (R11)
Feb 2010			
pH	7.62	7.2	7.42
DO	2.32	2.67	1.74
BOD	144.8	93.3	113.33
COD	142	194	175
Feb 2011			
pH	7.22	7.38	7.32
DO	2.81	1.83	2.01
BOD	125.4	146.2	118.3
COD	218	223	212
Feb 2012			
pH	7.4	7.4	7.2
DO	1.3	1.6	1.9
BOD	184	174	162
COD	276	268	245

Source:* Moef

*** Average calculation of January 2012 and March 2012***

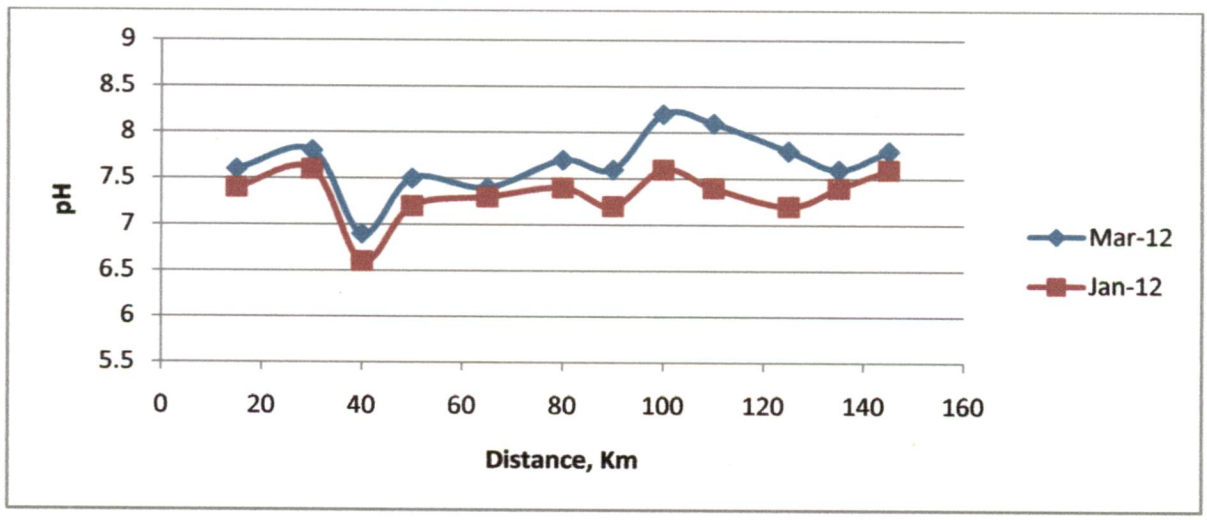

Fig 4.8: Longitudinal variations of pH

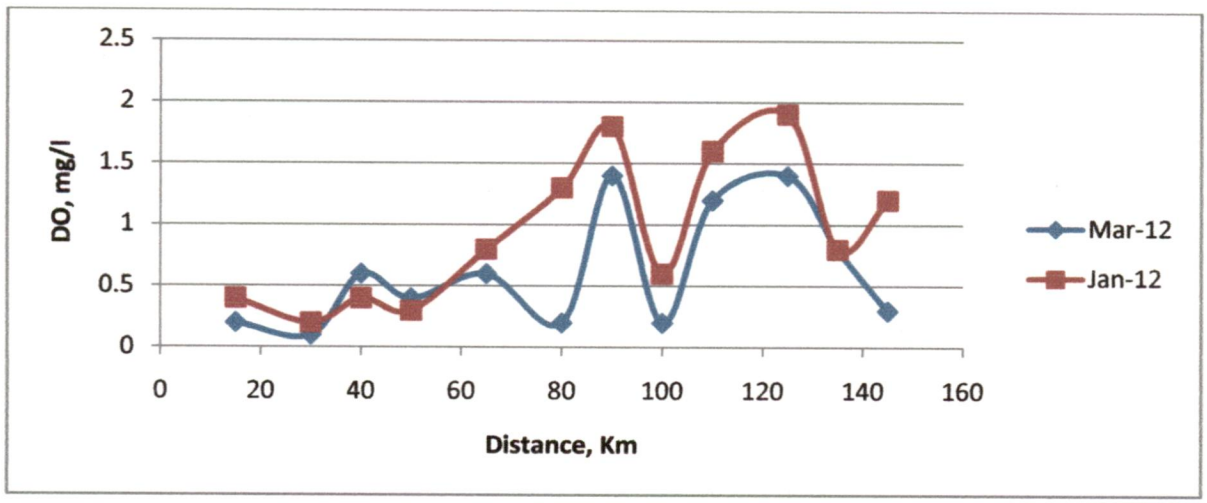

Fig 4.9: Longitudinal variations of DO

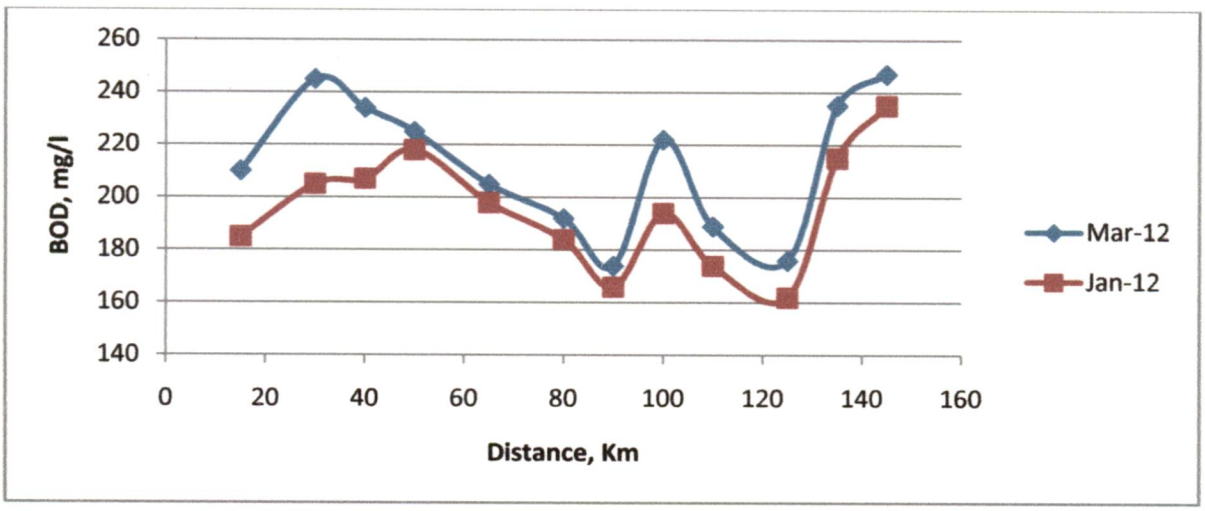

Fig 4.10: Longitudinal variations of BOD

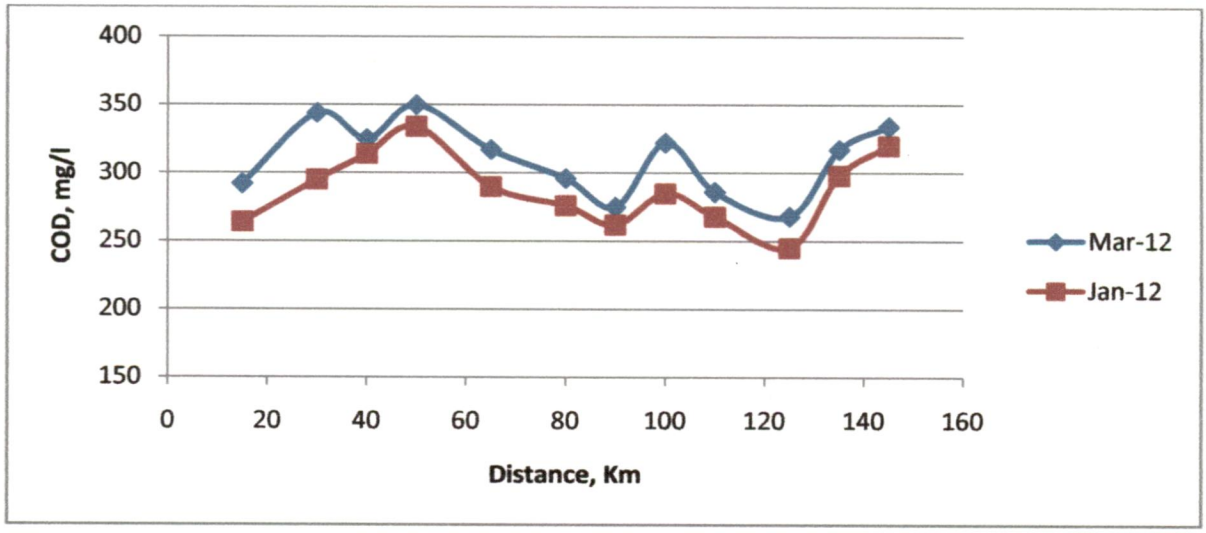

Fig 4.11: Longitudinal variations of COD

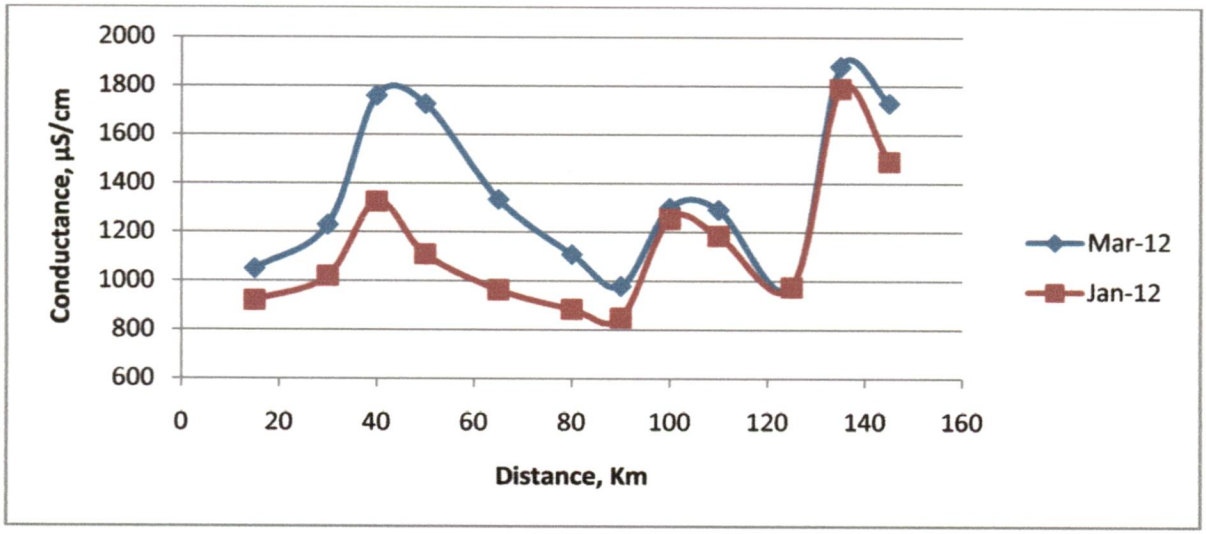

Fig 4.12: Longitudinal variations of Conductance

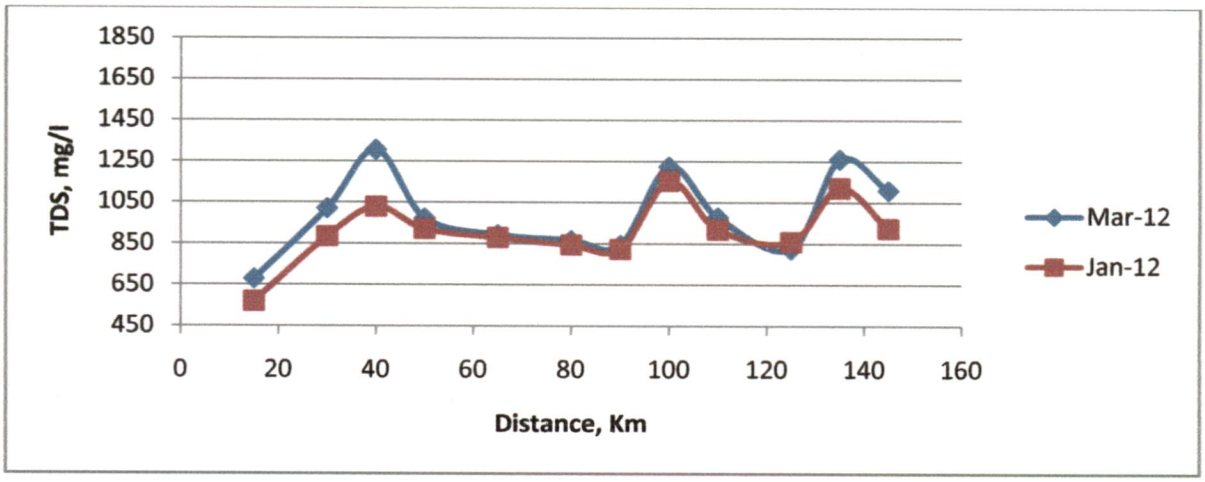

Fig 4.13: Longitudinal variations of TDS

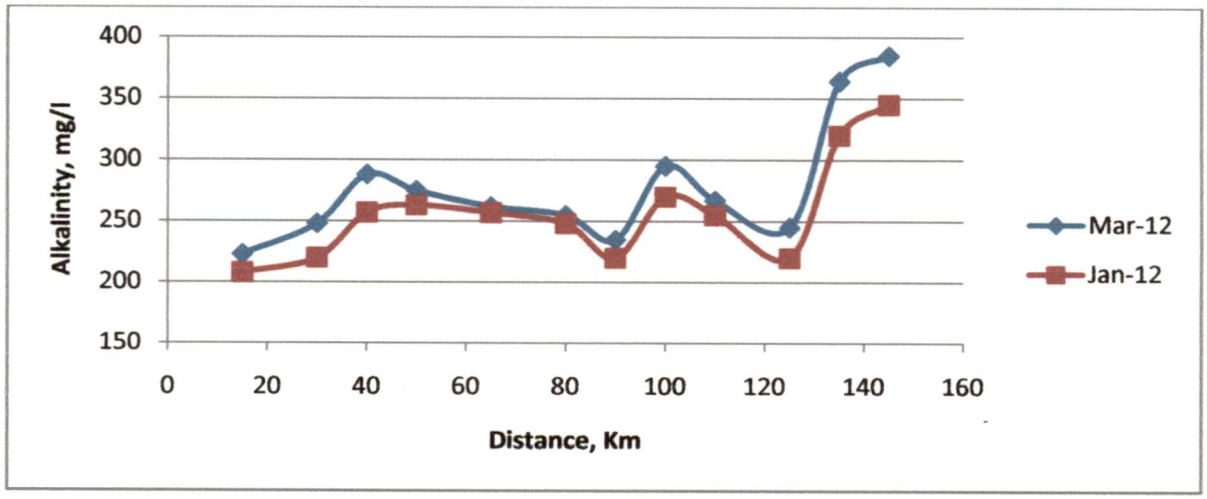

Fig 4.14: Longitudinal variations of Alkalinity

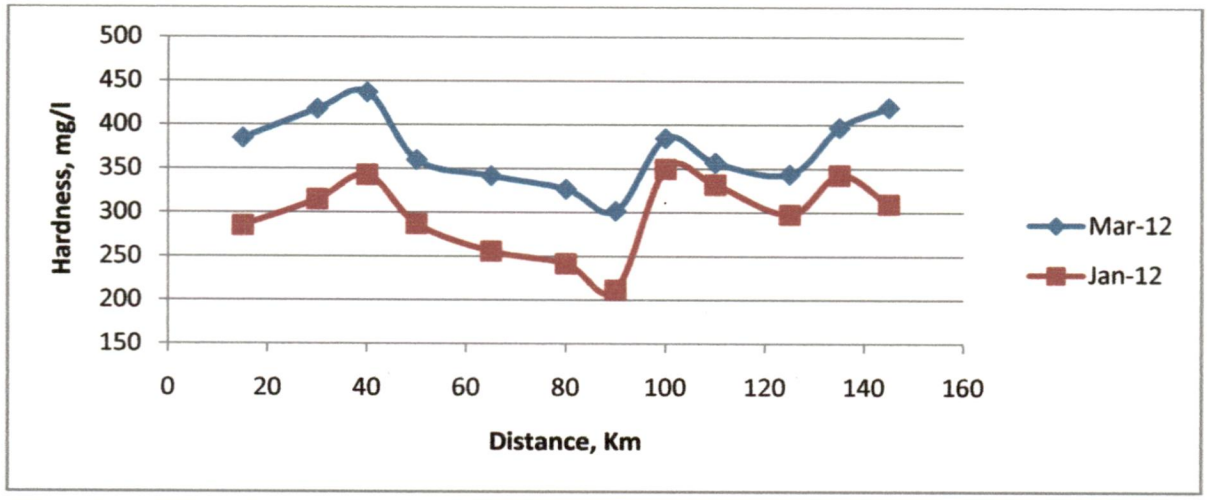

Fig 4.15: Longitudinal variations of Hardness

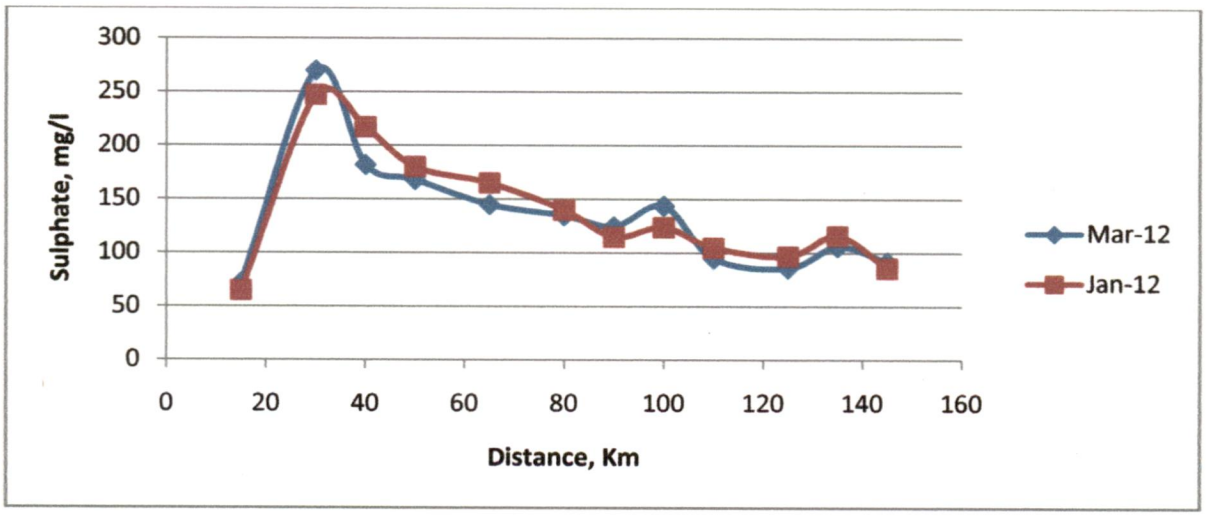

Fig 4.16: Longitudinal variations of Sulphate

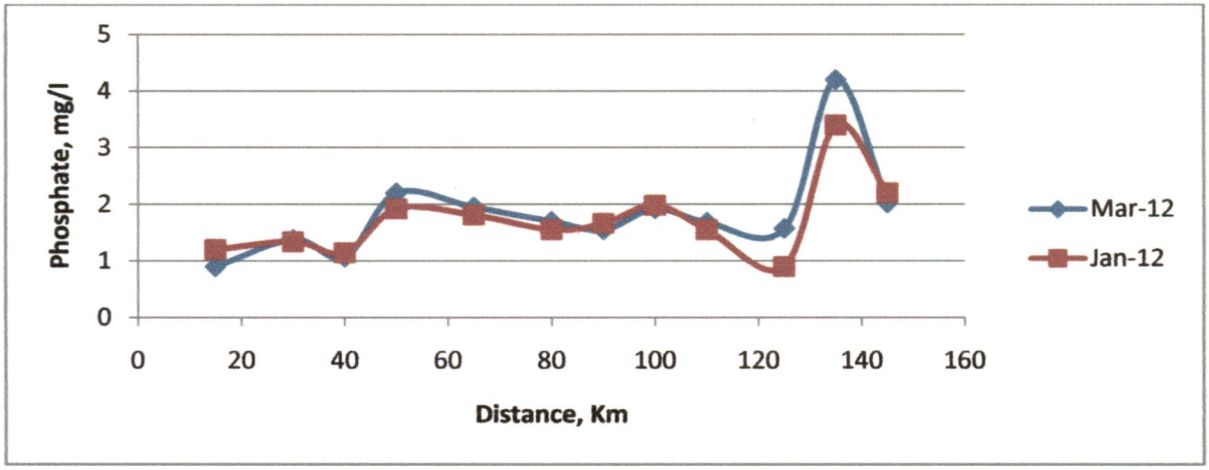

Fig 4.17: Longitudinal variations of Phosphate

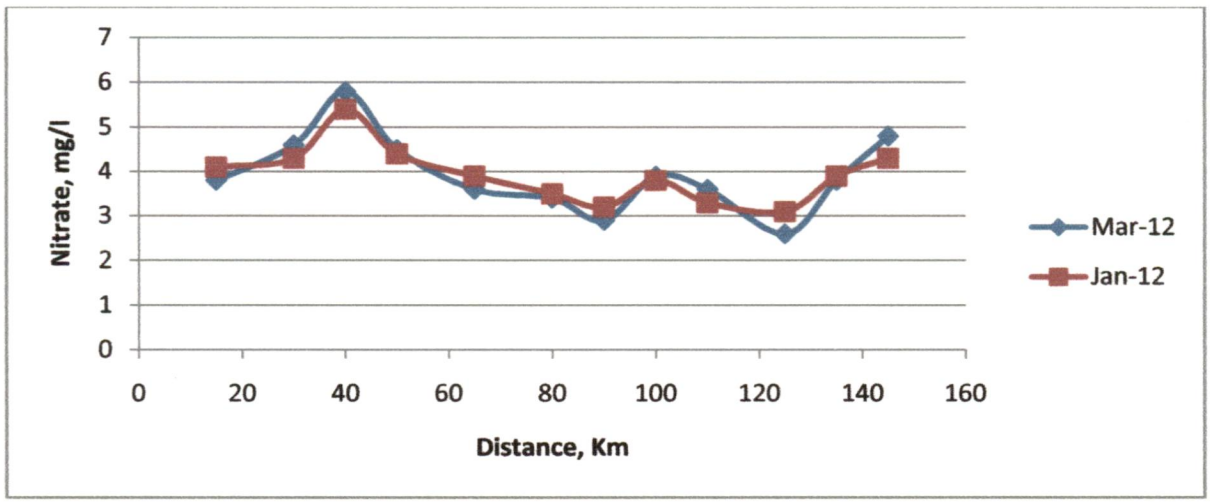

Fig 4.18: Longitudinal variations of Nitrate

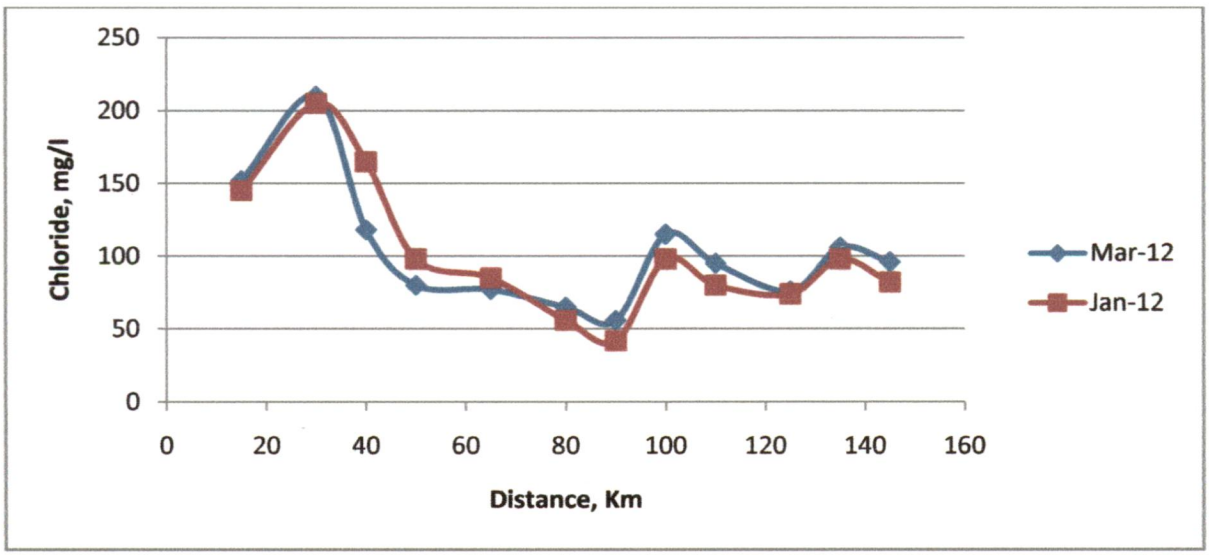

Fig 4.19: Longitudinal variations of Chloride

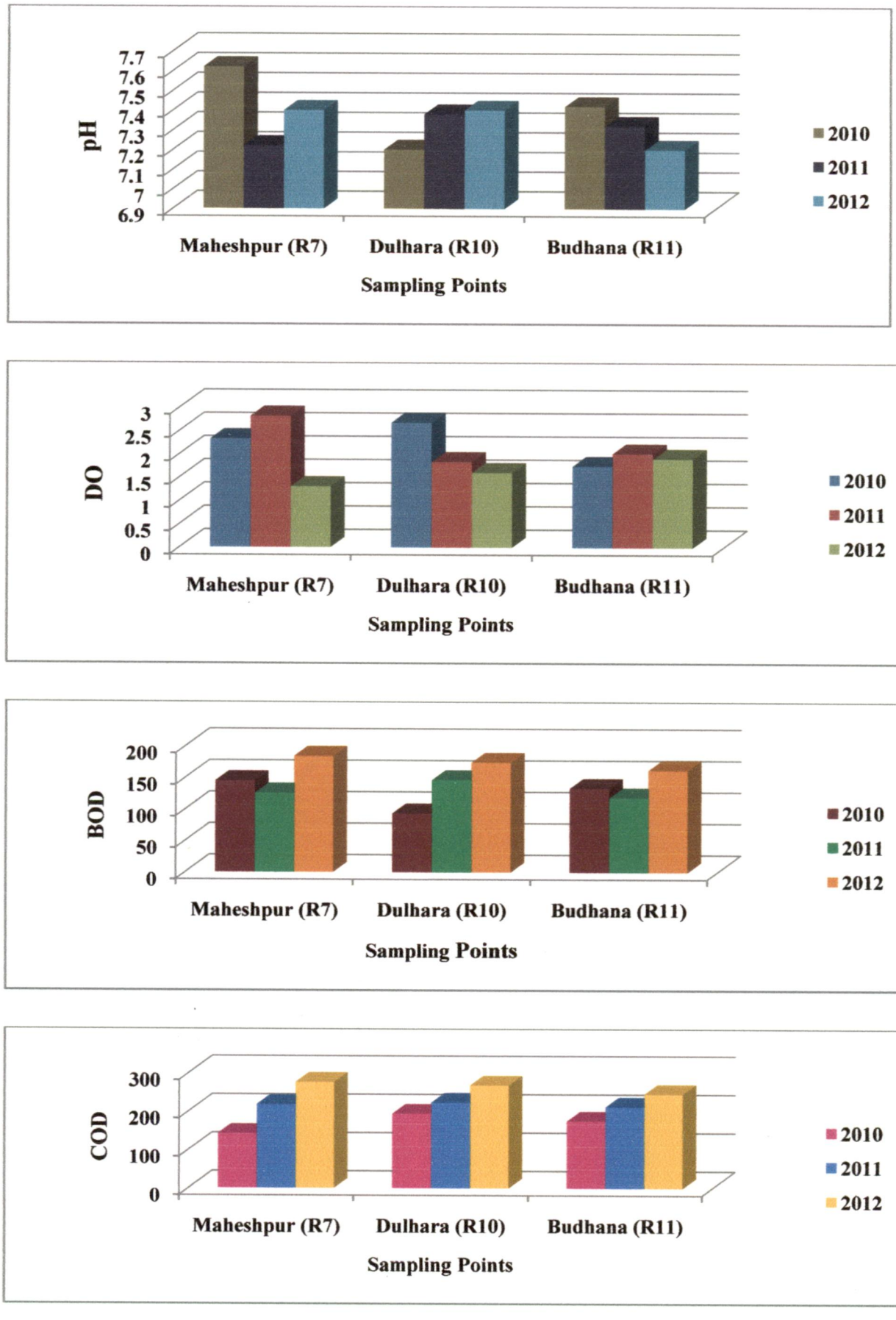

Fig 4.20: Comparison of Hindon River water quality at three sampling points for three consecutive years 2010, 2011, 2012

CHAPTER 5

SEWERAGE SCHEMES IN THE CATCHMENT

5.1 GENERAL

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 (Grag et al., 2004). The color of sewage is caused by solids which are untreated sewage range from 100 to 350 mg/l. A measure of the strength of the waste water is biochemical oxygen demand or BOD_5 (Kirishima et al., 2003).

Present study area across Hindon River is mostly affected at upward location due to effluent coming from industries and Saharanpur and Deoband municipal area sewage and at downward due to Muzaffarnagar, Khatauli, Kandhla, Budhana, Sisauli, Shahpur, Charthaval sewage.

In coming years, volume and nature of waste water bound to increase and change. In future, waste management in scientific manner confirming to the standards and advance planning keeping in view the rate of waste water generation, change in waste characteristics and rate of growth of population; is bound to pose a daunting task ahead. Solution lies with organized monitoring, quantification, impact assessment and advance planning for managing the waste to start implementing waste management projects (Grag et al., 2004).

5.2 DEMOGRAPHY

There are 2 out of 10 towns and 3 out of 12 blocks of Saharanpur District and 7 out of 20 towns and 6 out of 14 blocks of Muzaffarnagar District, which located in the catchment, are contributing the major wastewater source to the Hindon River stretch under this study.

5.2.1 Urban Population *(Rural-Urban distribution Census of India: Census Data, 2011)*

SAHRANPUR DISTRICT

1. Saharanpur is a city and a Municipal Corporation in the state of Uttar Pradesh in northern India. It is the administrative headquarters of Saharanpur District as well as Saharanpur Division. Surrounded by a very fertile agricultural region famous for plentiful yields in grains and fruits, Saharanpur is now one of the most flourishing cities of Uttar Pradesh. Saharanpur is internationally famous for its wood carving work cottage industry. It is a thriving market of local agricultural produce, including basmati rice and mangoes. A variety of agro-based industrial enterprises – such as textiles, sugar, paper, cigarette factories – are located in it. Saharanpur is located at 29.97°N 77.55°E. It has an average elevation of 269 meters. As of 2011 India census, Saharanpur had a population of 549,898. Total length of roads and streets of this town is 127.6 km.

2. Deoband is a city and a Municipal Board in Saharanpur District in the state of Uttar Pradesh, India. It is located in the upper Doab region of Uttar Pradesh. Deoband used to be surrounded by dense forests. Deoband is located at 29.7°N 77.68°E. It has an average elevation of 248 meters. As of 2011 India census, Deoband had a population of 1, 96,328. Total length of roads and streets of this town is 53.76 km.

MUZAFFARNAGAR DISTRICT

3. Muzaffarnagar is a city and a municipal board in the Indian state of Uttar Pradesh. It is the headquarters of the Muzaffarnagar district. Muzaffarnagar is located at 29.47°N 77.68°E. The city's total area in 2000 amounted to 4049 square km. National Highway-58 passes through Muzaffarnagar city and it is situated midway on this Delhi-Roorkee-Dehradun highway. It is also well connected by roads and the national railway network. According to the 2011 India census, Muzaffarnagar had a population of 617,736. Muzaffarnagar is an important industrial town with sugar, steel and paper being the major products. It has 13 sugar mills; more than 70% of the region's population is engaged in agriculture and kautoli mill is the largest in Asia. The Muzaffarnagar market of Jaggery (heat-dried sugar-cane juice, called 'Gud' in local language) is the largest in Asia. According to Economic Research firm *Indicus*

Analytics Muzaffarnagar has the highest agricultural GDP in Uttar Pradesh. Total length of roads and streets of this town is 151.4 km.

4. **Kandhla** is a city and a municipal board in Muzaffarnagar district in the Indian state of Uttar Pradesh. Kandhla is situated midway on the State Highway connecting Delhi to Saharanpur via Baghpat Baraut Shamli. As of 2011 India census, Kandhla had a population of 48,786. The town is home of large number of Muslim Shaikhzadas, Jains and Vaishs. It has the distinction of getting one of the first central sewage. Total length of roads and streets of this town is 17.26 km.

5. **Khatauli** is a town and a municipal board in Muzaffarnagar district in the Indian state of Uttar Pradesh. It is located on NH-58 between Muzaffarnagar (22 km) and Meerut (32 km). As of 2011 India census, Kandhla had a population of 71,021. Khatauli has the largest sugarcane mill in world, run by Triveni Engineering and Industries. It also has big cottage industries for tractor pulleys and diesel engine parts. Total length of roads and streets of this town is 39.4 km.

6. **Budhana** is a town and a nagar panchayat in Muzaffarnagar district in the state of Uttar Pradesh, India. Budhana is located at 29.28°N 77.47°E. It has an average elevation of 231 meters (757 feet). As of 2011 India census, Budhana had a population of 40,003. Villages have agriculture as their mainstay. This area is Upper Doab region and very fertile being close to the Upper Ganges Canal. Main crops are wheat, sugarcane and mustard. People from the surrounding villages come to the Budhana for their buying and selling needs. Bajaj Sugar Mill is just outside the town. Total length of roads and streets of this town is 15.63 km.

7. **Sisauli** is a town and a nagar panchayat in Muzaffarnagar district in the Indian state of Uttar Pradesh. Sisauli is located at 29.42°N 77.47°E. It has an average elevation of 238 meters (780 feet). As of 2011 India census Sisauli had a population of 18,419. Sisauli is the centre of the farmers' revolution against the price of the sugarcane and the other problems of farmers. Total length of roads and streets of this town is 22.30 km.

8. **Shahpur** is a town and a nagar panchayat in Muzaffarnagar district in the Indian state of Uttar Pradesh. Shahpur is located at 29.35°N 77.55°E. It has an average elevation of 237 meters (777 feet). As of 2011 India census, Shahpur had a population of 20,866. Total length of roads and streets of this town is 18.96 km.

9. **Charthaval** is a town and a nagar panchayat in Muzaffarnagar district in the state of Uttar Pradesh, India. As of 2011 India census, Charthaval had a population of 38,236. Charthaval is located at 29.32°N 77.37°E. Charthaval has a good market for garment and Jewellery. There are big furniture houses at bus stand where you can buy all type of furniture, electronic appliances for daily use, trunks for quilts, and columns for wheat storage. There are four sugar cane crusher and Sugar Cane Small scale plant (Kolhu) which produces Jagerry after processing sugar cane juice in Charthaval. Bajaj Hindustan Ltd., titawi sugar mill and Rohana Sugar Refinery are around the Charthaval. Charthaval is also famous for wholesale market of wood. There are more than 10 whole sale shops for wood sale. They purchase the wood of Eucalyptus, Poplar and different type of wood from farmers and sale it to the plywood industries. The turnover of the wood market of Charthaval is around two million Indian Rupees per day. There are 67 villages in block Charthaval. Some villages are having big population as the villagers demand to the government to turn their village into town so that they can facilitate the infrastructure according to their need. Total length of roads and streets of this town is 30.30 km.

5.2.2 Rural Population *(Rural-Urban distribution Census of India: Census Data, 2011)*

In Saharanpur district Nagal, Baliakheri, Deoband blocks are located in the catchment. In Muzaffarnagar district Baghra Charthaval are located in the catchment. A part of the Baghra and Purkazi blocks only located under the catchment and all other blocks are fully located within the catchment. The census 2011 population of these rural areas is furnished in Table 5.1.

5.3 SOURCE AND QUANTITY OF WASTE WATER

The catchment of Hindon River stretch does 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. Waste water generated by catchment population is discharged into the streams of the river untreated.

Adopting a water usage rate at 135 lpcd and waste water generation rate at 80 percent of the water used (as per CPHEEO manual), the catchment population is expected to generate approximately 334 MLD of waste water in the design year, 2045 as shown in Table 5.2 for urban population and for rural population.

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 is let into the river through several big nallahs and numerous drains unabated. Sewage generated from the rural area of the catchment is reached into the river along with storm runoff. It has been found that following nallahs and drains are discharging the major portion of the waste water into the selected catchment area of the river:

1. Nagdev Nala
2. Star paper mill drain
3. Cooperative distillery drain
4. Dhamola Nala
5. Budhana sewage drain
6. Kali river

Table 5.1: Rural population 2011 of the catchment

RURAL POPULATION							
		Total Population			Within the Catchment		
S. No.	NAME OF BLOCK	No. of GP	No. of Villages	Population 2011	No. of GP	No. of Villages	Total Population 2011
	SAHARANPUR DISTRICT						
1	Nagal	68	119	194459	68	119	194459
2	Baliakheri	83	149	235178	83	149	235178
3	Deoband	36	58	197881	36	58	197881
	MUZAFFARNAGAR DISTRICT						
1	Baghra	46	54	181562	32	40	125801
2	Charthaval	54	68	158736	54	68	192722
3	Khatauli	72	111	191741	72	111	232793
4	Shahpur	39	51	133379	39	51	161936
5	Muzaffarnagar	42	66	175987	42	66	213666
6	Purkazi	29	43	158792	11	21	79396

Table 5.2: Population projections and calculation of waste water generated for Urban population

S.No.	Name of Town	Category	POULATION				WASTE WATER GENERATED	
			Census 2011	Present 2015	Intermediate 2030	Ultimate 2045	Intermediate 2030	Ultimate 2045
	Decadal growth rate of Saharanpur District	**19.59**	**Per decade**	**1.959**	**Per Year**		**(in MLD)**	**(in MLD)**
1	Saharanpur	MC	549898	594271	795001	1063534	86	115
2	Deoband	MT	196328	212170	283836	379709	31	41
	SUBTOTAL 1		**746,226**	**806441**	**1078837**	**1443243**	**117**	**156**
	Decadal growth Rate of Muzaffarnagar District	**16.80**	**Per decade**	**1.68**	**Per Year**		**(in MLD)**	**(in MLD)**
1	Muzaffarnagar	MC	617736	667583	893076	1194736	96	129
2	Khatauli	MT	71021	76752	102677	137359	11	15
3	Kandhla	MT	48786	52723	70532	94356	8	10
4	Budhana	NP	40003	43231	57834	77369	6	8
5	Sisauli	NP	18419	19905	26629	35624	3	4
6	Shahpur	NP	20866	22549	30166	40355	3	4
7	Charthaval	NP	38236	41321	55278	73950	6	8
	SUBTOTAL 2		**855067**	**924064**	**1236192**	**1653749**	**133**	**178**
	GRANDTOTAL		**1,601,293**	**1,730,505**	**2,315,029**	**3,096,992**	**250**	**334**

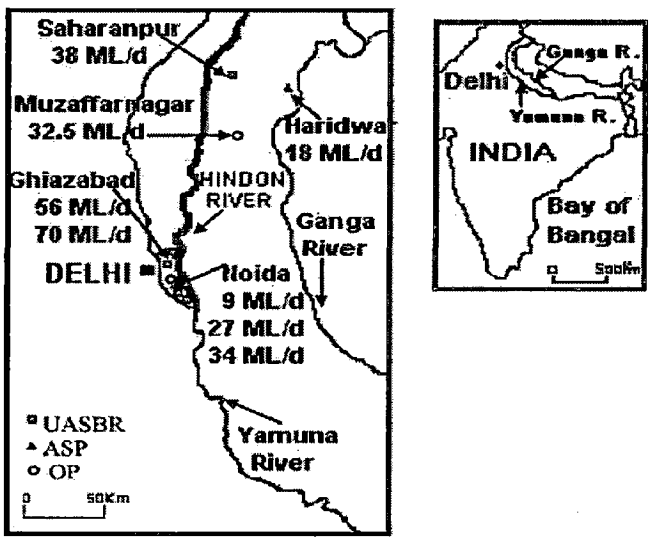

Fig 5.1 Location of existing STPs in Saharanpur and Muzaffarnagar

Table 5.3: Population projections and calculation of waste water generated for Rural population

S. No.	Name of Block	No. of Villages	POULATION				WASTE WATER GENERATED	
			Census 2011	Present 2015	Intermediate 2030	Ultimate 2045	Intermediate 2030	Ultimate 2045
	Decadal growth rate of Saharanpur District	**19.59**	**Per decade**	**1.959**	**Per Year**		**(in MLD)**	**(in MLD)**
1	Nagal	119	194459	210151	281135	376095	30	41
2	Baliakheri	149	235178	254155	340003	454847	37	49
3	Deoband	58	197881	213848	286081	382712	31	41
	SUBTOTAL 1	**326**	**627518**	**678154**	**907219**	**1213654**	**98**	**131**
	Decadal growth Rate of Muzaffarnagar District	**16.80**	**Per decade**	**1.68**	**Per Year**		**(in MLD)**	**(in MLD)**
1	Baghra	40	125801	135952	181873	243305	20	26
2	Charthaval	68	192722	208273	278623	372735	30	40
3	Khatauli	111	232793	251578	336555	450236	36	49
4	Shahpur	51	161936	175003	234115	313193	25	34
5	Muzaffarnagar	66	213666	230908	308903	413243	33	45
6	Purkazi	21	79396	85803	114785	153557	12	17
	SUBTOTAL 2	**357**	**1006314**	**1087517**	**1454854**	**1946269**	**156**	**211**
	GRANDTOTAL	**683**	**1633832**	**1765671**	**2362073**	**3159923**	**254**	**342**

In 2001 a UASB process STP of 38 MLD (Fig 5.1) capacity was constructed on the north-east corner of the river to treat of the sewage generated in the urban catchment of the Saharanpur district. STP is receiving 44 MLD of sewage and is thus overloaded. Another STP of 32.5 MLD (Fig 5.1) capacity with Waste Stabilization Ponds system has been constructed in Muzaffarnagar Municipality in 2005 (Nobuyuki et al., 2006). But this STP is not being run from the last two years (2008) because of non-availability of funds. Ponds have not been cleaned since commissioning due to this ponds are filled with sludge/silt, primary tanks are silted more than 60% of water depth and in one of the ponds an island has been formed inside the pond with the deposition of sludge and growth of plants/weeds over it.

Whole of the urban area of the catchment has not been covered by sewerage. New colonies are coming up. Existing sewer is now not capable to carry the increased

amount of sewage. A master plan with realistic projection and regulation of population growth and development of the area and a well designed sewerage and sewage treatment planning and implementation project is needed for Saharanpur and Muzaffarnagar district in general and for the catchment of the Hindon River in particular, which should be implemented in phases to take up the future loads.

5.4 SELECTION OF STP TECHNOLOGY

To safeguard the Hindon River from the inflowing waste water, we must treat waste water to the existing standards before discharging into the river by installation of STPs, at various locations. There are various conventional and advanced technologies in current use which explains how they are applied for the effective treatment of municipal waste-water. The selection of technologies should be environmentally sustainable, appropriate to the local conditions, acceptable to the user, and affordable to those who have to pay for them (Grag et al., 2004). Simple solution that are easily replicable, that allow further upgrading with subsequent development, and that can be operated and maintained by the local community, are often considered the most appropriate and cost-effective (Foundation for Greentech Environmental Systems, 2004).

As treatment methods range from the physico-chemical to the biological, from the aerobic to anaerobic, the following technologies are considered for analysis:

1. Activated Sludge Process (ASP).
2. UASB Technology with post treatment final polishing pond (UASB+FPP).
3. Fluidized Aerobic Bed Reactor (FAB).
4. Sequencing Batch Reactor (SBR).
5. Waste Stabilization Pond (WSP).

5.4.1 Activated Sludge Process (ASP)

The activated sludge process is an aerobic suspended growth process generally used in mechanized plants. Activated Sludge Plant essentially consists of the following components.

1. Primary Sedimentation Tank
2. Aeration Tank containing micro organisms in suspension in which the reaction takes place

3. Activated Sludge re circulation system
4. Aeration systems to transfer oxygen
5. Secondary sedimentation tank to separate and thicken activated sludge
6. Excess sludge wasting and disposal facilities

In an activated sludge system, the raw water undergoes screening, grit removal and primary settling before aeration. The wastewater is then aerated and the mixed liquor from the aeration tank is settled to give a clear supernatant which may be disinfected and discharged or treated further depending upon intended end-uses. The sludge withdrawn from settling tank is called the activated sludge. It is recycled to aeration tank, while a small fraction wasted in order to keep the system in steady state. The fraction wasted is generally mixed with primary sludge, thickened and digested, anaerobically, before being dewatered. Wastewater is aerated in a tank where bacteria are encouraged to grow by providing oxygen, food (BOD), Nutrients, correct temperature and time. As bacteria consume BOD, they grow and multiply. Treated wastewater flows into secondary clarifier while bacterial cells settle, removed from clarifier as sludge and part of sludge is recycled back to activated sludge tank to maintain bacteria population and remainder of sludge is wasted. It is probably the most widely used biological process for the treatment of organic and industrial waste waters. This process simply creates an agitated environment where the same microbes are able to stabilise the degradable material at a fast rate than before suspended and colloidal material is removed rapidly from the waste water by adsorption and agglomeration on to the microbial flocs (Cook et al., 1981).

Advantages:-

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

Disadvantages:-

1. The major problems encountered in the operation of an ASP are sludge bulking, rising sludge and Nacardia foam.
2. The cost for installation is higher than UASB plant.
3. For operating ASP large electric power is required.

4. It involves a large no. of electro-mechanical equipment which needs high technical and skilled personnel.

Land Requirement:

- Land required for Activated Sludge Process system is about 0.65 acres/MLD.

Power Requirement:

- Process Power requirement per MLD is about 328 to 410 KWh.

5.4.2 Upflow Anaerobic Sludge Blanket (UASB)

Upflow Anaerobic Sludge Blanket (UASB) technology, normally referred to as UASB reactor, is a form of anaerobic digester that is used in the treatment of wastewater. It is an anaerobic treatment system wherein the organic matter is digested, absorbed and metabolized into bacterial cell mass and bio gas. The UASB process is a combination of physical and biological processes. The main feature of physical process is separation of solids and gases from the liquid and that of biological process is degradation of decomposable organic material under anaerobic conditions. 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 the effluent gutters and discharged out of the reactor to the final polishing unit (FPU) to meet discharge standards (Hammad, 1996).

Advantages:-

1. The cost of 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 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 UASB 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 plants self sustaining for power requirement.

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

Disadvantages:-

1. The corrosive potential of anaerobic system is a major negative point and makes it important to choose the right construction materials.
2. The optimum pH range is from 6.6 to 7.6. The wastewater temperatures should not be <5°C because low temperatures can impede the hydrolysis rate of phase 1 and the activity of methanogenic bacteria. Therefore in winter season, methane gas may be needed to heat the wastewater to be treated in the reactor.
3. The Suspended solids concentration in the feed to the reactor should not exceed 500 mg/l.

Land Requirement:

- Land required for UASB Process system is about 1.35 acres/MLD.

Power Requirement:

- Process Power requirement per MLD is about 85 to 105 KWh.

5.4.3 Fluidized Aerobic Bed Reactor (FAB)

This Sewage Treatment Plant is based on the Fluidized Aerobic Bed (FAB) technology. Since the process is aerobic hence air is supplied to sewage in which micro organism metabolize the soluble and suspended organic matter. Part of the organic matter is synthesis into new cells and part is oxidized to carbon dioxide and water, so this procedure does not exit any foul gases. Hence no odor problem occurs by this STP. In fluidized bed reactors, cells are "immobilized" in small particles, which move with the fluid. The small particles create a large surface area for cells to stick to and enable a high rate of transfer of oxygen and nutrients to the cells. The fluidized bed reactor is most suitable when a high viscosity substrate solution and a gaseous substrate or products are used in a continuous reaction system (Steven et al., 1997).

Advantages:-

1. Small space requirement: This occupies much less space, making the plants more manageable.
2. Lower operating power requirements: The system utilizes aeration tanks of much smaller size, thereby reducing the overall power required in aeration the raw sewage.
3. Low temperature sustaining capability: It operates in low temperatures too, which are experienced for the least 2-3 months in a year.
4. Simplicity: The system adopted has much less moving part (only pumps blowers) and all the pumps / blowers are manufactures in India only, and hence there is no problem of availability of spaces.
5. E-Coli: The bio-reactor system adopted in STPs is provided with removal of disease causing E-coli bacteria.
6. Coliform removal: Most of the coliform are killed in the reactor itself and remaining coliforms are killed by nominal chlorine dosing (of the order of 2-3 mg/l).
7. Sludge handling: The sludge generated in the bio-reactors is totally digested & it does not envisage any sludge digestion.
8. Sludge production: It produced much small quantity of sludge which requires no further treatment such as digestion, so biogas cannot be produced by this technology.

Disadvantages:-

1. There is no N, P removal in FAB.
2. Treated effluent is not as good as SBR.
3. It requires highly trained and skilled personnel for operating the plant.

Land Requirement:

Land required for FABR system is less compared to ASP/EASP. As the capacity increases, the land required will decreases considerably. Land requirement for FABR for different capacities is furnished below in Table 5.4:

Table 5.4: Land required for FBR

S. No.	Capacity in MLD	Area required in acres	S. No.	Capacity in MLD	Area required in acres
1.	1	0.13	6.	20	1.73
2.	2	0.24	7.	25	2.23
3.	5	0.50	8.	30	2.60
4.	10	0.99	9.	40	3.46
5.	15	1.24	10.	50	4.20

Power Requirement:

Process power requirement per MLD is about 190 KWh to 300 KWh.

5.4.4 Sequencing Batch Reactor (SBR)

The sequencing batch reactor (SBR) is a fill-and-draw activated sludge system for wastewater treatment. In this system, wastewater is added to a single "batch" reactor, treated to remove undesirable components, and then discharged. Equalization, aeration, and clarification can all be achieved using a single batch reactor. To optimize the performance of the system, two or more batch reactors are used in a predetermined sequence of operations. SBR systems have been successfully used to treat both municipal and industrial wastewater. They are uniquely suited for wastewater treatment applications characterized by low or intermittent flow conditions. All SBR systems have four steps in common:

- Filling
- Aeration
- Sedimentation
- Decant

During the fill operation, volume and substrate (raw waste water or primary effluent) are added to the reactor. The fill process typically allows the liquid level in the reactor to rise from 50 % to 100 % of full life cycle time. During fill, the reactor is either mixed or mixed and aerated to promote biological reactions with the influent waste water. During the react period, the biomass consumes the substrate under controlled environmental conditions. Solids are allowed to separate from the liquid

under quiescent condition, resulting in a clarified supernatant that is discharged as effluent. Clarified effluent is removed during decant period. Floating type decanting mechanism is the most popular type adopted for decanting (Zaiat et al., 2001).

Advantages:-

1. Sequencing Batch Reactor (SBR) is a tool to combat against the bulking sludge.
2. Equalization, primary clarification (in most cases), biological treatment, and secondary clarification can be achieved in a single reactor vessel.
3. Operating flexibility, control and its operation is more stable.
4. Potential capital cost savings by eliminating clarifiers and other equipment as no separate settling tank, pump or piping's are required.

Disadvantages:-

1. A higher level of sophistication is required (compared to conventional systems), especially for larger systems, of timing units and controls.
2. Higher level of maintenance (compared to conventional systems) associated with more sophisticated controls, automated switches, and automated valves.

Land Requirement:

Land required for SBR system is less compared to ASP/EASP. As the capacity increases, the land required decreases considerably. Land requirement for SBR of different capacities is furnished below:

Table 5.5: Land required for SBR

S. No.	Capacity in MLD	Area required in acres	S. No.	Capacity in MLD	Area required in acres
1.	1	1.25	6.	20	1.98
2.	2	1.50	7.	25	2.47
3.	5	1.60	8.	30	3.10
4.	10	1.75	9.	40	4.00
5.	15	1.85	10.	50	4.35

Power Requirement:

Process power requirement per MLD is about 100 KWh to 125 KWh.

5.4.5 Waste Stabilization Pond (WSP)

A waste stabilization pond is a relatively shallow body of wastewater contained in an earthen basin, using a completely mixed biological process without solids return. Mixing may be either natural (wind, heat or fermentation) or induced (mechanical or diffused aeration). Stabilization ponds are usually classified, on the basis of the nature of the biological activity that takes place in them, as aerobic, anaerobic, or aerobic-anaerobic.

Aerobic ponds are used primarily for the treatment of soluble organic wastes and effluents from waste-water treatment plants. Aerobic-anaerobic (facultative) ponds are the most common type and have been used to treat domestic waste-water and a wide variety of industrial wastes. Anaerobic ponds, for their part, are particularly effective in bringing about rapid stabilization of strong concentrations of organic wastes. Aerobic and facultative ponds are biologically complex. The bacterial population oxidizes organic matter, producing ammonia, carbon dioxide, sulfates, water and other end products, which are subsequently used by algae during daylight to produce oxygen. Bacteria then use this supplemental oxygen and the oxygen provided by wind action to break down the remaining organic matter. This is a treatment process that is very commonly found in rural areas because of its low construction and operating costs (Cavalcanti, 2001).

Advantages:-

1. Stabilization pond can be cost-effective to design and construct in areas where land is inexpensive.
2. They use less energy than most wastewater treatment methods.
3. They are simple to operate and maintain and generally require only part-time staff.
4. The effluent from lagoon systems can be suitable for irrigation (where appropriate), because of its high-nutrient and low pathogen content.

Disadvantages:-

1. They are less efficient in cold climates and may require additional land or longer detention times in these areas.
2. Odor can become a nuisance during algae blooms, spring thaw in cold climates, or with anaerobic ponds and ponds that are inadequately maintained.

3. Unless they are property maintained, lagoons can provide a breeding area for mosquitoes and other insects.
4. They are not very effective at removing heavy metals from wastewater effluent from some types of lagoons contains algae and often requires additional treatment or "polishing" to meet local discharge standard.

Land Requirement:

Land required for Waste Stabilization Pond system is about 2.5 acres/MLD.

Power requirement:

Process Power requirement is Nil.

Detailed evaluation and technology/process comparisons of various technologies are presented in Appendix II.

5.5 DESIGN PERIODS

In case of sewerage projects, flow is a function of contributory population and water consumption. Economical and judicious design of any infrastructure, therefore, requires the estimation of forecast of population in various design years (Grag et al., 2004). The design population will have to be estimated with due regards to future growth and development of the project area in the industrial, commercial, educational, social and administrative spheres. Sewerage projects are designed normally to meet the requirements over a period of 30 years after their completion. The period between design and completion is also taken into account, depending upon type, size and importance of the project. In the project under consideration, design period of various components, has been taken as mentioned in the following Table 5.6 and population projections have been worked out accordingly.

Table 5.6: Design Periods for Sewerage system

S. No.	Component	Design Period in years	Clarification
1	Sewer system	30	The system shall be designed for prospective population of 30 years, as its replacement or duplication is not economical.
2	Pumping Stations (Civil works)	30	Cost of civil works is economical for full design period.
3	Pumping Machinery	15	Life of pumping machinery is generally 15 years.
4	STP	5	Initially the flows may not reach the design levels. It will, therefore, be uneconomical to build the full capacity plant initially and construction may be done in a phased manner as the population grows.
5	Effluent disposal and utilization	30	Provision of design capacities in the initial stages itself is economical.

5.6 SANITATION FACILITIES TO RURAL POPULATION

Sewage generated in the villages of the catchment should be treated with natural system before it goes into the river. Due to availability of plenty of land and lack of power supply in rural areas waste stabilization ponds or oxidation ponds are recommended.

Location of the pond system shall be fixed on the basis of topographical survey and drainage pattern. Pond system shall be constructed at place between lowest village and the river stretch. All the villages upstream shall be connected with covered gravity drains to the first pond. There shall be set of five ponds of designed size in accordance with peak flow rate and retention time with zigzag connection. Treated effluent shall be used for irrigation purpose or released into the River.

In the absence of individual sanitary toilets in rural households with safe disposal of human waste within the catchment of the river and public conveniences, like community toilets, urinals and bathing places, the liquid and solid wastes find their way into the river and pollute them. Besides this, the laborers and daily workers who come from adjoining states, villages or cities to earn their livelihood also defecate in

open, finding no community toilets or unable to pay for the use of "pay and use" community toilets.

On the basis of the above problems, following suggestions are recommended for the sanitation in the rural catchment of the river which is the important part of the Conservation Plan for Hindon River:

a) Installation of Individual household Latrines (IHHL) in the rural population of the catchment

b) Construction of twenty numbers of free Community Toilet Complexes to reduce the pollution load into the river incurred by open defecation by floating population

5.7 RATE ANALYSIS

The unit rate for various items of work is as per the U.P. Jal Nigam Standard schedule of rates for the year 2011-2012 wherever possible. The unit rates have also been derived for certain items of work based on U.P. PWD standard Data Book. The land guideline values as per the U.P. Revenue Department are adopted for arriving land cost. For all electric energy related items, the current U.P. Electricity Board (UPEB) Rates are adopted. Wherever the rates are not feasible to arrive in above 3 ways, a lump sum rate as adopted by U.P. Jal Nigam as observed data on the basis of practical experience is adopted, for items below:

Table 5.7: Unit rate for various items

S. No.	Description	Rate (Rs)
A	**SEWERAGE SCHEMES**	
1	Installation of STP with SBR technology on DBOT (Design built operator and take over) contract	95 lakhs per MLD
2.	Pumping Station	
a)	Pump set and accessories	3.8 lakhs per MLD
b)	Sewage Pumping station consists of screen, grit & collection wells.	1.50 lakhs per MLD
3.	Pumping Main	20.45 lakhs per km

4.	Sewer Network	37.55 lakhs per km
5.	STP with WSP Technology	53.5 lakhs per MLD
B	**LOW COST SANITATION FACILITIES**	
5.	Individual Toilets for 5 persons	0.35 lakhs per each
6.	Community Toilets for 100 persons	3.5 lakhs per each

5.8 COST ESTIMATION

The cost estimation of sewerage schemes proposed for the urban population and sanitation facilities for the rural population is done based on the quantity measurement and rate analysis as shown in Table 5.8.

Table 5.8: Cost estimate for sewerage schemes and sanitation facilities

S. No.	Description of Item	Quantity	Unit Rate (Rs in lakhs)	Unit	Amount (Rs in lakhs)
1.	Installation of STP with SBR technology on DBOT (Design built operator and take over) Total requirement - 250 MLD Existing capacity - 38 MLD Net requirement - 212 MLD	195	95	MLD	18525
2.	STP with WSP Technology	17	53.5	MLD	909.5
3.	Pump set and accessories	212	3.8	MLD	805.6
4.	Sewage Pumping station consists of screen, grit & collection wells	212	1.50	MLD	318
5.	Pumping Main	32	20.45	Km	654.4
6.	Sewer Network	420	37.55	Km	15771
7.	Land Requirement	60	15	acre	900
8.	STP with WSP Technology	254	53.5	MLD	13589
9.	Individual Toilets for 5 persons	108297	0.20	Each	21660
10.	Community Toilets for 100 persons	20	3.5	Each	70

5.9 WORK PLAN

5.9.1 Plan for treatment of Waste Water of the Urban Catchment

Sewage treatment facility is planned to be implemented in a period of 5 years. Projected population of 2030 seems more realistic to develop sewage treatment facility for the population in the urban portion of the catchment. In 2030, 250 MLD of sewage shall be required to be treated to check it from going to the river. This area is being served by a 38 MLD of STP in Saharanpur city. There is a gap of 212 MLD in the existing capacity of treatment. Therefore, new STPs to be provided are shown in Table 5.9. Process and Technique for the STP is selected as recommended in article 5.4 and Appendix II. Sequencing Batch Reactor (SBR) is adopted for all towns except Khatauli and Charthaval where the WSP is proposed. The treated effluent is proposed to be either discharged into the streams of river or used for irrigation. In the year 2045, estimated sewage generation in the urban portion of the catchment is 334 MLD. Advance planning is needed to tackle the future challenge of sewage treatment.

Presently, treated effluent is not 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.

Table 5.9: Details of new STPs to be proposed

S. No.	District	Name of Town	STP Capacity (MLD)	STP Technology	Land Requirement (in acres)
1.	Saharanpur	Saharanpur	46	SBR	4.21
2.	Saharanpur	Deoband	31	SBR	3.19
3.	Muzaffarnagar	Muzaffarnagar	50 + 46	SBR	4.35+4.21
4.	Muzaffarnagar	Khatauli	11	WSP	27.5
5.	Muzaffarnagar	Kandhla	8	SBR	1.69
6.	Muzaffarnagar	Budhana	6	SBR	1.63
7.	Muzaffarnagar	Sisauli	3	SBR	1.53
8.	Muzaffarnagar	Shahpur	3	SBR	1.53
9.	Muzaffarnagar	Charthaval	6	WSP	15

Sewerage system is designed for a period of 30 years. Therefore, projected population for the year 2045 may be considered. The sewerage system should be capable of taking care of 334 MLD of sewage. Well designed sewerage system on the

basis of extensive topographical study and latest software should be implemented to minimize the energy cost incurred in numerous Intermediate Pumping Stations.

5.9.2 Treatment of Sewage of the Rural Catchment

Sewage generated in the villages of the catchment should be treated with natural system (Waste Stabilization Pond or oxidation pond) before it goes into the Hindon River. Location of the pond system shall be fixed on the basis of topographical survey and drainage pattern. Pond system shall be constructed at place between lowest village and the river stretch. All the villages upstream shall be connected with covered gravity drains to the first pond. There shall be set of five ponds of designed size in accordance with peak flow rate and retention time with zigzag connection. Treated effluent shall be released into the Hindon River.

There are 20 numbers of community toilets planned to be executed in 4 numbers per year of 5 years period. For promoting the establishment of individual toilets, a subsidiary scheme of 50 percent financial assistance (grant) may be offered in the rural households. These community toilets and individual toilets shall be constructed by the Gram Panchayat with financial and technical support from Department of Rural Development under NAREGA. A committee shall be formed from among the Panchayat Samiti of beneficiary villages which shall collect user charges as per the size of households and maintain it.

CHAPTER 6

SOLID WASTE MANAGEMENT

6.1 GENERAL

Solid waste management is one of the major global environmental challenges faced within urban and semi urban areas. Solid wastes damage 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 (Arun et al., 2010).

A population of 1,633,832 is sparsely distributed among 9 blocks in the rural catchment of the river (Table 5.1). However, urban population is dense and the population in the urban portion of the catchment is 1,601,293 according to 2011 census (Table 5.2) which mainly generates solid waste and contributes to the pollution of the river. The pastureland in the catchment exists and is extensively used by villagers for grazing the cattle. The cow dung and other fecal matter, randomly deposited in the catchment are directly carried into the river, increasing thereby the pollution of the river. Approximately one third of the river dries up in summer forming a grazing land for the livestock and for open defecation.

6.2 MUNICIPAL SOLID WASTE MANAGEMENT

Management of Solid Wastes is a growing concern to the general public at large, local authorities and business communities in cities across the country. The problem is aggravating in urban areas due to swift strides in population growth coupled by an economic boom that has marked a huge surge in consumption of goods leading to generation of wastes by leaps and bounds. Hence it becomes the need of the state of Uttar Pradesh to take plunge into managing the solid waste since its accumulation in open areas lead to multifarious problems such as:

- Negative impact on the living conditions of human beings as well as the overall environment
- Spread of communicable and non-communicable diseases among human beings and animals, thus affecting the welfare, livelihood and economic productivity

- Contamination of soil, surface water, ground water and generation of toxic and green-house gases
- A breeding ground for insects and other vectors as well as human beings
- Diminishing real estate and property value
- Causes odour nuisance, reflects the unorganized nature of the community

Indian waste management system is starved of resources to tackle the increasing demands associated with growing urbanization. Due to budgetary constraints, inadequate equipment and poor planning with poor solid waste management is more prevalent in India, particularly in certain low-income areas, where waste is not collected at all. It is estimated that about 30-40 percent of disposed solid wastes are left uncollected leading to detrimental effects on the environment and human beings.

Solid waste management, even in large and medium cities and towns in India, is far from satisfactory and significant proportions are disposed by land filling/dumping (Sunil, K., 2010). Most dumping sites are serious health hazards to people living in the neighborhood and are liable to contaminate ground water (MOUD, 2000). The Municipal Solid Wastes (Management & Handling) Rules, 2000 (MSW Rules) are applicable to every municipal authority responsible for collection, segregation, storage, transportation, processing and disposal of municipal solid wastes. These rules are given in Table 6.1.

Table 6.1: Municipal Solid Waste Management Schedule

S. No.	Schedule	Relates to
1	Schedule-I	Relates to implementation Schedule
2	Schedule-II	Specifications relating to collection, segregation, storage, transportation, processing and disposal of municipal solid waste wastes (MSW).

3	Schedule-III	Specifications for land filling indicating site selection, facilities at the site, specifications for land filling, Pollution prevention, water quality monitoring, Specifications for ambient air indicate waste processing options including standards for composting, treated leachates and incinerations, plantation at landfill site, closure of landfill site and post care.
4	Schedule-IV	Indicate waste processing options including standards for composting, treated leachates and incinerations

Table: 6.2 Authorities and Responsibilities

S. No.	Authorities	Responsibilities.
1	Municipal Authorities	i. Ensuring that municipal solid wastes to be handled as per rules. ii. Seeking authorization from State Pollution Control Board (SPCB) for setting up waste processing and disposal facility including landfills. iii. Furnishing annual report. iv. Complying with Schedule I, II, III and IV of the rules.
2	**State Government** Secretary In-Charge of Department of Urban Development District Magistrates/ Deputy Commissioner	Overall responsibility for the enforcement of the provisions of the rules in the metropolitan cities. Overall responsibility for the enforcement of the provisions of the rules within the territorial limits of their jurisdiction.

3	Central Pollution Control Board (CPCB)	i. Co-ordinate with State Boards and Committees with reference to implementation and review of standards and guidelines and compilation of monitoring data. ii. Prepare consolidated annual review report on management of municipal solid wastes for forwarding it to Central Government along with its recommendations before the 15th of December every year. iii. Laying down standards on waste processing/ disposal technologies including approval of technology.
4	State Pollution Control Board (SPCB)	i. Monitor the compliance of the standards regarding ground water, ambient air leachates quality and the compost quality including incineration standards as specified under Schedule II, III & IV. ii. Issuance of authorization to the municipal authority or an operator of a facility stipulating compliance criteria and standards. iv. Prepare and submit to the CPCB an annual report with regard to the implementation of the rules.

Some of the local bodies have taken initiatives to improve management practices relating to collection, segregation, storage and transportation of waste. Such efforts are restricted to either a few wards/ area or for entire town. Waste Processing and Disposal Many of the cities and towns have taken initiatives to set-up waste processing and disposal facilities. Generally the risks associated with improper management of solid waste are given in Fig 6.1.

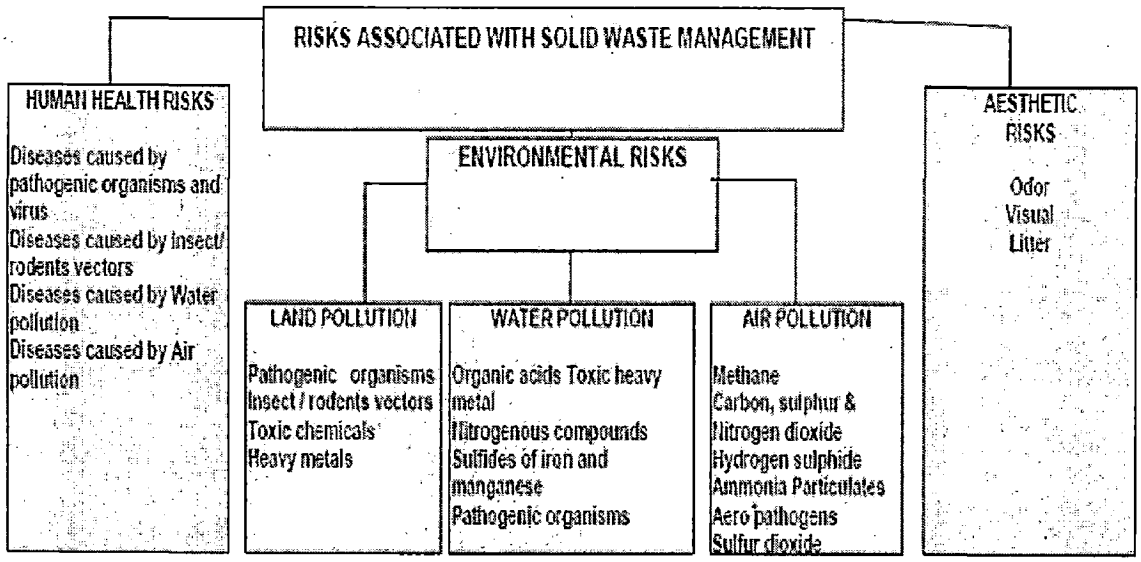

Fig 6.1: Risks Associated with Solid Waste Management

6.3 STATUS OF SOLID WASTE GENERATION

Assessment of status of solid waste generation is based on annual reports being furnished by local bodies to State Pollution Control Boards and forwarding consolidated Annual Report to CPCB. The urban population in the catchment (Saharanpur and Muzaffarnagar district) generates a solid waste of **928.75MT** per day at the per capita rate of daily **0.58 kg** for the census urban population 2011, 1,601,293. This quantity would be increased to 1003.69MT in 2015 (Present), 1342.71MT in 2030 (Intermediate) and 1796.25MT in 2045 (Ultimate) years.

The rural population in the catchment (Saharanpur and Muzaffarnagar district) generates a solid waste of **408.46MT** per day at the per capita rate of daily **0.25 kg** for the census urban population 2011, 1,633,832. This quantity would be increased to 441.42MT in 2015 (Present), 590.52MT in 2030 (Intermediate) and 789.98MT in 2045 (Ultimate) years. These wastes include domestic solid waste, street sweepings, commercial and institutional refuses, hotel and hospital solid waste etc. Rate of domestic solid waste generation in Saharanpur and Muzaffarnagar is 0.38kg per capita per day. This underlines the need of advance planning for SWM for Saharanpur and Muzaffarnagar. Also, SWM system in Catchment area needs reorganization and should be provided with necessary equipment and staff.

Table 6.3: Projected Population and Waste Generation in Catchment

S. No.	Year	Projected Population	Waste Generation (MT/d)
		Urban Area	
1	2011	1,601,293	928.75
2	2015	1,730,505	1003.69
3	2030	2,315,029	1342.71
4	2045	3,096,992	1796.25
		Rural Area	
5	2011	1,633,832	408.46
6	2015	1,765,671	441.42
7	2030	2,362,073	590.52
8	2045	3,159,923	789.98

Note: Per capita solid waste rate 0.58kg daily for urban population
Per capita solid waste rate 0.25kg daily for rural population

6.4 SOURCES OF MSW

The main solid waste generation sources are residential, commercial and market, slum, slaughterhouses, institutional organization like hospitals, hotels and restaurants, small and big scale industries, construction and demolition waste (debris) etc (Arun et al., 2010). Major portion of MSW constitutes the domestic solid waste which comes from residential sources. 81.4 percent of MSW comes from domestic sources. Second biggest source of MSW is street sweepings which constitute 6.7 percent of the MSW as Saharanpur and Muzaffarnagar has 620 km of roads. Various sources of MSW in Saharanpur and Muzaffarnagar with its potential of generation have been detailed in the Table 6.4.

Commercial refuse and solid waste from institution/offices constitutes each of around 4.2 percent of MSW. Approximately 50,000 people visits Saharanpur and Muzaffarnagar everyday that generates 8.5MT of solid waste per day which is approximately 2 percent of MSW while hotel and restaurants generates 5MT/day of food waste i.e. 1.4 percent of the total MSW generated per day. Hospitals produce 3.0MT of solid waste daily which is 0.1 percent approximately.

Table 6.4: Sources of Solid Waste in Saharanpur and Muzaffarnagar

Sl. No.	Sources of Waste	Rate of Waste Generation (Kg/unit)	Total Unit	Total Waste Generation (MT/d)
1	Residential	0.38	1220988	463.98
2	Commercial refuse	1.5	10000	15.0
3	Street sweeping	40 kg/km	620km	24.8
4	Institutions/offices	Lump sum		15.0
5	Hotel/Market/Restaurant	Lump sum		5.0
6	Hospital	Lump sum		3.0
7	Floating population	0.15	50000	8.5

Source: Department of Urban Development, Uttar Pradesh

6.5 COMPOSITION OF MSW

Physical composition of the MSW of Saharanpur and Muzaffarnagar can be seen in the Table 6.5 below. A perusal of this table reveals the characteristics of the solid waste as mentioned below:

a) The compostable portion in the waste is 51.49% whereas the non-decomposable waste is 48.51% respectively.

b) Similarly the percentages of the recoverable and suitable for recycling such as paper, cardboard, plastics, glass, metal etc consists 9.86 percent of the waste.

c) The percentage of inert materials consisting rubbers, leather, wooden matter, rags, coconut etc is 38.65. Land filling is the best option only for this portion of waste.

Chemical properties of the MSW generated in Saharanpur and Muzaffarnagar city can be seen in the Table 6.6.

It is clear from the chemical composition as mentioned in the table that MSW generated in Saharanpur and Muzaffarnagar is neither acidic nor alkaline. Calorific value of the waste has been found low and moisture content which is 49 percent is high enough. Hence incineration of the waste is not advisable. The C/N ratio is sufficient enough to opt for composting as a feasible method of waste management if segregation

of waste is accomplished. N: K: P ratio for the municipal solid waste of Saharanpur and Muzaffarnagar has been found to be 14:13:10.

Table 6.5: Physical Composition of MSW of Catchment

Sl. No.	Composition		(%)	Percentage (%)
1	Total Compostable			51.49
2	Paper, Cardboard etc.			3.17
3	Plastics			3.45
4	Glass			1.79
5	Metal			1.45
6	Others including inert			
	6.1	Inert	25.92	
	6.2	Rubber & leather	4.97	
	6.3	Rags	2.74	
	6.6	Others	4.02	38.65
		Total		**100**

Source: Department of Urban Development, Uttar Pradesh

Table 6.6: Chemical Composition of MSW Catchment

Sl. No.	Chemical Parameters	Values
1	pH	6.96-8.02
2	C/N Ratio	20.23
3	HCV (Kcal/kg)	1060.00
4	Moisture (%)	49.00
5	VM at 55 °C (%)	29.70
6	Carbon (%)	17.20
7	Nitrogen (%)	0.85
8	Phosphorous as P2O7 (%)	0.61
9	Potash as K2O (%)	0.79

Source: Department of Urban Development, Uttar Pradesh

6.6 EXISTING SYSTEM OF SOLID WASTE MANAGEMENT (SWM)

At present the system is incapable of handling the solid waste. Scientific management of solid waste requires collection, segregation, transfer and disposal of MSW in compliance with the MSW (Management & Handling) Rule, 2000 which requiring money, man and machines. Solid waste management at Saharanpur and Muzaffarnagar is accomplished by their Municipal Corporations.

6.6.1 Saharanpur Municipal Corporations

SMC has 780 numbers of sanitary staff. Inventory of machines and equipments employed by SMC for collection and transport of MSW has been mentioned in the following Table 6.7.

Table 6.7: Inventory of Machines and Equipments of SMC

Sl. No.	Machine/Equipment	No. of Machines/Equipments
1	Tractors	12
2	Dumper Tripper	5
3	Water Tanker	27
4	Metal Container	59
5	Dozer	3
6	Tipper	10
7	JCB	5
8	Wheeler machine	2

Source: Saharanpur Municipal Corporation, Uttar Pradesh

6.6.2 Muzaffarnagar Municipal Corporations

MMC has total strength of 1,072 including temporary workers. Few of them are also working as supervisors and drivers. The workers are working in three categories depending upon the length of service i.e. permanent workers, daily wages workers, working through contractor and contract basis. On an average there are 3 sweepers for every 1000 population. Inventory of machines and equipments employed by SMC for collection and transport of MSW has been mentioned in the following Table 6.8.

The primary collection of solid waste is carried out through street and road sweeping because all kind of solid waste is thrown from windows/doors and put in open places. Sanitation workers are using long coconut broom. Workers are also supplied spade, pick axe, shovel, pan, gumboot and other tools as per the requirement. About 800 metallic un-containerized handcarts are distributed among 1, 072 sanitation workers thus all the workers are not provided with equipment. The capacity of wheelbarrow is approximate 40-50 kg.

Asset available with SMC and MMC in view of present load of MSW is unsatisfactory. Various aspect of SWM in Saharanpur and Muzaffarnagar has been detailed in the following sections:

Table 6.8: Inventory of Machines and Equipments of MMC

Sl. No.	Machine/Equipment	No. of Machines/Equipments
1	Tractors	20
2	Dumper Tripper	8
3	Water Tanker	35
4	Metal Container	72
5	Loader	4
6	JCB	3
7	Nala cleaning Machine	2
8	Rickshaw trollers	160

Source: Muzaffarnagar Municipal Corporation, Uttar Pradesh

Collection and Transport

Presently, collection and transport of MSW in Saharanpur and Muzaffarnagar by municipal corporations is quantitatively unsatisfactory. However, the waste was found littered around these carts at many places showing the apathy of the users and their ignorance about sanitation.

Housekeepers store wastes generated daily in their own containers or bins. These wastes are collected by rickshaw carts to a common and suitable place in the locality from where the waste is transported to the disposal point by bigger transport vehicle and from here wastes are transfer on tractors which transport it to the landfill site.

The shops / markets and other establishments normally start business after 9:30 to 10:00 AM. These timing do not synchronize with the work schedule of the sweepers, as by this time most of the collection procedure is over. The waste from these business communities again accumulates on streets and road. The city does not appear clean. The same is true in the case of hotels, restaurants and vegetable market waste.

Segregation

No segregation of waste is done at any point from storage at home to disposing it at landfill. Comingled waste is accumulated at home. It is neither segregated during transferring it to bigger transport vehicle nor at the landfill. However, only inert portion of MSW should go to the landfill. This is increasing unnecessary load on landfill. As seen in Table 6.5, more than 60 percent of the load can be eliminated by segregating the waste as only 38.65 percent of the total waste has been found to be inert. Rest can be

either composted or recovered and recycled. There is a potential of cost recovery by the segregation of waste.

On the one hand segregation recovers a portion of MSW and on the other disposable amount of waste reduces. Consequently, requirement of area for landfill decreases and the life of the existing landfill increases.

Recovery, Reuse and Recycle

Recovery, reuse and recycle options are considered as the integral part of scientific management of solid waste nowadays. Since there is no proper transfer station in Saharanpur and Muzaffarnagar, segregation of waste is not practiced. Consequently recovery, reuse and recycling from wastes is completely absent at Saharanpur and Muzaffarnagar.

Disposal

SMC and MMC have adopted dumping as method of disposal of waste as of today; this practice has been called as sanitary landfill. These landfill sites have not been select, designed, constructed and operated as per the guidelines envisaged in Municipal Solid Waste (Management & Handling) Rules, 2000.

6.6.3 Initiations taken by the State Government

Considering the importance of management of solid waste in various parts of the State, the Government is implementing SWM projects under Public Private Partnership (PPP) model in 26 cities of Uttar Pradesh that includes Saharanpur and Muzaffarnagar also. Under this model, a concessionaire shall operate the projects in these cities, the responsibilities of whom would include door-to-door collection of waste, primary storage, secondary collection, transfer, transportation, development of processing plant and landfill etc.

The private agency has to manage and maintain the project for a period of 30 years and also would have to shoulder the responsibilities of replacement and capacity enhancement etc. and has to make all related investments during the concession period. The tipping fees shall be paid to them by the concerned Nagar Nigam. All the projects shall be implemented under JNNRUM scheme of Government of India, which is a reforms-driven, fast-track, planned development of identified towns with focus on efficiency in urban infrastructure.

The purpose of adopting PPP in SWM projects in these cities is to impart more efficiency and cost effective services which may not be effectively provided by the existing infrastructure/manpower of the municipality.

The concentrated endeavor of the Govt. of U.P. bore fruitful results and in a near future, citizens of Uttar Pradesh can enjoy a cleaner, contamination-free environment. It will also boost confidence amongst prospective investors across the globe to step in here and set up their dream projects in the State.

A Solid waste Project has been started on June 2011 to make the city clean, beautiful and to prevent pollution of the environment of the nearby areas. The scheme of manufacturing compost manure through transplant plan will be implemented by collecting rubbish materials. Before that, a Solid waste management plant situated at Kidwainagar where about 94% of municipal waste gets dumped and by this the risk of polluting the environment remains. Not only that, the energy that can be produced from this solid waste that was also not produced. In so far as plastic that can be used that also cannot be used. To prevent this pollution and natural loss, the India government has started Jawaharlal Nehru National Urban Renewal Mission (JNURM) programme. Municipality, A2Z Company and CNDF are jointly doing this work. This scheme has received consent for Rs 8.49 crore. In this scheme integrated processing plant and scientific land-fill is to be established.

The present scenario of SWM and works done for management of Solid waste in Saharanpur and Muzaffarnagar is described in Fig 6.2 to 6.15.

Fig 6.2: Solid waste lying in open

Fig 6.3: Worker with Push Cart

Fig 6.4: Waste Unloading

Fig 6.5: Stray Animal

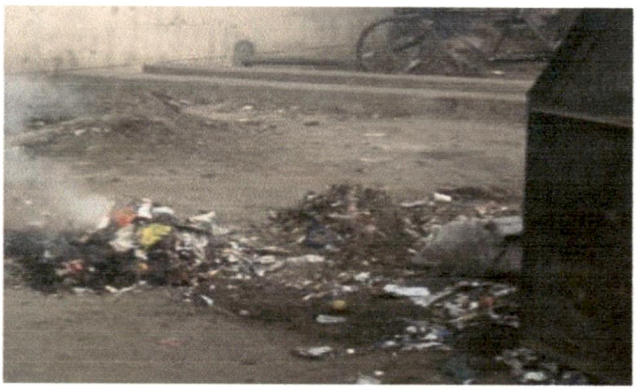

Fig 6.6: Waste Scattered Near Bin

Fig 6.7: Dumper Placer Bin

Fig 6.8: Construction Waste On Road Side

Fig 6.9: Crude dumping at disposal site

Fig 6.10: MSW recycling starts here, employees working for a waste paper dealer, Muzaffarnagar

Fig 6.11: Recyclables from waste pickers reach here, for secondary separation, Muzaffarnagar

Fig 6.12: Handling wastes at a composting plant, Muzaffarnagar

Fig 6.13: Handling wastes at a municipal solid waste (MSW) Composting plant, Saharanpur

Fig 6.14: Rejects from a municipal solid waste (MSW) composting plant, Saharanpur

Fig 6.15: Bags of municipal solid waste (MSW) compost, Muzaffarnagar

ITC group has launched a pilot public-private project of solid waste management in Saharanpur city of Uttar Pradesh. The project, being implemented by an NGO, Muskan Jyoti Samiti, in joint collaboration with local municipal authorities and the district administration has adopted "Khalasi Line" locality, covering 2500 households. This was the first project of its kind in the entire country. With the firm backing of a corporate group, they have started this model project for waste management through door to door waste collection, segregation of waste into recyclable and organic waste, sale of recyclable waste and decomposition of organic waste into manure. Encouraged by the success of the project they are planning to extend it to the entire city in due course.

6.7 THE PROBLEMS

Apart from the population increase in Saharanpur and Muzaffarnagar, other factors responsible for the augmentation of the solid waste management system, are as follows:

1. Some of the waste storage facilities are open and unhygienic as well as inadequate. They seem to be an open invitation to rag pickers, animals, birds, rodents and parasites. This needs to be organized.
2. Waste is transported openly collection point to the disposal site openly against the existing rule.
3. Streets and public places are often treated as receptacles of solid waste by general public, in absence of demarcated community bins. In higher reaches the receptacles are drains bringing storm water to the river.
4. The public attitude is to blame the municipal corporations for its inefficient and unsatisfactory functioning. Neither the public wants to assume any responsibility for the state of affairs or are there more institutions coming forward to rope them in.
5. The Community participation and awareness about the sanitation of the town is generally lacking. It seems that the public education for participatory activities by the community has been ignored or has been generally inadequate.
6. Some of the waste storage facilities are open and unhygienic as well as inadequate. They seem to be an open invitation to rag pickers, animals, birds, rodents and parasites. This needs to be organized.

7. Waste is transported openly collection point to the disposal site openly against the existing rule.
8. Streets and public places are often treated as receptacles of solid waste by general public, in absence of demarcated community bins. In higher reaches the receptacles are drains bringing storm water to the river.
9. The public attitude is to blame the municipal corporations for its inefficient and unsatisfactory functioning. Neither the public wants to assume any responsibility for the state of affairs or are there more institutions coming forward to rope them in.
10. The Community participation and awareness about the sanitation of the town is generally lacking. It seems that the public education for participatory activities by the community has been ignored or has been generally inadequate.
11. The health risks of solid waste workers (Safai Karmacharies) and waste pickers as well as general public are overlooked.
12. The menace of substantial quantity of Polythene bags plastics- the non-degradable waste is still not checked.
13. The disposal of waste at dumping sites is invariably done by dumping, resulting into fly and mosquito breeding.
14. There are no dustbins provided on the shoreline of the river. Visitors throw the solid waste into the river or are found scattered between embankment and water surface. Proper and attractive dust bins need to be provided to reduce littering.
15. On the road, at many places, bins or containers were placed which were serving as collection and storage points. However most of the waste was lying outside, as the containers were full to the brim. With the storm water, these waste materials are transported to the river and create pollution. So community bins are required to be constructed as collection and storage points.
16. People thrown the religious wastes like flowers and other objects used in religious rituals directly into the river. Currently, these are also serving as a major pollutant in the river. Even after putting up railings along the bridges and their peripheries, people did not refrain from throwing waste into the river from vehicles and trains.

17. Some visitors who come to the river, throw paper/plastic/polythene bags and covers bags, the food leftovers etc in the waters of the river, affecting the ambience of the river. No visitor should be allowed to carry such things and punitive fines shall be imposed on such visitors.

6.8 SUGGESTIONS AND RECOMMENDATIONS

6.8.1 General Suggestions

Based on the studies conducted and analysis of the data procured for the existing solid waste management of Saharanpur and Muzaffarnagar city from the concerned authorities, for the rehabilitation of Hindon River, the following suggestions are recommended:

a) Along the shoreline of the Hindon River, the bins must be provided to collect and store the solid waste thrown by the visitors walking around and disposed of with the waste of city.

b) Hydramech containers should be provided in the city at strategic points to which the Safai Karmacharies will bring the solid waste from alleys and houses through hand carts and put in these containers. These will be transported to the landfill site by the Hydramech dumpers and only few concrete/brick structure can be provided as community bins.

c) Organization of public awareness programs at all levels and instruction booklets for the residents of the city and villages in the catchment of the river for "what you may do and what you should not do" with the provision of suitable punitive measures for violation of instructions.

d) Regular cleaning of the dustbins and waste material collection from sites including their proper maintenance with time.

e) In the catchment only non polluting industries shall be planned and allowed and their solid waste scheme should be essential component before the No Objection is given.

f) In all the area in the catchment of the river, the provision for the two dustbin system is adopted for the isolated habitation. Arrangements shall be made to

collect the materials from these houses and they may be paid for the waste as an incentive.

g) The houses in the far flung areas be provided with GARBAGE or COMPOST pits and the NGOs be associated to teach them the composting methodologies through small workshops/TV local channel, help them in preparing compost pits and the compost can be collected and sold to farmers with payment to the house owners as incentive. This type of incentive for the isolated habitation may be helpful in managing the solid waste from catchment of the river, where SMC and MMC do not exist and thus prevent the pollution of rivers by solid waste.

6.8.2 Segregation and Transport

a) Well designed and adequately equipped Transfer Station and Disposal Facility (TSDF) should be constructed either near the proposed Sanitary landfill (SLF) or at some suitable place need to be constructed. This must have a modern and mechanized segregation facility and loading bays with least human involvement.

b) Segregation of waste in at least two separate groups e.g. inert and the rest should be accomplished at source by educating the public. These portions of waste should be collected in partitioned Rickshaw cart to the bigger vehicle. Inert portion of the waste shall go directly to the SLF for land filling after compaction. While the other parts of the waste shall go to the TSDF where recoverable materials are segregated and the compostable waste is sent to the composting unit.

c) Waste must be covered during transportation to avoid littering on the routes and to avoid the nuisance look.

6.8.3 Disposal/Treatment Methodologies

Based on the characteristics of the solid waste produced in city and on the periphery of the river, the following three methods can be considered for the final disposal of the solid waste generated:

1. Composting
2. Incineration
3. Land-filling

Composting

The characteristics of the solid waste generated from the city show high percentage of compostable matter (Table 6.5). If the segregation is done at the generation point, composting can be thought of as a method of disposal (MOUD, 2000). The cost involved in the segregation, the attitude of the public towards the two dustbin system, other important analyses for composting are the C/N ratio, moisture contents, land acquisition, winter temperatures etc are the parameters that requires in-depth study before selecting this as the method of disposal (Saha et al., 2010).

With the present data and the paucity of funds, land and the cost involved in two-dustbin system, this method may not be suitable for the whole town. However, for the areas on with scattered population where the collection and transportation with the rest of the town is not possible, if land is made available, composting can be resorted to on pilot plant basis (Appendix IV) and on success it can be a good solution for the unapproachable habitation.

Incineration

The combustible contents of the solid waste seem to be very low. Also, in winter months the moisture contents of the solid waste may become high. The solid waste generated in Indian cities has been found to be unsuitable for incineration as three-component diagram shows the waste characteristics to lie beyond the zone in which self sustaining combustion reaction can be obtained (Saha et al., 2010). Hence incineration cannot be advocated for the waste generated in Saharanpur and Muzaffarnagar.

Land Fill

At present the solid waste from Saharanpur and Muzaffarnagar is basically disposed of for land-filling. However the required methodology for Sanitary Land-filling is not being followed where the solid waste is compressed in place by various rollers and covered with earth to avoid smell and breeding of flies and mosquitoes (MOUD, 2000). It is proposed to develop a new disposal site as sanitary landfill site. Following operation and management guidelines should be followed:

1) The site should be designed and developed as per international standard for minimum design period of 20 years. The site should finally be selected and

developed after it fulfills specific criteria and provisional no objection certificate is issued from regulatory agencies.

2) Site specific data such as topographic, social and environment survey details, geotechnical analysis report, EIA and EMP reports, detail design, operation and management guidelines including daily reporting format should be available at the site.
3) Only residual from processing plants and non-biodegradable waste should be accepted. No toxic or hazardous waste should find access to the site.
4) Operating hours should be according to operating hours of landfill equipment operators. Night operations should not be allowed except in emergency situation.
5) Vehicles entering to the facility should be visually inspected, registered, before proceeding to the working area. Waste should be unloaded only at the working area/face under supervision.
6) Waste should be spread and compacted in layers but should not be more than 1m after compaction before inert layer should be laid. Compaction of the waste should be on a slope of 20-30% and worked out from the bottom of the slope to the top.
7) A Soil cover of inert material of at least about 15 cm thick should be placed over the waste and compacted, preferably at the end of each day or after compacted waste of 1 m height. Daily cover material should be provided near the disposal area to facilitate covering of the waste.
8) Inactive areas should be covered with an intermediate cover of at least 1ft or 0.30 m.
9) Rag picking should not be allowed.
10) Trained supervisors should supervise site operations. The operation guideline manual should be available to guide field personnel.
11) All necessary quality control measures such as ground water quality, air quality and noise control should be periodically checked and properly recorded.

A proposed system of solid waste management is given in Fig 6.10. This seems to be the most economical and feasible solution and after surveying for a site for the land-filling, the norms as provided by Central Pollution Control Board New Delhi (Appendix III) must be followed.

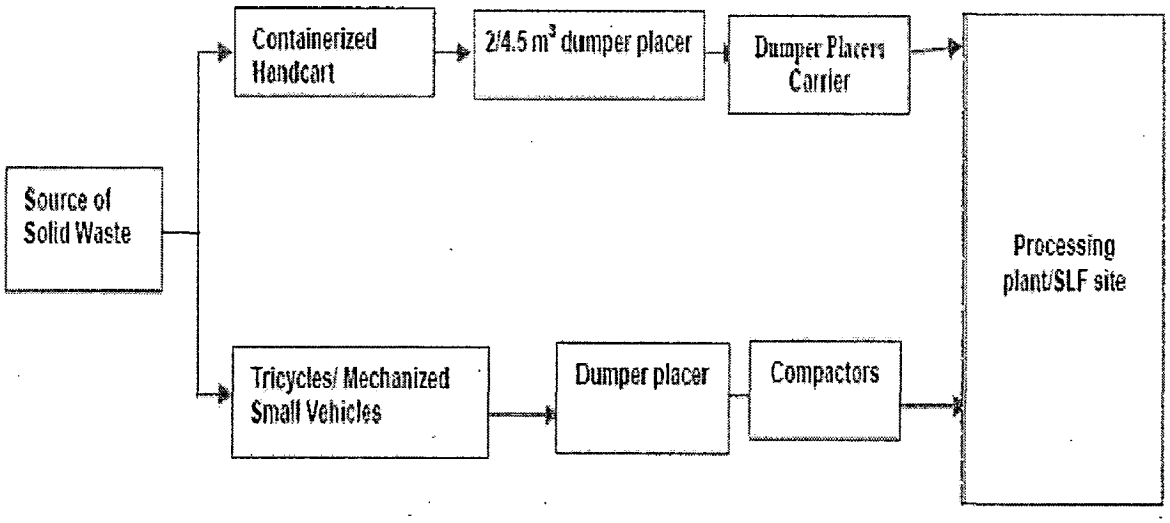

Fig 6.16: Proposed System of Solid Waste Management

6.9 SLAUGHTERHOUSE WASTE

There are approximately more than 200 slaughterhouses in Catchment area. 72 of these slaughterhouses are unauthorized. 200 cattle are slaughtered in each shop. As of today, wastes from slaughterhouse are discharged untreated to the river and environment. It is suggested to construct a separate slaughterhouse with treatment facility at Saharanpur and Muzaffarnagar district.

6.10 BIOMEDICAL WASTE

Most biomedical waste generated from health care facilities are at present, collected without segregation into infectious and non-infectious categories and are disposed in municipal bins located either inside or outside the facility premises. Sanitary workers pick this waste from here along with MSW and transport and dispose it at municipal dumpsites. Since the infectious waste gets mixed with municipal solid waste, it has potential to make the whole lot infectious in adverse environmental conditions. Moreover, biomedical waste also contains sharp objects (scalpels, needles, broken glasses/ampoules, etc.,) the disposal of which poses a risk of injury and exposure to infection to sanitary workers and rag pickers working at these dumpsites. Since most of these dumpsites are unscientifically managed, the chances of pathogens contained in infectious waste becoming airborne and getting released to nearby water bodies or affecting the local resident population (Sunil, K., 2010) .

Saharanpur and Muzaffarnagar city has a large number of Nursing homes, pathology centers and hospitals. Expected generation is about 3 MT of biomedical

waste daily. These wastes are hardly managed in accordance with the provisions of Biomedical Waste (Management and Handling) Rule, 1989. It has been found that liquid portion is discharged into drains and solid portion is mixed with MSW. However, river is not being threatened by biomedical waste at present such is its catchment. But storm runoff brings biomedical waste from urban catchment into the river along with water in rainy season. Hence, education and encouragement to the hospitals and nursing homes needs to be extended along with a strict punitive action against erring units to safeguard the river from biomedical waste.

6.11 INDUSTRIES WASTE

Industrial waste generated by Industries situated in Industrial areas/Estates is supposed to recycle/process within the industrial area and no waste from industries should be allowed to mix with Municipal Solid Waste; however waste generated by most of the industries is getting mixed with MSW, because - firstly, the industrial area is almost merging with residential and commercial areas of the city and secondly, there is no check or control over the industrial waste disposal system. There are 10 industrial areas but details about waste generation from various industries are not available. Waste from Industries is of hazardous nature hence suitable provision for disposal separately as per Hazardous Waste Rules 1989 amended in 2000 is required.

6.12 COST ESTIMATION

Total infrastructure requirement for 20 years with base as 2011 and design year as 2030 is shown in Table 6.9, Table 6.10, Table 6.11, and Table 6.12 respectively for SMC and MMC Area. Cost estimates (based on the block costs and subjected to change after detailed site surveys) are shown in the following Table 6.13 for SMC area and Table 6.14 for MMC Area. Cost of land has not been included presuming that land should be provided free of cost. The total requirement is estimated as Rs. 1026.6 million for SMC Area, and Rs. 1135.1 million for MMC Area. This is excluding contingencies.

Table 6.9: Collection & Transportation Equipment Requirement for SWM in SMC Area (2015-30)

S. No.	Item	Criterion/Assumptions	2015	2020	2025	2030
1.	Population (no's)	Master Plan & Analysis	5,94,271	6,54,805	7,215,06	7,95,001
2.	Sanitation worker for sweeping and drain cleaning (no's)	28 per 10000 population; additional 17% for leave reserve	1664	1834	2020	2226
3.	Push cart for worker (no's)	1 for 2 sweepers	831	917	1010	1113
4.	Push cart 4 containerized (no's)	1 for each worker; 25% more for repairs	1039	1146	1263	1391
5.	Storage bin 4.5 cum capacity - for entire population and area (no's)	1 for 2000 persons; add 25% more for repairs	372	409	451	497
6.	Carriers - for entire population and area (no's)	1 for 15 containers; add 25% more for repairs	30	42	55	67
7.	Coverage for primary collection (% population)	Design criteria	50%	60%	70%	80%
8.	Population Covered (no's)	--do--	2,97,135	3,92,883	5,05,054	6,36,001
9.	Waste generation (MT/d)	--do--	172	228	293	369
10.	Mini waste collector 1.5 cum for primary collection (no's)	1 for 7 MT/d add 25% for repairs	31	41	52	66
11.	Compactors (no's)	1 for 35 MT waste per day; add for 25% more for repairs	6	8	10	13

Table 6.10: Collection & Transportation Equipment Requirement for SWM in MMC Area (2015-30)

S. No.	Item	Criterion/Assumptions	2015	2020	2025	2030
1.	Population (no's)	Master Plan & Analysis	6,67,583	6,98,268	7,58,927	8,24,855
2.	Sanitation worker for sweeping and drain cleaning (no's)	28 per 10000 population; additional 17% for leave reserve	1869	1955	2125	2310
3.	Push cart for worker (no's)	1 for 2 sweepers	935	978	1063	1155
4.	Push cart 4 containerized (no's)	1 for each worker; 25% more for repairs	1168	1222	1328	1443
5.	Storage bin 4.5 cum capacity - for entire population and area (no's)	1 for 2000 persons; add 25% more for repairs	417	437	474	516
6.	Carriers - for entire population and area (no's)	1 for 15 containers; add 25% more for repairs	35	48	62	74
7.	Coverage for primary collection (% population)	Design criteria	50%	60%	70%	80%
8.	Population Covered (no's)	--do--	3,33,792	4,18,961	5,31,249	6,59,884
9.	Waste generation (MT/d)	--do--	194	243	308	382
10.	Mini waste collector 1.5 cum for primary collection (no's)	1 for 7 MT/d add 25% for repairs	35	44	55	69
11.	Compactors (no's)	1 for 35 MT waste per day; add for 25% more for repairs	7	9	11	14

Table 6.11: Waste Processing and Landfill Facilities for SWM in SMC Area (2015-30)

S. No.	Item	Criterion/Assumptions	2015	2020	2025	2030
1.	Expected waste generation MT/day	As per sample survey	345	380	418	461
2.	Net compostable quantity (MT/day)	56% biodegradable	193	213	234	258
3.	Residual from compost plant and non biodegradable (MT/day)	10% from compost plant + 16% of total waste as inert and non-biodegradable	75	82	90	100
4.	Capacity of SLF required for 15 years (MT/d)		125			
5.	Total volume of landfill required, m^3	Assume density as 850 Kg/cum	1073998			
6.	Total land area required or landfill include facilities, infrastructure & buffer (ha)		30			
7.	SLF equipment					
	Loader backhoe		2	2	3	3
	Tipper		4	4	6	6
	Bull dozer		2	2	3	3
	Landfill Compactor		2	2	3	3
8.	SLF infrastructure		As required	-	-	-
9.	Operation and maintenance of primary collection equipment (per annum)	10% of capital cost	-	-	-	-
10.	Operation and maintenance of transportation equipment with transfer station (per annum)	30% of capital cost	-	-	-	-

Table 6.12: Waste Processing and Landfill Facilities for SWM in MMC Area (2015-30)

S. No.	Item	Criterion/Assumptions	2015	2020	2025	2030
1.	Expected waste generation MT/day	As per sample survey	387	405	440	478
2.	Net compostable quantity (MT/day)	56% biodegradable	217	227	246	268
3.	Residual from compost plant and non biodegradable (MT/day)	10% from compost plant + 16% of total waste as inert and non-biodegradable	84	88	95	104
4.	Capacity of SLF required for 15 years (MT/d)		130			
5.	Total volume of landfill required, m^3	Assume density as 850 Kg/cum	1116957			
6.	Total land area required or landfill include facilities, infrastructure & buffer (ha)		35			
7.	SLF equipment					
	Loader backhoe		2	2	3	3
	Tipper		4	4	6	6
	Bull dozer		2	2	3	3
	Landfill Compactor		2	2	3	3
8.	SLF infrastructure		As required	-	-	-
9.	Operation and maintenance of primary collection equipment (per annum)	10% of capital cost	-	-	-	-
10.	Operation and maintenance of transportation equipment with transfer station (per annum)	30% of capital cost	-	-	-	-

Table 6.13: Capital Investment Requirement for MSWM System in SMC Area (2015-30)

S. No.	Item	2015-20		2021-25		2026-30	
A	Collection and Transport Equipment	No.	Amount (Rs lakhs)	No.	Amount (Rs lakhs)	No.	Amount (Rs lakhs)
1.	Containerized push carts with accessories @ Rs 7,000 each	1989	139	2156	151	2457	172
2.	Dumper placer containers 4.5 cum @ Rs 40,000 each	625	250	816	326	962	385
3.	Dumper placer carriers @ Rs 12 lakhs each	55	660	66	792	76	912
4.	Mechanized mini garbage collectors @ Rs 5 lakhs	52	260	75	375	87	435
5.	Transport Compactor (14 cum) @ Rs 26 lakhs	7	182	9	234	13	338
A	Total	2728	1491	3122	1878	3595	2242
B	**Land Fill Site**						
B1	Equipment						
1.	Loader Backhoe @ Rs 20 lakhs	2	40	3	60	3	60
2.	Bulldozer @ 60 lakhs	2	120	3	180	3	180
3.	Land Fill Compactor @ 35 lakhs each	2	70	3	105	3	105
4.	Tipper @ Rs 12 lakhs	4	48	6	72	6	72
5.	Land fill site development		3543				
B	Total	10	3821	15	417	15	417
	Total (A+B)		5312		2295		2659
	Grand Total		Rs 1026.6 million				

Source: Analysis

Table 6.14: Capital Investment Requirement for MSWM System in MMC Area (2015-30)

S. No.	Item	2015-20		2021-25		2026-30	
A	**Collection and Transport Equipment**	**No.**	**Amount (Rs lakhs)**	**No.**	**Amount (Rs lakhs)**	**No.**	**Amount (Rs lakhs)**
6.	Containerized push carts with accessories @ Rs 7,000 each	2132	150	2268	159	2553	179
7.	Dumper placer containers 4.5 cum @ Rs 40,000 each	703	281	913	365	1095	438
8.	Dumper placer carriers @ Rs 12 lakhs each	59	708	68	816	80	960
9.	Mechanized mini garbage collectors @ Rs 5 lakhs	56	280	79	395	92	460
10.	Transport Compactor (14 cum) @ Rs 26 lakhs	9	234	11	286	15	390
A	Total	2959	1653	3339	2021	3835	2427
B	**Land Fill Site**						
B1	Equipment						
6.	Loader Backhoe @ Rs 20 lakhs	2	40	3	60	3	60
7.	Bulldozer @ 60 lakhs	2	120	3	180	3	180
8.	Land Fill Compactor @ 35 lakhs each	2	70	3	105	3	105
9.	Tipper @ Rs 12 lakhs	4	48	6	72	6	72
10.	Land fill site development		4138				
B	Total	10	4416	15	417	15	417
	Total (A+B)		6069		2438		2844
	Grand Total		Rs 1135.1 million				

Source: Analysis

CHAPTER 7

COMMON EFFLUENT TREATMENT PLANTS

7.1 GENERAL

Urbanization and need for better living has incessantly generated requirement of consumer goods and infrastructural inputs. With market potential and easy finance available, the mushrooming rise in the number of small scale industries can be seen in any Indian city. Besides being a resource for market economy and production of large number of consumer items, it is generally observed that, either due to their economies of scale coupled with their unplanned growth and dearth of affordable and cost- effective treatment technology, efforts by small scale units in achieving the environmental compliance have not been effective. Their large number and diverse trade have further aggravated the problem.

During the past 30 years the industrial sector in India has quadrupled in size simultaneously, the major waste generators in India including the petrochemical, pharmaceutical, pesticide, paint, dye, petroleum, fertilizer, asbestos, caustic soda, inorganic chemicals and general engineering industries (Rajaram et al., 2008).

The bulk of industrial pollution in India is caused by the small and medium scale industrial (SMIs) sector. Small-scale industries (SSIs) have a very important role in overall industrial development in India and growth of SSI units has been actively promoted by Government of India to induce balanced economic growth and to distribute the benefits of industrial development in an equitable manner. Industries having capital investment up to Rs.10 millions are classified as SSI units. It is estimated that more than 300,000 SSI units are spread all over India, mainly in about 867 clusters/industrial estates of the country (Rajaram et al., 2008).

7.2 INDUSTRIES IN THE CATCHMENT

The Hindon River is utilized by a wide range of industrial uses along its length. These industries both abstract large volumes of water from the river for their manufacturing processes , and also discharge their industrial effluents, often with nominal or no treatment, directly to the river. A list of major industries discharging to the river and its tributaries is presented in Table 7.1.

Table 7.1: Number and Types of industries in the catchment

S. No.	Saharanpur District			Muzaffarnagar District			
	Type of industries	Nos.	Effluent in MLD	Type of industries	Nos.	Effluent in MLD for CETP-1	Effluent in MLD for CETP-2
1	Sugar mill	4	6	Sugar mill	14	4	6
2	Paper Mill	5	38	Paper Mill	25	12	10
3	Distillery	2	15	Distillery	7	18	14
4	Dairy units	55	20	Dairy units	35	8	10
5	Textile Mill	2	1.07	Textile Mill	8	3.17	2.85
6	Slaughter Houses	6	0.03	Slaughter Houses	15	0.004	0.005
7	Ply Wood Industry	5	0.005	Ply Wood Industry	2	0.002	0.002
8	Rice Mill	7	0.02	Rice Mill	3	0.01	0.001
9	Furniture	15	0.007	Furniture	2	0.001	0.001
Total		**101**	**80**		**111**	**45**	**42**

Source: Saharanpur and Muzaffarnagar Statistical department

The heavy loading of industrial effluent discharge directly into the Hindon River places an intolerable burden on the rivers natural ability to assimilate pollutants. Key contaminants identified within the effluents of these industries include a very high loading of organic pollutants and suspended particulate matter (paper mills, sugar mills, distilleries, tanneries, slaughter house and dairies), heavy metals (sugar and paper manufacture) and frequently pathogens as a result of contaminated raw materials entering the plants (Priyanka, 2010).

Dilution of effluent with fresh water is a commonly used and can be an effective treatment. However, this treatment requires good quality and adequate quantity of water within the receiving river. The Hindon river and tributaries receive such a high loading of effluent that dilution with freshwater is no longer a viable treatment.

7.3 COMMON EFFLUENT TREATMENT PLANTS

It is difficult for each industrial unit to provide and operate individual wastewater treatment plant because of the scale of operations or lack of space or technical manpower. However, the quantum of pollutants emitted by SSIs clusters may be more than an equivalent large scale industry, since the specific rate of generation of pollutants is generally higher because of the inefficient production technologies adopted by SSIs.

Under these constraints, setting-up of individual full-fledged treatment device is no longer feasible. Hence the desirable option is of the shared or combined treatment, wherein, managerial and operational aspects are collectively addressed and the cost of treatment becomes affordable as enunciated in the scheme of the common effluent treatment plants (CETP), which are proving to be a boon especially for small entrepreneurs, given the methodical planning, regular operation and equitable contribution of member units (Rajaram et al., 2008). Such common facilities also facilitate proper management of effluent and compliance of the effluent quality standards.

Keeping in view the key role played by SSI units and the constraints in complying with pollution control norms individually by these units, the Ministry of Environment and Forests (MoEF) initiated an innovative technical and financial support scheme to ensure their growth in an environmentally compatible manner. The scheme promoted common facilities for treatment of effluents generated from SSI units located in clusters through liberal financial assistance.

The concept of CETP was adopted as a way to achieve end-of-pipe treatment of combined wastewater at lower unit cost than could be achieved by individual industries, and to facilitate discharge, monitoring and enforcement by environmental regulatory agencies and the investment of substantial government finances in the CETP scheme was justified on the basis of potential benefits in terms of pollution reduction and environmental improvements (IL & FS Escomart Ltd., 2009). Fig 7.1 and 7.2 shows the Scenario of Common effluent treatment plants in India.

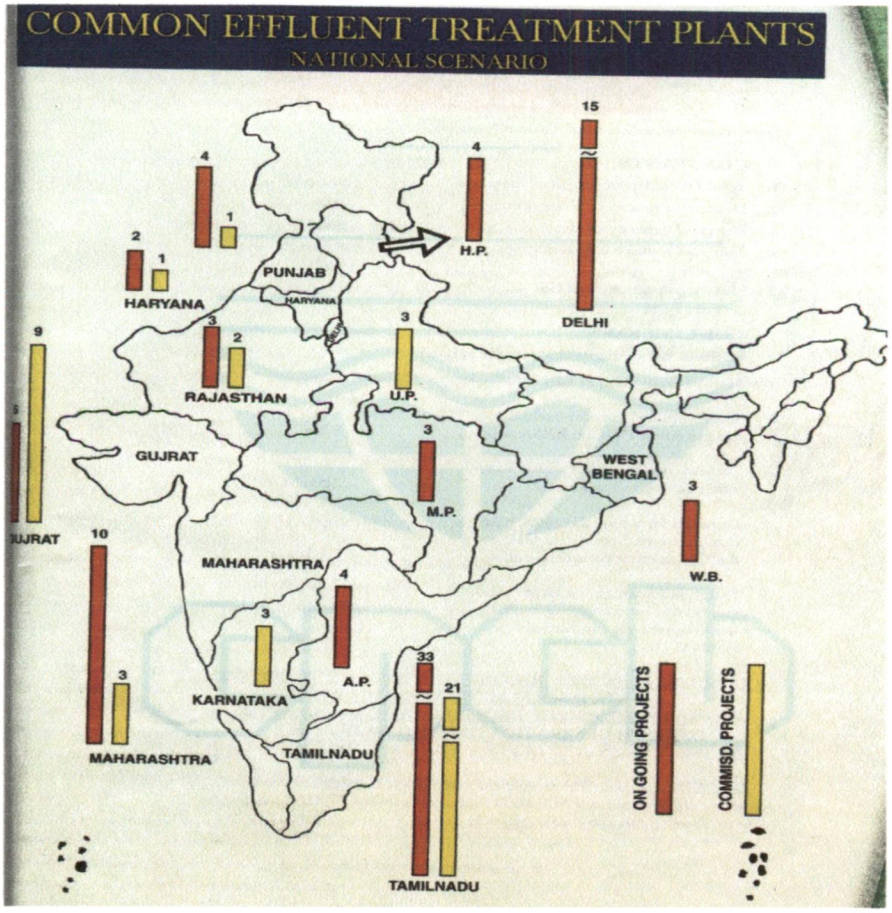

Fig 7.1: Common effluent treatment plants National scenario

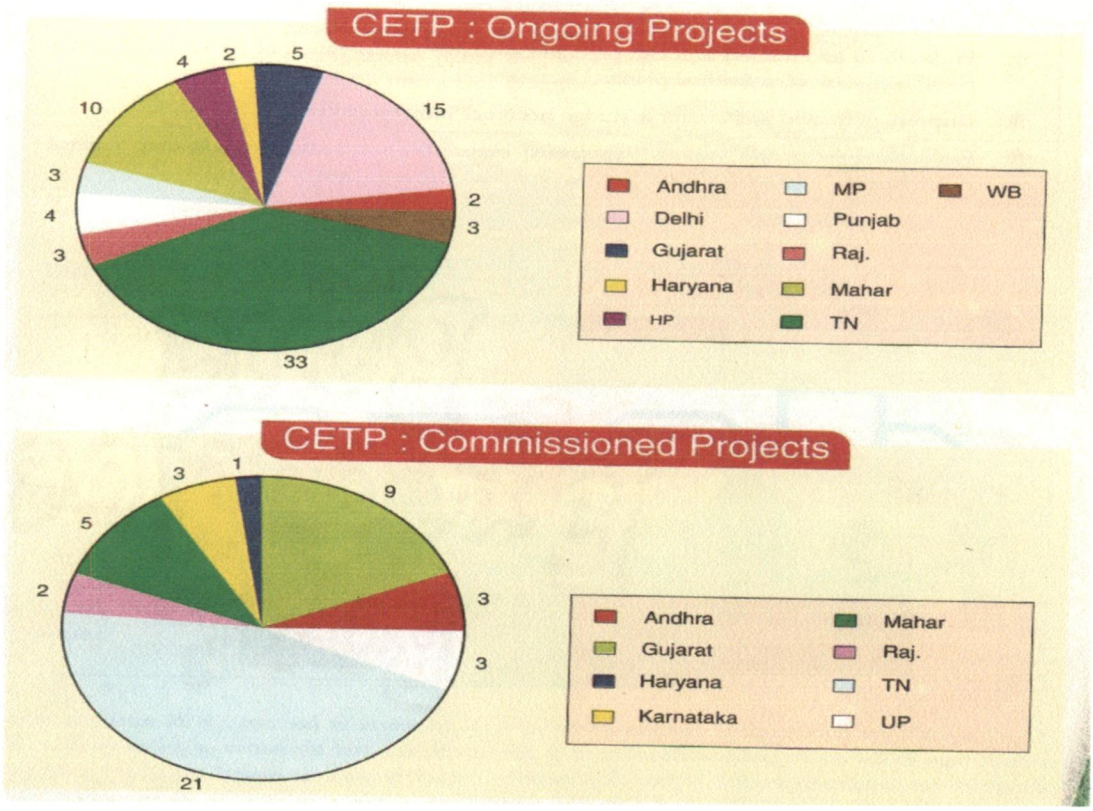

Fig 7.2: Common Effluent Treatment Plant Indian Scenario

7.3.1 Advantages of Common Effluent Treatment Plants

- Saving in Capital and operating cost of treatment plant. Combined treatment is always cheaper than small scattered treatment units.
- Availability of land which is difficult to be ensured by all individual units in the event they go for individual treatment plants. This is particularly important in case of existing old industries which simply do not have any space.
- Contribution of nutrient and diluting potential, making the complex industrial waste more amenable to degradation.
- The neutralization and equalization of heterogeneous waste makes its treatment techno-economically viable.
- Professional and trained staff can be made available for operation of CETP which is not possible in case of individual plants.
- Disposal of treated wastewater & sludge becomes more organized.
- Reduced burden of various regulatory authorities in ensuring pollution control requirement.

7.4 FINANCIAL ASSISTANCE TO CETPs

To promote the installation of Common Effluent Treatment Plant (CETP) in India, a special scheme has been made by Govt. of India, to assist in setting up of CETPs for clusters of small scale units (IL & FS Escomart Ltd, 2009). The financial assistance provided under this scheme is as follows:

Central Government subsidy- 25% of the project capital cost,
State Government subsidy- 25% of the project capital cost,
Loans from financial institutions- 30% of the project capital cost, and
Entrepreneurs' contribution- 20% of the project capital cost.

Under this scheme, assistance is provided to clusters of tanneries, textile, and chemical units. The CETP scheme was instituted initially for a period of 10 years with effect from the year 1991 but MoEF has decided to continue financial assistance under the scheme beyond this period. So far 88 CETPs have been constructed and commissioned under the scheme.

7.5 CONCEPT OF COMMON EFFLUENT TREATMENT PLANT

The concept of effluent treatment, by means, of a collective effort, has assumed reasonable gravity by being especially purposeful for cluster of small scale industrial units (Goel et al., 1996). Common effluent treatment plant (CETP) not only helps the industries in easier control of pollution, but also act as a step towards cleaner environment and service to the society at large. Small scale industries, by their very nature of job cannot benefit much from economies of scale and therefore the burden of installing pollution- control equipment, falls heavy on them. Realizing this practical problem, under the policy statement for abatement of pollution the Govt. felt to extend the scheme for promoting combined facilities for treatment of effluent and management of solid waste for clusters of small scale industrial units and also to provide technical support to them. Accordingly, Ministry of Environment & Forests, Govt. of India, had instructed various State Pollution Control Boards, to examine the possibilities of establishing CETPs in various Industrial estates in the respective states.

The concerted approach of joint or common effluent treatment provisions has many advantages. Wastewater of individual industries often contain significant concentration of pollutants; and to reduce them by individual treatment up to the desired concentration, become techno-economically difficult The combined treatment provides a better and economical option because of the equalization and neutralization taking place in the CETP (Performance Status of Common Effluent Treatment Plants in India, CPCB, 2005).

Other important issues for the merit of common treatment include scarcity of land at the industry's level and a comparatively easier availability of professional and trained staff for the operation of CETP, which can otherwise be difficult, at the individual industry level. For the regulatory authorities also, common treatment facility offers a comparatively easier means of ensuring compliance of stipulated norms. The handling and disposal of solid- waste also becomes increasingly easier as the infrastructure is created in the project itself. The concept of common treatment, based on feasibility, should be part of the new industrial estates as essential component of infrastructure, In fact, the location of industries should always be such that units with compatible nature of activity are located in a cluster which in-turn can facilitate in providing common treatment.

7.6 VIABILITY OF COMMON EFFLUENT TREATMENT PLANTS

Different View points

Since last few years there has been a debate on various aspects regarding participation of large & medium units (located in industrial area) in the CETP. There are different views of experts on this issue. An effort has been made to compile various opinions (IL & FS Escomart Ltd. 2009).

Viewpoint no.1

- To allow all categories of industries to join CETP is against the spirit of CETP.
- In case of large scale industries, the responsibility of controlling pollution will be diluted
- In case of failure of CETP the entire untreated effluent shall be released to environment. The volume of effluent shall be phenomenal considering the inclusion of large & medium units also contributing to CETP
- Hence the idea of CETP should be kept limited to small scale industries however the present limit of 25 m3/d for discharging to CETP may be revised
- The large & medium units joining CETP shall not be entitled for Central subsidy, although SPCBs may consider allowing subsidy to CETP as per merit.
- Large & medium industries will have to pay differential treatment cost to CETP Company on "Polluter Pays Principle.

Viewpoint no.2

- Although CETPs are intended for small scale industries where the maximum flow are up to 35 cubic meters/day, there are many instances of the limit is exceeded.
- It is imperative to consider the removal of criteria of maximum flow for joining the CETP schemes as some small scale units may send effluent for higher pollution potential and lesser quantity and vice-versa.
- There are quite a few advantages of considering large & medium units in CETP. Some of these advantages are
    a. Enough quantity of effluent is always available

b. With large & medium units as nuclius members along with the small scale units, this is a greater chance of efficient running of the CETP inb mutual interest.

c. Many large & medium units don't have high quantum of wastewater generation hence they can ensure cost effective treatment through CETP.

Although the policy decision for inclusion of large and medium industries in CETP is yet to be taken the above view points are significant to frame an idea

7.7 ASPECT OF OWNER SHIP

Various owner ship alternatives include the plant owned by government, consortium of industries or by an independent body. Whatever be the case, the primary emphasis should be on responsiveness in terms of effective and optimal operation of the plant and accountability. The member industries should also be made to realize that they are equally responsible for the sustenance of the plant.

7.8 CONVEYANCE SYSTEM

Different from the discharge characteristics of an integrated (big) industrial unit, small scale units usually generate higher proportion of floating or suspended particles in their effluent streams. At times their job operation result in high corrosive effluent. In either of these cases, to effectively convey their effluent to the CETP, it becomes necessary for individual units to set-up a 'pre - treatment' device. It is also necessary that the conveyance network be so designed as to ensure their periodic de-sludging. Care should also be taken to minimize on cost of operation by facilitating conveyance through gravity flow, instead of multistage pumping. In fact the location of CETP should be selected after a careful topographical survey of the drainage area to keep the conveyance route as short as possible. The chances of flooding in monsoon and accidental surface run-off into the conveyance route should also be looked into. Conveyance by tankers is another option, provided the chances of leakage are effectively checked and their transit is strictly monitored in accordance to a properly laid down system.

7.9 COST OF TREATMENT & CRITERIA FOR COST

The cost effective treatment supported with a system of regular collection/payment of treatment charges by each member unit, while maintaining its effluent quality within acceptable norms are some of the prerequisites. The system of

payment should be legally supported to provide a check for non-payment of dues and to take steps against defaulters.

The cost sharing should be decided in such a way that volume of effluent becomes an important norm, but its share in the total cost should not be such as to encourage by-passing of dilute streams and conveying highly toxic/non-biodegradable waste to CETP. The treat ability factor should also be given due consideration in cost estimation. An effort by the industry to segregate toxic, highly acidic/highly basic, or toxic metal bearing waste be made to explore the possibility to detoxify/neutralize or to attempt the recovery of metals by installing recovery plants, which are feasible and economically viable on account of their pay-back potentials (IL & FS Escomart Ltd., 2009).

7.10 PLANT DESIGN

The approach to provide treatment at low cost, an important factor in common treatment, depends on appropriate design of CETP. In keeping with the diverse nature and scale of operations, typical of small scale units, low capital investment and lower operation and maintenance cost incurred on treatment is a prime factor. In such a situation mechanical and chemical processes are advantageous over bio-logical systems. And the least preferred are conventional anaerobic processes on account of huge space requirements and least flexibility. Though, the advanced UASB technique with less hydraulic retention and space requirement being significantly low, anaerobic system is also a possible option. In order to obviate the need of excessive civil work at CETP in making huge equalization and settling units, the member units should also provide settling and neutralization of their individual waste. In order to minimize on the electrical cost, the possibility of substituting bio-energy should be explored to the extent possible. Proper management of sludge with its nutritive value would mobilize resources to substitute the operational cost. While designing the plant it would be of additional advantage to keep manpower requirement as low as possible but high in technical skills to reduce down-time for maintenance (Performance Status of Common Effluent Treatment Plants in India, CPCB, 2005).

7.11 COST ESTIMATION

The cost estimation of CETPs schemes proposed for the different types of industries is done based on the quantity measurement and rate analysis as shown in Table 7.2..

Table 7.2: Cost estimate for CETPs

S. No.	Description of Item	Quantity (in MLD)	Unit Rate (Rs in lakhs)	Unit	Amount (Rs in lakhs)
1.	CETP for 101 industries in Saharanpur District	80	125	MLD	10000
2.	CETP for 61 industries in Muzaffarnagar District	45	135	MLD	6075
3.	CETP for 50 industries in Muzaffarnagar District	42	135	MLD	5670
Total (Rs in lakhs)					21745

7.12 WORK PLAN

CETPs facility is planned to be implemented in a period of 5 years. The CETPs are implemented through the Department of Infrastructure and Industrial Development (Udyog Bandhu), Govt. of Uttar Pradesh. The treated effluent is proposed to be either discharged into the streams of river or used for irrigation. Advance planning is needed to tackle the future development of industrial effluent treatments.

CHAPTER 8

PUBLIC AWARENESS AND PUBLIC PARTICIPATION

8.1 INTRODUCTION

People's participation and public awareness programs are thus not only essential instruments for successful and sustainable river management but are also important tools in countering negative attitudes toward rivers. For an environmental project like conservation and management of Hindon River, participation of duly aware people who has some stake in the river is prerequisite. Participation of the public can only be solicited when the people are aware about the project. The project shall be successful only when their interests and reservations are incorporated in planning and execution of the project (Craps et al., 2004).

It becomes necessary to identify the stakeholders, exchanging information with stakeholders, regarding their needs, interests and reservations with respect to project, introducing the project to the people, enthusing ownership feeling, choosing target 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 woos of negatively affected group must be redressed by rehabilitation and resettlements, compensation and/or guarantee of certain collateral benefits free of cost (Joss et al., 1999).

In case of Hindon River, the government has the capability to be an effective lobbying force to ensure the development and implementation of program to protect and clean up the rivers. 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, thereby augmenting the government efforts. Fig 8.1 shows the process of community participation for conservation of Hindon River. (Leslie et al., 1999)

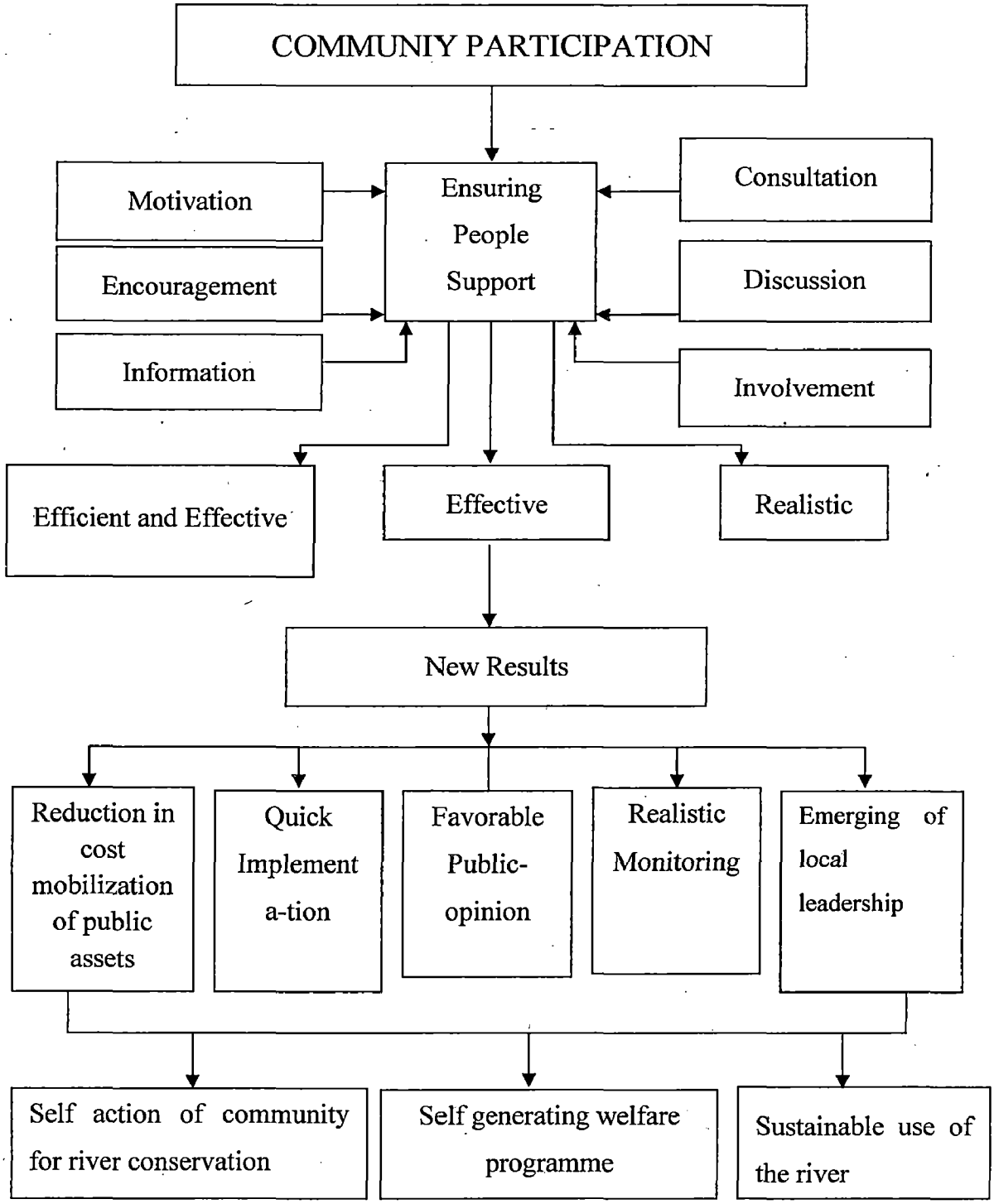

Fig 8.1: Process of community Participation

8.2 OBJECTIVE

Recognizing the need to involve people (who are both perpetrator and victims of over-exploitation of the river) into the river development process, this initiative aims to provide inputs to the overall developmental planning process through action-oriented activities and program to increase knowledge and awareness of rivers and their values. The aim is to conserve the existing rivers and initiate a collaborative approach to their management, ensuring the sustainable and equitable use of the resource starting with the shared analysis of the problem and later including the implementation of the proposed measures.

8.3 METHODOLOGY

Methodology is based on an approach for interacting with local people and learning from and with them about local natural resources and related issues. It also involves participatory methods to enable local people to participate in knowledge-building exercises, investigate and analyze their problems, evaluate constraints, opportunities and take informed decisions regarding local natural resource management. Attitude awareness and Perception survey was conducted to understand the awareness levels of various target groups.

This technique is based on the premise that local communities have an intrinsic relationship with local natural resources, which are important for their lives and livelihoods. They have their own perspective on such resources with a diverse inventory of knowledge and experience. Such knowledge can be revealed only through participatory interactions for learning and action.

The principles are:

- Listening and learning
- Offsetting biases
- Proper utilization of precious community time
- Seeking diversity
- Cross-checking

The process of Participatory Management for sustainable river environment is illustrated below:

Analysis of the needs and requirements of the community

Understanding the positive as well as negative attitudes of the members of the community in regard to various practices

With the involvement of the people designing the development programme as per their needs and requirements

Through formal and informal channels educating the people and making them aware of the conservation issues and utilizing the river environment in a sustainable manner

With aided guidance leaving the people to operate the action oriented programme designed by them

To sort out problems in a participatory manner if any occasional follow up is needed

Birth of a sustainably managed River Environment

The participatory methods consist of ways, tools and techniques to evoke and organize participation so as to make it creative, interactive, and analytical. The methods

help in involvement of local communities because it is they who do their own analysis through such methods, explain their findings and propose action on that basis.

In this study, the aim is to share and gather information methodically in order to suggest a public awareness and participation plan for the conservation and management of Hindon River in a selected stretch. It has been tried to observe the catchment area personally, meet the people from the different groups living in the villages, colony of the city, visitors to the river, peoples living in tolas and bustis on the shoreline of the river.

8.4 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 Hindon River which can be broadly classified in three major groups:

(a) Public sector

1. Drinking Water and Sanitation Department, Govt. of Uttar Pradesh
2. Department of Urban development, Govt. of Uttar Pradesh
3. Department of finance, Govt. of Uttar Pradesh
4. Department of Planning and Development, Govt. of Uttar Pradesh
5. Water Resource department, Govt. of Uttar Pradesh
6. Department of Forest and Environment, Govt. of Uttar Pradesh
7. Department of Fisheries, Govt. of Uttar Pradesh
8. Department of Agriculture, Govt. of Uttar Pradesh
9. Department of Rural Development, Govt. of Uttar Pradesh
10. Local Government Bodies Concerned

(b) Private sector

1. Chairman, Uttar Pradesh Chamber of Commerce
2. Chairman, Hotel and Restaurant Owners Association
3. Chairman, Farmers Association
4. Chairman, Industrialist Association
5. Chairman, Truck Owners Association
6. Chairman, Bus Operators Association
7. Chairman, Shopkeepers Association

(c) Non-profit sector

1. Secretary of different NGOs working in or near the catchment area like Samvardhan, Janhit Foundation etc.
2. Senior and most respected person from fisherman community living in the catchment
3. Senior and most respected person from washer man community living in the catchment
4. Eminent personality/ Social worker living in the catchment

8.4.1 Perception

Perception of the local community regarding their surroundings – the river environment, its usage, the problems and the possible solutions and potentials is very significant for conservation and better management of the river. These participatory techniques also revealed the community people's perception regarding problems and solutions related to the natural resources of the area. Following information has been gathered from the people in the catchment:

1. Earlier, there were a lot of trees of varying variety in the catchment and some forests which has been illegally felled. This underlines the need of community awareness program regarding the importance of trees in conserving the river environment. Need of fresh tree plantation and restoration of extinct variety of trees in the catchment has been noted down.

2. Very few household has Individual household Latrine (IHHL) and very poor sanitation facility. Majority of rural population and the slum dwellers in the tolas near the river openly defecate. Dry zones of the river are used for grazing cattle's. Community awareness programme is required regarding sanitation and its relation with their health and with the health of the river.

3. They use the river for idol immersion. Earlier, variety of fish was available in the river and they cherish to enjoy angling again. Now, they do not enjoy swimming in the river as the water is dirty. This underlines the deterioration of water quality. Awareness regarding the restoration of water quality and importance of their participation and required habitual change for the same need to be conveyed.

4. A lot houses has been constructed in the river illegally which earlier used to be river area. This emphasizes freeing of river from illegal encroachment and securing the original river area so that no further encroachment may occur.

8.4.2 Needs Assessment (Usage Factor)

People living in the upper portion of the river catchment were found to be least bothered about the river and quite ignorant about the deterioration of the river and its environment. They are also unable to perceive that their change in habits has done much the wrong. Awareness is required regarding the effect of changes in land use pattern; usage of fertilizer and insecticide, open defecation and open cattle grazing on the health of river needs to be undertaken.

People living in the catchment in the city were found to be concerned only related to the affect on the supply of water and the odor coming from the water. Majority of them were found aware that their actions are responsible for the same. But they were one up in blaming that government is doing nothing and engineers are planning to misappropriate the money meant for desilting of the river. They think that only remedy for the river is to desilt the sediments and garbage from the bed of the river. In their opinion now the only purpose of the river is to accumulate enough water for uninterrupted supply to them. They are also much bothered that odor should not come out from water. They are not aware about the inter relation between them and the river. Much sensitization is needed among this group of people.

8.4.3 Problems, Issues and Threats

A sequence of open questions helped in conducing in-depth probing of issues of river concern and their cause-effect relationship.

- Community opinion is that the river is really threatened by industrial effluent, sewage and siltation is being discharged into the river through nallahs and drains.

- Lowering of water level in the river is of significant importance as irrigation and drinking water is supplied to them from it.

- According to community following are the issues of the river conservation:
    - Deterioration in water quality
    - Lowering of water level in the river

- Odor in river water
- Sewage, industrial and waste disposal
- Siltation
- Decrease in number of fish in the river

All these problems in the rivers have acquired a serious dimension and should be taken care of else the river environment will be degraded beyond easy solutions. Though a number of studies conducted on river water quality and related issues have revealed that the river water suffers contamination from agricultural, household and industrial activities, local people seem to disagree with these except industrial effluent. All the people who were interviewed expressed their concern towards keeping the water clean and denied any threat by agricultural or household activities.

8.4.4 Awareness level (Usage, Problems and Solutions)

Outcome of the interview of people residing in the catchment and stakeholders to gauge the level of awareness has been mentioned in the Table 8.1.

- In the areas around the river, sewage is discharged into the river. Open defecation and cattle grazing in the river is generally used.

- Awareness levels regarding ecological benefits of river are not that impressive. Important ecological functions of river like ground water recharge, nutrient retention, micro-climate stabilization, etc. are not known by many people.

- Community people are against the discharge of industrial effluent into the river.

- People are very much in favor of development of the river area as a tourist spot as they do realize that will inflow of money to them.

- People also want that the cleaner and more attractive landscape in and around the river. In general, they have been receptive to the development works.

Table 8.1: Awareness Level of Community

S. No.	Issues	Percentage of Aware people
1.	Odor in river water	92
2.	Deterioration of water Quality	90
3.	Discharge of Industrial Effluent	85
4.	Siltation	55
5.	Nutrient retention	15
6.	Algal bloom	22
7.	Ground water recharge	27
8.	Micro-climate Stabilization	12

8.4.5 Developmental Proposals by local Community

As local population around the rivers is quite aware of the importance of River Environment, the participatory techniques succeeded in getting some good proposal points for development in the river areas. Participatory techniques aided in identification of problems specific to each group of stakeholders along with their solutions as proposed by the community people (Table 8.2).

Table 8.2: Problems and Proposed Solutions Specific to Stakeholders

Stakeholders	Issues/problems	Proposed Solutions
Local High Income Group	➢ Odor in water, ➢ Discharge of Industrial effluent, ➢ Road around river becomes unsafe in the evening, ➢ Approach to the river is not good.	➢ Stringent policy measures to be taken up in this regard and infringing violators are punished, ➢ Change of process of treatment of water at STP, ➢ Installation of ETPs, ➢ Lightening on the road around the river periphery.
Local middle income group	➢ Odor in river water ➢ Employment of unemployed youths in managing the river and in catering visitors.	➢ Financial support should be provided to local people to start small business, hotels, restaurants, shops etc. ➢ Awareness generating

		activities to be undertaken on large scale like group meeting, slide shows, competitions, eco-rallies and teachers' training programmes.
Local low income group	➢ Unable to get low cost IHHL due to lack of government holding, ➢ No grazing land left as Green belt has been encroached, and lack of livelihood.	➢ Community involvement in development activities encouraged. This to be done by formation of eco-clubs, self help groups, instituting awards, community demonstration projects and capacity building through training and development.
Visitors	➢ Non-existent adventure activities like ecological park, fishing, boating etc.	➢ Other river related sport activities should also be promoted. ➢ Education/awareness programme for visitors to be organized and innovative measures undertaken to involve them.
Drinking Water and Sanitation Department: responsible for managing the river.	➢ Lack of efforts towards river conservation and management ➢ Nothing has been done for the health of the river; ➢ Dependent on Department of Urban Development for fund and approval.	➢ The department to undertake intensive river management activities focusing on water quality, infrastructure development conducive to river environment. ➢ A helping hand needs to be extended to the local population by providing them financial support as well as information dissemination. ➢ Change in Institutional Linkage to act independently or better to institute an independent river development authority

To deal with the disposal of sewage and waste, local people suggested that nallahs and drains which are discharging to the river need to be intercepted and diverted.

Thus, the field experience of participatory techniques for development suggests the following underlying facts:

- Local people are more willing to participate when they feel the need for river conservation.
- Local people make rational economic decisions in the context of their own environment and circumstances rather than those prescribed by government and project staff.
- Voluntary local commitment of labor, time, material and money to a conservation project is a necessary condition for breaking patterns of conservation paternalism that reinforces local passivity and indifference.
- Control of the amount, quality and especially the distribution of benefits from conservation activities are directly related to those activities becoming self-sustaining.

Two critical issues on which the involvement of community in conservation projects depends are:

- Firstly, the community participation for project implementation has got to be based upon persuation and understanding and not simply on short-term incentives or even coercion. River conservation is inevitably seen as an urgent priority and the urgency equally inevitably dictates the approach whilst this might be necessary in certain circumstances, a less immediate perspective often gives an opportunity to develop better local participation.
- Secondly, if local people can share in explaining the causes of resource degradation, they may more readily identify with the solution. In this respect, conservation projects have invariably seen resource degradation as a purely physical problem requiring technical solutions whilst these solutions may have been technically appropriate, they are in fact treating the symptoms rather than the causes. It is to be rather understood that local people do not deliberately degrade the river area and that their knowledge of the level of locally available technologies might be contributing to the poor use of the river and its resources. Understanding the problem on the local people's terms will provide a stronger basis for participation and effective conservation measures.

8.5 AWARENESS GENERATION INITIATIVE

The aim of such an initiative 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.

Earlier through public participation we determined on how best to communicate with people to know/change their environmental attitude towards rivers. What perceptions do they have? What knowledge they lack? What are their concerns? How do the economics of tourism development activities be integrated into River preservation/conservation? The aim would now be to provide ecological knowledge. 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 (Leslie et al., 1999). Through education they can be made to see how tourism development is linked to the needs of local economy? And how nature can be promoted as a tourist product and a balance found between these acts and nature conservation. It can be shown to them how external investment, remain inside the region and generate local benefits.

A comprehensive public awareness and participation plan for three years under the conservation plan of Hindon River with an estimated cost of Rs. **395.05** lacs has been formulated which can be seen in Table8.3. The implementation mechanism for the creating awareness and generating public participation for achieving the objective of river conservation has been detailed out below, phase-wise:

Phase I

The local communities residing around the rivers have a sense of emotional attachment to rivers that has to do with their former and present usefulness and with the aesthetic value of it as diversity source in the very monotonous and degraded present landscape. This inherent feeling itself gives a sound starting point for program aimed to increase environmental awareness, particularly addressed to those people whose activities cause

more impact. Attitude awareness and Perception survey was conducted to understand the awareness levels of various target groups.

Table 8.3: Public Awareness and Participation Plan

S. No.	Activity	Nos.	Unit Cost (in Rs.)	Total Amount (in Lacs.)
1	Audi-visual films	10 nos. of 15 minutes duration each	500000/-	50.00
2	Group Meetings with slide shows, screening of audio-visual films and interactive work shops	6 each year for a period of 3 years	40000/pm	86.40
3	Children workshops with Nature Trails/games; Eco-rallies			17.00
4	Support to Eco-clubs	4 club to support for 3 yrs.	35000/pm	50.40
5	Support to self-help groups	4 groups to be supported for 3 yrs.	25000/pm	36.00
6	Training programmes	2 workshops each year for 3 yrs.	45000/per workshop	32.40
7	Eco-conservation Award Felicitation ceremony	Once for every year for 3 yrs.	95000/-	2.85
8	Printing pamphlets & Brochures & Awareness kits			8.00
9	Administrative costs for facilitating formation of Eco-clubs, Self-help groups and workshops including misc. expenses for PR and other associated works for a period of 3 yrs.			12.00
	TOTAL			**395.05**

Phase II: Implementation Phase

The second phase would be restricted to creation of awareness among the stake-holders through education. This phase should be spread over a period of six months. During this phase several awareness programmes as proposed below should be conducted for locals in the catchment villages and also for the incoming tourists/visitors.

A. For Local Community:

In order to enlarge the acceptance of nature conservation by the local people, these programmes should aim at building up positive attitude of local people towards nature conservation and making them feel proud of 'their' nature area. Following activities can be undertaken for this:

- Group meetings: Such meetings and discussions are to be the first method deployed to convey the aim of the programmes and the need for such awareness programmes.
- Slide shows: Different sets of slides of the common floral and faunal species and ecological problems of the area to be prepared and showed with relevant commentary in local languages. Questions to be asked at the beginning and end of each programme to test recapitulation of the visuals and messages presented.
- Audio-visual films: need to be created and screened at appropriate locations for creating awareness.
- Pamphlets: Information to be provided in pamphlets and circulated in hotels, resorts, travel agents and airlines, adventure tour operators and nature camp owners

B. For Tourists/visitors

Proper education helps the visitors to aware of the natural and ecological values of the area and the harmful input unknowingly delivered by them to the nature. Following information helps the tourists:

- Educational cum entertainment programme for visiting school groups: This will prove to be a very effective way of imparting environmental awareness among the visitors. The sightseeing trip should include quiz, competitions and discussions at the visiting sites.

- Audio-visual films: need to be created and screened at appropriate locations for creating awareness.

Phase III:

Community Involvement in Development Activities can be promoted through initiatives:

Young Volunteer Eco-clubs

The Eco-clubs should be established to try to create awareness about the depletion of the resources and the environmental degradation taking place in the river region. The main objective of the club would be to cultivate a desire for river conservation among the local people. The club should also aim to promote realization of the economic, recreational and aesthetic, ecological values of the river resources

through participation and rational utilization of the rivers' resources. The central focus of the club should be school children who shall be able to carry this message to their respective families too. Thus it will initiate conservation consciousness in the population of tomorrow. The eco-club should bring out a quarterly newsletter containing write-ups from the local community on river related issues with examples of good practices. A nodal school or a local NGO can be selected each year to co-ordinate the activities so the club. After this duration further grants can be reviewed on the basis of performance. The clubs can also be encouraged to invite local donations and corporate sponsorships for the various club events.

Creation of Self-help Groups

Formation of Self-Help Groups is to be initiated to involve the local population in various development activities. Some of the salient features of these groups should be:

- Homogeneity of the groups: They should have common concern and should discuss it freely from a common platform. Initially it is proposed to create at least 2 such groups – Boatmen and local shopkeepers for each of the rivers.
- Membership and its size: The membership in the group should be in the range of 15 to 30. Bigger groups should be discouraged, as these are not conducive to the group's cohesiveness.
- Regular meetings: Groups should hold regular meetings at least once in a fortnight to review progress of their ongoing activities and also to review their plans for the future.
- Group savings: A group saving scheme is an important aspect of group activities. It should be made compulsory that every member of group should contribute in a sharing fund regularly. The money shared should be used for advancing loans to needy members to meet their emergency and subsistence needs, thereby reducing their dependence on moneylenders or landlords. Resources of the sharing fund may also be used for expanding group activities.
- Group leaders: A group leader is selected from the group members by consensus. Other members are also assigned different responsibilities. Thus everybody shares the work of the group.

- Financial Support: The government/non-government organizations may provide limited financial support to such groups for the initial duration of 3 yrs. Further grants can be considered subject to the performance benefits for such groups.
- Credit: As groups are organized around productive activities, the need for credit arises. Banking institutions should advance credit to members of small groups not on the basis of collateral but on the basis of the collective guarantee of the group concerned. Alternatively, total land assets of all the members of a group may be used as collateral for loans to individual members for the purposes approved by the group concerned. Similarly, collective loans may also be secured for collective and joint projects to be undertaken by groups.
- Associations: As several small groups are formed and as they are involved in several activities, it would be useful to share their inexperience, to learn from each other's mistakes and success. The several small groups in a village or an area therefore may be federated into an association which can occasionally meet and discuss common problems, of member groups. Such associations can also undertake, on behalf of their member groups, joint marketing of their products and procurement of inputs with a view to taking advantage of the economy of sale in production. The formation of the association and its transformation into a co-operative society must not be hastened or forced in a structural or bureaucratic manner. The higher institutions should be allowed to gradually develop the small groups. It is the smaller groups that are the most important and need to be nurtured very gently as they have so far proved to be the most viable institutional forms for mobilization of the resource and conservation issues.
- Cooperative society: The association can then grow into a cooperative society fully controlled by the groups. The board of directors of the co-operative society may be elected by representatives of its members groups or may be composed of group leaders serving on the board for a fixed term on a rotational basis. The group organizer/outside agency referred to earlier will be attached to the co-operative society and his primary responsibility would be to assist in forming groups and helping them in preparing their group plans with the assistance of extension agents of different departments at the local or district level. Group organizers and managers of the co-operative society should be provided by the

banking system at least for the initial formative period of 5 to 10 years or until the co-operative societies appoints their own organizer and co-operative manager. These officials should be held accountable to the general membership of the co-operative society and its constituent groups for their performance.

Capacity Building through Awareness & Training Programmes

Capacity building through awareness, training programmes for various stakeholders and interest groups in the river regions include awareness modules through training programmes in the following area:

- River eco system analysis and management
- Modern water management practices in rivers and their catchment
- Water quality monitoring
- Soil and water conservation in catchment area
- Database management
- Hydrological modeling, reservoir operation and flood mitigation management.

Other interest groups for which programmes could be undertaken include:

- Teachers (16 workshops in a year for 3 consecutive years)
- Farmers (4 workshop)
- Hoteliers (4 workshops)
- Shopkeepers (4 workshop)
- Transporters (4 workshop)

Eco-Conservation Award

It is proposed to institute an award for the person who displays outstanding participation, interest and contribution towards river conservation activities. The award should become an annual feature with an award felicitation ceremony.

Community Demonstration Projects

Such projects can be undertaken with the help of self-help groups, eco-clubs and other NGO's in the region.

CHAPTER 9

INSTITUTIONAL ARRANGEMENT

9.1 INTRODUCTION

Water pollution control is typically one of the responsibilities of a government as it aims to protect the environment for the good of the general public. Governments undertake to do this by establishing an appropriate set of organizations and launching specific programmes. Effective implementation of Waste Water and Solid Waste Management are extremely difficult. In reality, wastewater control always receives the lowest priority, although its infrastructure is at least as expensive as that for water supply. So, it is more important to organize and execute the governmental policy effectively; for example that wastewater treatment plants are actually built and operated or that sanitation facilities, once constructed, are actually used and remain maintained. Water is an environmental resource with a profound impact on public health, economic activity and environmental (and ecosystem) quality. Therefore, the prerequisite for any sustainable development scenario is that the organizations that are assigned with water management actually possess the capability to carry out this task. A well-balanced arrangement of flexible, dynamic organizations and other related institutions is the best assurance that unpolluted water resources remain available in the future, that the right quantity and quality of water are delivered to the water users (including the ecosystems), and that people can live in a healthy environment. These organizations, however, can only execute these functions if they have access to an appropriate financial base to expand and maintain the infrastructure, to attract qualified professionals, and to prepare well for the future (Alaerts, 1997).

9.2 U.P. JAL NIGAM

U.P. Jal Nigam has been given power to prepare, execute & promote water supply, sewerage/ River pollution Control Works etc. all over the state. U.P. Jal Nigam shall hand over such works for maintenance to local bodies in urban areas and to respective Jal Sansthans, in their jurisdiction. In the rural area, other than as specified in the jurisdiction of Jal Sansthan, water supply projects are being maintained by U.P. Jal Nigam. Hand pumps in rural areas all over UP were earlier maintained by UP Jal Nigam, which has been handed over to respective village panchayats.

9.2.1 Functions

The functions of U.P. Jal Nigam shall be the following namely

- The preparation, execution promotion and financing the schemes for the supply of water and for sewage disposal.
- To render all necessary services in regard to water supply and sewerage to the State Government and local bodies, on request to private institutions or individuals.
- To prepare State plans for water supply, sewerage and drainage on the directions of the State Govt.
- To assess the requirement of materials and arrange for their procurement and utilization.
- To establish state standards for water supply and sewerage services.
- To review annually the technical, financial, economic and other aspects of water supply and sewerage system to every Jal Sansthan or local bodies which has entered into an agreement with the Nigam under section 46 of the act.
- To establish and maintain a facility to review and appraise the technical, financial, economic and other pertinent aspects of every water supply and sewerage scheme in the state.
- To operate, run and maintain any water works and sewerage system if and when directed by the State Govt. on such terms and conditions and for such period as may be specified by the State Govt.
- To assess the requirements for man power and training in relation to water supply and sewerage services in the state.
- To carry out applied research for efficient discharge of the functions of the Nigam or a Jal Sansthan.

These functions are carried by the following special units which are headed by one joint chief Engineer:

1) **Project Development Cell (PDC)** for reviewing the investigation works and scrutiny of Detailed Project Reports (DPRs) prepared by Project Formulation (PF) Divisions at District level. The PDC is also responsible for incorporation of mitigation measures in design and construction and construction-stage environmental monitoring.

2) **Contract, Operation & Maintenance (COM) wing** for finalising contract documents, tender evaluation and fixing of agencies/contractors for implementation of the project and to look after the operation and maintenance related works of combined water supply schemes (CWSSs) maintained by U.P. Jal Nigam Maintenance Divisions at District level.

3) **Programme Management (PM) wing** for monitoring and reviewing the progress of project execution by the implementing Divisions (RWS Divisions, urban divisions and Sewerage Divisions at District level).

4) **Quality Assurance and Technical Audit (QATA) cell** for verifying quality of work and materials used on works by the implementing Divisions and for providing adequate in-house training for capacity building.

5) **Establishment wing** deals with staffs transfer and postings, personal claims, pension.

Besides the above, there are some other units are also functioning at U.P. Jal Nigam, Head office, Lucknow for proper control, monitoring and guiding the Project Implementation Units (PIUs) such as

- **Board Secretariat** headed by the General Manager for administrative matters,
- **Financial, Audit & Accounting wing** headed by Finance Director,
- **Consultation and Communication Development Unit (CCDU)** headed by Director(CCDU) for conducting public awareness programmes and providing adequate training programmes to maintenance staffs of local government bodies,
- **Water Quality Monitoring wing** headed by Chief Water Analyst for monitoring periodical water sample testing process and maintenance of District level Water Testing Laboratories,
- **Hydro-Geological wing** headed by Senior Hydro-Geologist for monitoring the Geophysical investigation works of scientific source finding for water supply schemes by the Assistant Hydro-geologists at Division level,

- **Vigilance cell** headed by a Superintending Engineer for Anti-corruption,
- **Law cell** headed by Law Officer for legal opinions and looking after court cases,
- **Information and Communication** (IAC) wing headed by Manager (IAC) for advertisements, publications and public relations related activities,
- **Electronic Data Processing (EDP) unit** headed by EDP Manager for developing computerized own software packages and website related activities.

The Investigation and Execution for this sub project (Sewerage Scheme to said towns in Saharanpur and Muzaffarnagar District) are likely to be undertaken by U.P. Jal Nigam. The Implementation/Augmentation of water supply scheme to these towns is also under taken by U.P. Jal Nigam. The PIUs are assisted by the various state level units of U.P. Jal Nigam (as stated above) who provides program management support, assure the technical quality of design and construction, and provide advice on policy reforms.

The various line departments involved in implementing developmental investment program and inter-linked with implementation of this sub-project in any way may include:

1. Saharanpur and Muzaffarnagar Municipal Corporation
2. Department of Urban Development
3. Department of Environment and Forest
4. U.P. State Pollution Control Board
5. Department of Land Development and Water Resources
6. Tourism Department
7. Department of Agriculture, Horticulture and Soil Conservation
8. Public Works Department
9. Town Planning Department
10. Department of Rural Development

9.2.2 Organization Structure

Jal Nigam Board consists of a Chairman appointed by the State Government besides the members.

The members other than the Chairman are as follows namely:

- A Managing Director (to be appointed by the State Government) who shall be a qualified engineer having administrative experience and also the experience of water supply and sewerage works.
- A Finance Director to be appointed by the State Government from amongst the persons possessing such qualifications & experience and in accordance with such manner as may be prescribed.
- The Secretary to the State Government in the Finance Department.
- The Secretary to the State Government in the Nagar Vikas Vibhag (Urban Development Department).
- The Secretary to the State Government in Planning Department.
- The Secretary to the State Government in Rural Development Department.
- The Director of Local Bodies Uttar Pradesh.
- The Director of Medical and Health Services, Uttar Pradesh.
- Three elected heads of local bodies in the State to be nominated by the State Government.

Besides above 12 regular members, Director General Sarvajanic Udyam Bureau (Burea of Public Enterprise) is also invited in the Board meeting as permanent invitees.

9.2.3 Construction & Design Services

The Construction & Design Services is a commercial wing of the UP Jal Nigam to diversify the activities of the Parent Organization (the UP Jal Nigam) in the fields of Consultancy Services, Project Management, Land Development & Construction of buildings of all types and magnitude, Interior Designing and Furnishing, Land Soaping, Fire Protection, Air Conditioning etc., in addition to our traditional fields of Environmental Engineering viz., Water supply Sewerage including Sewage Treatment and Effluent Treatment for Industrial Units, River Pollution Abatement etc.

Organizational Structure:

The Construction & Design Services wing is headed by Director, who is a Chief Engineer of the U.P. Jal Nigam. There are 3 Chief General Managers, 11 General Managers and 50 Project Managers & 300 Employees. The field units are located at all

important works. At present 45 field units are located in different parts of Uttar Pradesh.

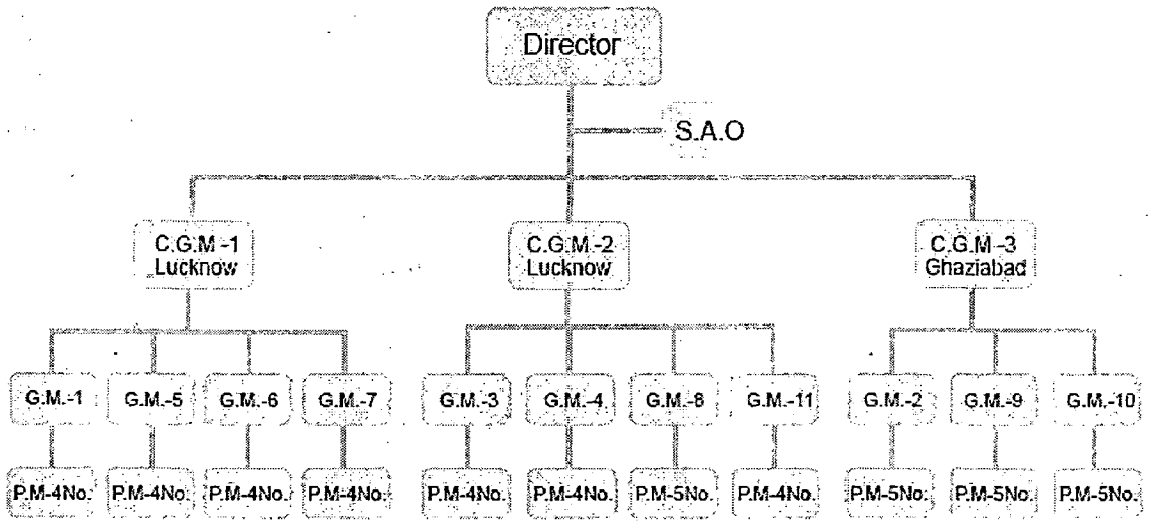

Fig 9.1: Organization Structure of Construction & Design Services

9.3 BLOCK DEVELOPMENT OFFICERS (BDO) FOR DISTRICT RURAL DEVELOPMENT AGENCIES (DRDA)

Block Development Officer is the prime incharge of all planning and developmental work pertaining to the block under jurisdiction. DRDA is responsible for execution of all Rural Developmental schemes. Therefore the construction of community toilets and contribution to individual toilets in rural areas are to be implemented by DRDA or BDOs concerned.

9.4 URBAN LOCAL GOVERNMENT BODIES

Urban Local Government Bodies (Nagar Nigam, Nagar Parishad, and Nagar Panchayat) are responsible for planning implementation and maintenance of all sorts of developmental activities under their jurisdiction. The Solid Waste Management works will be implemented by Local Government Bodies concerned.

9.5 DEPARTMENT OF INFRASTRUCTURE AND INDUSTRIAL DEVELOPMENT (Udyog Bandhu)

Udyog Bandhu is a registered society focused on attracting investment in the state of Uttar Pradesh. Proactively contributing in policy formulation for rapid

development of infrastructure, manufacturing and service sectors, the organization facilitates resolution of problems of prospective and existing entrepreneurs by providing them advisory services and taking up their issues at the appropriate level in the Government of Uttar Pradesh and other public bodies, institutions and organizations. Udyog Bandhu functions with transparency and swift responsiveness and serves its clients with a friendly and courteous approach."

Infrastructure and Industrial Development is responsible for monitoring the implementation of ETPs or CETPs by industries.

CHAPTER 10

ENVIRONMENT IMPACT ASSESSMENT

10.1 GENERAL

The Environmental Impact Assessment (EIA) is an important tool for incorporating environmental concerns at the project level. EIA should be carried out as early as the project planning stage as part of feasibility thus it can assure that the project will be environmentally feasible.

10.2 OBJECTIVES

The general objectives of the EIA study are to provide:

i) Baseline information about the environmental, social, and economic conditions in the project area;
ii) Information on potential impacts of the project and the characteristic of the impacts, magnitude, distribution, who will be the affected group, and their duration;
iii) Information on potential mitigation measures to minimize the impact including mitigation costs;
iv) To assess the best alternative project at most benefits and least costs in terms of financial, social, and environment. In addition to alternative location of the project, project design or project management may also be considered; and
v) Basic information for formulating environmental management plan.

EIA requires an in-depth analysis because of the potential significance of environmental impacts from the project. EIAs demand (i) comprehensive analysis of the potential impacts; (ii) works to be carried out to formulate practical mitigation measures; (iii) in-depth economic valuation of impact to screen and evaluate the best alternative, and (iv) in-depth analysis to prepare an adequate environmental management plan.

EIA reports should be presented in certain way to meet the requirements of ADB and the DMC. However, wherever possible, ADB requests that the Borrower follow ADB-prescribed format for EIA. This is to ensure that environmental assessment results are presented in a clear and concise fashion to contribute most effectively to decision-making. However, if several other financial institutions fund the

proposed Project in the form of co-financing modality, it is necessary for ADB to come up with an agreement with those institutions on EIA reporting requirement. In this context, it is necessary to ensure that the content of the EIA reports cover all issues required by ADB.

An environmental assessment report is required for all environment category A and B projects. Its level of detail and comprehensiveness is commensurate with the significance of potential environmental impacts and risks.

10.3 EFFECTIVENESS OF EIA

In the mid-1990s, a major international review of the effectiveness of EIA was implemented (Sadler, 1996). This study was wide-ranging in its scope and comprehensive in the depth of its analysis and provides the most recent comparative information on the benefits of EIA, and also of its major weaknesses. The review showed that to date, no country has abandoned EIA, or weakened its EIA procedures. Indeed, any legal amendments that have been made have tended to strengthen these procedures and increase their scope and effectiveness. Thus, EIA has been "tried and tested" at the project level.

The main advantages and benefits of EIA are:

1) Improved project design/siting;
2) More informed decision-making (with improved opportunities for public involvement in decision-making);
3) More environmentally sensitive decisions;
4) Increased accountability and transparency during the development process;
5) Improved integration of projects into their environmental and social setting;
6) Reduced environmental damage;
7) More effective projects in terms of meeting their financial and/or socio-economic objectives; and
8) A positive contribution towards achieving sustainability

10.4 ELEMENTS OF EIA SYSTEMS

A typical EIA report contains the following major elements, and an IEE may have a narrower scope depending on the nature of the project. The substantive aspects of this outline will guide the preparation of environmental impact assessment reports, although not necessarily in the order shown (Brown, 1997).

1. **Executive Summary:** This section describes concisely the critical facts, significant findings, and recommended actions.
2. **Policy, Legal, and Administrative Framework:** This section discusses the national and local legal and institutional framework within which the environmental assessment is carried out. It also identifies project-relevant international environmental agreements to which the country is a party.
3. **Description of the Project:** This section describes the proposed project; its major components; and its geographic, ecological, social, and temporal context, including any associated facility required by and for the project (for example, access roads, power plants, water supply, quarries and borrow pits, and spoil disposal). It normally includes drawings and maps showing the project's layout and components, the project site, and the project's area of influence.
4. **Description of the Environment (Baseline Data):** This section describes relevant physical, biological, and socioeconomic conditions within the study area. It also looks at current and proposed development activities within the project's area of influence, including those not directly connected to the project. It indicates the accuracy, reliability, and sources of the data.
5. **Anticipated Environmental Impacts and Mitigation Measures:** This section predicts and assesses the project's likely positive and negative direct and indirect impacts to physical, biological, socioeconomic (including occupational health and safety, community health and safety, vulnerable groups and gender issues, and impacts on livelihoods through environmental media, and physical cultural resources in the project's area of influence, in quantitative terms to the extent possible; identifies mitigation measures and any residual negative impacts that cannot be mitigated; explores opportunities for enhancement; identifies and estimates the extent and quality of available data, key data gaps, and uncertainties associated with predictions and specifies topics that do not require further attention; and examines global, transboundary, and cumulative impacts as appropriate.
6. **Analysis of Alternatives:** This section examines alternatives to the proposed project site, technology, design, and operation—including the no project alternative—in terms of their potential environmental impacts; the feasibility of mitigating these impacts; their capital and recurrent costs; their suitability under local conditions; and their institutional, training, and monitoring requirements. It

also states the basis for selecting the particular project design proposed and, justifies recommended emission levels and approaches to pollution prevention and abatement.

7. **Information Disclosure, Consultation, and Participation:** This section:

- Describes the process undertaken during project design and preparation for engaging stakeholders, including information disclosure and consultation with affected people and other stakeholders;
- Summarizes comments and concerns received from affected people and other stakeholders and how these comments have been addressed in project design and mitigation measures, with special attention paid to the needs and concerns of vulnerable groups, including women, the poor, and Indigenous Peoples.

8. **Grievance Redress Mechanism:** This section describes the grievance redress framework (both informal and formal channels), setting out the time frame and mechanisms for resolving complaints about environmental performance.

9. **Environmental Management Plan:** This section deals with the set of mitigation and management measures to be taken during project implementation to avoid, reduce, mitigate, or compensate for adverse environmental impacts (in that order of priority). It may include multiple management plans and actions. It includes the following key components (with the level of detail commensurate with the project's impacts and risks):

a) Mitigation:

a) Identifies and summarizes anticipated significant adverse environmental impacts and risks;

b) Describes each mitigation measure with technical details, including the type of impact to which it relates and the conditions under which it is required (for instance, continuously or in the event of contingencies), together with designs, equipment descriptions, and operating procedures, as appropriate; and

c) Provides links to any other mitigation plans (for example, for involuntary resettlement, Indigenous Peoples, or emergency response) required for the project.

b) Monitoring:

a) Describes monitoring measures with technical details including parameters to be measured, methods to be used, and sampling locations, frequency of measurements, detection limits and definition of thresholds that will signal the need for corrective actions.

b) Describes monitoring and reporting procedures to ensure early detection of conditions that necessitate particular mitigation measures and document the progress and results of mitigation.

c) Implementation arrangements:

a) Specifies the implementation schedule showing phasing and coordination with overall project implementation;

b) Describes institutional or organizational arrangements, namely, who is responsible for carrying out the mitigation and monitoring measures, which may include one or more of the following additional topics to strengthen environmental management capability: technical assistance programs, training programs, procurement of equipment and supplies related to environmental management and monitoring, and organizational changes)

c) Estimates capital and recurrent costs and describes sources of funds for implementing the environmental management plan.

d) Performance indicators:

It describes the desired outcomes as measurable events to the extent possible such as Performance indicators, targets, or acceptance criteria that can be tracked over defined time periods.

10. **Conclusion and Recommendation:** This section provides the conclusions drawn from the assessment and provides recommendations.

CHAPTER-11

CONCLUSIONS AND SCOPE OF FUTURE WORK

11.1 CONCLUSIONS

The present study brings out the following conclusions:

1. As per the NSFWQI calculations parameters such as pH, BOD, COD, Nitrate & phosphate at sample locations Ghagreki, Santagarh, Nanandi, Sadhauli Hariya, Bhagwanpur, Mahespur, Kanheri, Titawi, Dulhra, Budhana, Chandheri, and Atali found to be bad. So the water of Hindon River is not suitable for any needful purpose.
2. Presently, there is a gap of 212MLD in the capacity of treatment of sewage generated in the urban portion of the catchment. The open defecation which is still practiced on the banks and catchment of the river pollutes the river.
3. Solid waste is being generated at the rate of 928.75MT/day in the urban catchment and at the rate of 408.46MT/day in rural catchment.
4. Industrial effluent is being generated at the rate of 167 MLD from various industries located in the catchment.
5. The 10 numbers of STPs (2 nos. of WSP and 8 nos. of SBR technology) are suggested for installation in the urban catchment to abatement of pollution due to the gap in treating of 212 MLD of sewage generated at the cost of 732.03 crores.
6. Efficient solid waste management plan for the catchment is suggested at the cost of 216.17 crores for a period of 20 years with base year as 2015 and design year as 2030.
7. The 3 numbers of CETPs (1 no. in Saharanpur and 2 numbers in Muzaffarnagar) are suggested for industries in the catchment at the cost of 217.45 crores.
8. Public awareness and their participation in the affairs of the river are unsatisfactory so a comprehensive public awareness and participation plan for three years under the conservation plan of Hindon River with an estimated cost of Rs. 3.95 crores has been formulated.

11.2 RECOMMENDATIONS

1. Immediate action is required to arrest the pollution load into the river due to sewage generation in the urban catchment. For rural population, community toilets or assistance to install individual toilets is found necessary to safeguard the river from the pollution due to open defecation
2. Prevention of pollution at source, treating the pollutants and recycling for various applications has been requested. For polluting industries, strict enforcement of Acts for make them as zero discharge effluent industries.
3. The site selection for waste water treatment plant and sanitary land fill is to be done in consultation with local residents.
4. Polluter pays principle should be followed by amending and enforcing the laws.
5. U.P. Jal Nigam shall be given power to prepare, execute & promote sewerage/ River pollution Control Works etc. all over the catchment. U.P. Jal Nigam shall hand over such works for maintenance to local bodies in urban areas and to respective Jal Sansthans, in their jurisdiction.
6. Block Development Officer (BDO) is the prime incharge of all planning and developmental work pertaining to the block under jurisdiction. District Rural Development Agencies (DRDA) is responsible for execution of all Rural Developmental schemes. Therefore the construction of community toilets and contribution to individual toilets in rural areas are to be implemented by DRDA or BDOs concerned.
7. The Solid Waste Management works will be implemented by Local Government Bodies concerned.
8. EIA should be carried out as early as the project planning stage as part of feasibility thus it can be assured that the project will be environmentally feasible.

11.3 SUGGESTED SCOPES FOR FUTURE STUDY

1. The conservation plan for the river after Muzaffarnagar upto Ghaziabad is to be formulated for achieving the goal.
2. The river quality data has to be collected throughout various time periods, both within the year and over the year in various suitable time steps so that the pollution parameters are brought within feasible range.

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Appendix I

Designated Best Use Criteria for Surface Waters (Source: CPCB)[1]

Designated Best Use	Class of Criteria	Criteria
Drinking Water Sources without conventional treatment but after disinfection	A	1. Total Coliforms organism MPN/100ml shall be 50 or less. 2. pH between 6.5 and 8.5. 3. Dissolved Oxygen 6mg/l or more. 4. Biochemical Oxygen Demand 5 days 20deg.C 2mg/l or less.
Outdoor bathing(Organized)	B	1. Fecal Coliforms Organism MPN/100ml shall be 2500(max. permissible) or 1000 (desirable). 2. pH between 6.5 and 8.5. 3. Dissolved Oxygen 5mg/l or more. 4. Biochemical Oxygen Demand 5 days 20deg.C 3mg/l or less.
Drinking Water Sources after conventional treatment and disinfection	C	1. Total Coliforms Organism MPN/100ml shall be 5000 or less. 2. pH between 6 and 9. 3. Dissolved oxygen 4mg/l or more. 4. Biochemical Oxygen Demand 5 days 20deg.C 3mg/l or less.
Propagation of Wild life and Fisheries	D	1. pH between 6.5 and 8.5. 3. Dissolved Oxygen 4mg/l or more. 4. Free Ammonia (as N) 1.2 mg/l or less.
Irrigation, Industrial Cooling, Controlled Waste Disposal	E	1. pH between 6 and 9. 2. Electrical Conductivity at 25 deg. C micro mhos/cm Max.2250 3. Sodium absorption Ratio Max.26 4. Boron Max.2mg/l.

Appendix II

Evaluation of Various Available Technologies

Description	WSP	UASB+FPP	ASP	FAB	SBR
Type of Process	Aerobic Suspended growth process	Anaerobic Suspended growth process	Aerobic Suspended growth process	Aerobic. Fixed film attached growth process	Aerobic, suspended growth process
Principle of operation	Organic matter converted to new cell mass with the aid of sunlight algal growth photosynthesis	Organic matter is reduced by anaerobic bacteria present in the sludge blanket.	The organic matter is brought in contact with bacteria in suspension	Organic matter is brought in contact with bacteria attached to plastic media, which is in suspension	Filling, Aeration, Settling and decanting carried out in a single or more Tanks in batches
Mode of Oxygen supply	No external supply of oxygen is required	No oxygen supply is required	Oxygen is supplied by surface aerators	Oxygen is supplied by blowers through air grid system	Oxygen is supplied by blowers through diffusers
Sludge recirculation in the reactor	Not required	Not required	Sludge recirculation to maintain MLSS in aeration tank	Not required.	Optional
Process variables	No monitoring Natural process depends on Temperature & Wind	Volatile fatty acids, sludge blanket levels, alkalinity, pH must be checked on daily basis	MLSS, SVI, F/M ratio must be monitored. Sludge recycle and wastage should be controlled	No sludge volume index / recycle need be checked. System is self sustaining, Excess biomass automatically gets wasted off	Oxygen requirement monitoring by sensor. All operations are done by PLC system
Cost for installation	Less, easy construction	Medium	Higher than USAB	Slightly higher than ASP	High

Annual Maintenance	Less, easy to maintain, no skilled personnel required	Slightly higher than WSP Requires Skilled personnel	High. Requires technical and skilled personnel	Slightly lower than ASP but higher than UASB requires skilled personnel	Very high. High technical & skilled personnel required
Area requirement	Large area is required	Moderately large area required	Medium area	Very small area required	Small area is required
Power requirement	No power	Almost negligible power	Large power required	Less power required than ASP as no recirculation of sludge, but higher than UASB	Large power requirement for aeration. Power optimization is done by PLC
Total coliform in treated sewage	10^4-10^5 MPN/100 ml	10^4-10^5 MPN/100ml	10^4-10^5 MPN/100 ml	10^3-10^4 MPN/100 ml	10^3-10^4 MPN/100 ml
Effluent quality	Meets the standard	Meets the Standard	Very Good Quality	Meets the standard	Best Quality
Sludge production	Less	Medium	More	Medium	Medium
Methane recovery	Methane recovery is possible but no reference in India	Yes.	Yes	No methane recovery	No methane recovery
Expandability	Higher loads possible by providing aerators	Limited	Limited	Higher loads accepted with extra media filling	Easy
Moving parts	Nil	Nil	High	Less than ASP	High
Sensitivity of process	Less sensitive	Highly sensitive.	Moderately sensitive	Sensitivity low due to high bacterial population	Less Sensitive

Appendix III

EXTRACT FROM DRAFT MINIMAL NATIONAL REQUIREMENT FOR MANAGEMENT OF MUNICIPAL SOLID WASTE (MSW). CENTRAL POLLUTION CONTROL BOARD (MINISTRY OF ENVIRONMENT & FORESTS) PARIVESTS BHAWAN, EAST ARJUN NAGAR, DELHI (JANUARY 1998) - FOR SANITARY LANDFILL

6.0 SECURED/ENGINEERED - SAN ITARY LAND-FILL

6.1 Civic authorities should restrain land-filling of all the municipal solid waste generated in city/town. Hospital waste and hazardous wastes shall not be subjected for land-filling. Instead, such waste shall be disposed off separately as prescribed under relevant rules.

6.2 The waste inert in nature and having low leachability shall only be land filled.

6.3 For disposal of waste through landfills 'Secured/Engineered' land-fill shall be practiced. Following criteria are prescribed to meet with:

a) Siting of Land-fill

i) Site should be sufficiently away from human habitation, airport (including air base) etc. The land fill site shall be located far away from airport or air base. The suggested distance for location of land-fill site should be more than 5 kilometers. Similarly, human settlement (colonies/residential or commercial complexes) shall be at least 3 kilometer away from land-fill site.

ii) Site should be supported with detailed Environment Impact. Assessment studies to consider environmental considerations.

b) Facilities at Land -fill Site

I. Site shall be fenced;
II. Approach roads and internal facility should exist;
III. Utilities such as water, drainage, electricity supply, etc; and
IV. Weighbridge, fire protection facilities should be provided

c) Operational Requirement for Land-filling

i) Waste subjected for land-filling shall be compacted in thin layers, preferably, not more than 300 mm depth. Compactors may be operated to weigh between 15-30 tones.

ii) Waste shall be covered immediately or at the end of each working day with 150 mm of earthen material.

iii) After completion of land-fill, a minimum final cover of 80 cm shall be provided.

iv) The final cover i.e. after completion of land - fill operations shall be so designed to minimize infiltration and erosion. The final cover system must be designed and constructed.

a) to have permeability less than or equal to the permeability of any bottom line system or natural sub soils present, or a permeability no greater than I X 10-5 cm per second whichever is less;

b) Minimum in-filtration through the closed land-fill site by the use of an in-filtration layer that contains a minimum of 18 inches of earth material, and

c) Minimize erosion of the final cover by the use of an erosion layer that contains minimum 6 inches of earthen material that is capable of sustaining native plants growth.

d) Measures for Prevention of Pollution

The following provisions shall be made to prevent environmental

Pollution:

i) Diversion of storm water drains to minimize leach ate generation and to prevent the pollution of surface water.

ii) Construction of low permeability lining system at the base and wall of all waste disposal areas to ensure the safe containment of leachate.

iii) Installation of leachate collection and treatment facility to minimize leachate build up above the lining system.

iv) To prevent overlain of rain-water on to land-fill site and checking run-off from land-fill area to enter in any stream, rivers, lakes, ponds etc.

v) Ground water quality monitoring shall be done during pre-operation, operational and post-operational period (after closure at site) at such locations in sufficient number of wells to yield ground water samples from the upper aquifer. The ground water quality shall, in particular to be monitored for following parameters and the values not to exceed:

Arsenic	5.05 mg/l
Cadmium	0.01 mg/l
Chromium	0.05 mg/l
Fluoride	4.0 mg/l
Lead	0.05 mg/l
Mercury	0.002 mg/l
Nitrate	10.0 mg/l

vi) Installation of a land-fill gas control system to minimize odor generation, prevent off-site migration of gases and to protect vegetation planted on the rehabilitated land-fill surface.

vii) The concentration of methane gas generated at land-fill site does not exceed 25% (twenty five percent) of the lower explosive limit (LEL).

viii) Installation of gas collection facility at land-fill to reduce non-methane organic compounds (NMOCs).

ix) Installation of a comprehensive monitoring system of ground and surface water.

e) Compliance with Ambient Air Quality Standards

At the land-fill site and the boundary of site, ambient air quality shall be monitored for following parameters and levels shall be maintained as prescribed

Surplus Dioxide (SO2)	120 mg/m^3
Suspended Particular Matter (SPM)	500 mg/m^3
Methane (CH4)	Not to exceed Explosive limits.
Odor causing and other land-fill gases	There shall not be any nuisance due
(H2s, NH_3)	to liberation of such gases.

f) Greenery/plantation at Land-fill site

The vegetation cover over the complete land-fill site should have the following specifications and characteristics:

- Locally adapted perennial plant that are resistant to drought and temperature extremes.
- Roots that will not disrupt the lower-permeability layer;
- The ability to survive and function with little or no maintenance (i.e. self supportive); and
- Sufficient variety of plant species to continue to achieve these characteristics and specifications over time.

g) Post-Closure Care Requirement

Land-fill site after closure should have post-closure care. The post closure care should be conducted for at least 30 years and consist of the following:

Maintaining the integrity and effectiveness of any final cover, including making repairs to the cover as necessary to correct the effectiveness of settlement, subsidence, erosion or other events and preventing run-on and run-off from eroding or otherwise damaging the final cover.

Monitoring leachate collection system in-accordance with the requirement and monitoring to protect threat to human health and the environment.

Monitoring the ground water in-accordance with the requirement and maintaining the ground water quality.

Maintaining and operating the gas monitoring system in accordance with the requirement to meet the prescribed standards.

Appendix IV

COMPOSTING

In upper reaches of the hills, composting at individual and community basis for (5 to 10houses) can be practiced. For individual houses garbage pits can be provided as detailed below:

Design of garbage pits (for individual family)

Assume

Number of persons in a family	= 5
Garbage waste per capita per day	= 0.25 kg
Density of waste	= 250 kg/m'
Detention time in pit	= 120 days
Waste per day	= 0.25 x 5=1.25 kg
Volume of waste per day	= 1.25/250 = 0.005 in m^3
Volume of waste for 120 days	= 120 x 0.05 = 0.6 in m^3

Provide two pits of size 1.Om x 1.Om x 0.8m for a family. While one pit is being composted, the other is being filled.

The pits may be partially or completely underground. A masonry lining/pitching is necessary. Pit must have side pitching or walls 10-15cms above ground level to prevent outside water from entering into the pit. Following points need attention during the construction of compost/garbage pit.

a) It should be 1O m away from a water source.

b) The water level should be more than 2m below the bottom of the pit.

C) It should not become breeding place for mosquito and flies.

d) It should be fenced to prevent children and animal from entering/falling.

e) Inert matter like pieces of glass, clay, silt tin, cans, bottles, plastics etc should not be added to the pit.

For community level comprising of 5 to 10 families) composting can be done on slopes (fig 9.5 a), when three wooden boxes are provided as stair stepped bins on a sloping ground. The top pit is filled with the garbage and when it is completely filled, the contents

are transferred to the lower pit. Similarly the contents are transferred to the lowest pit in sequence of filling. From the lowest pit the ready compost can be used for gardening.

A biodynamic heap can also be provided with layers of garbage alternated with layers of soil. Each layer is sprinkled with lime and the completed pit is covered with soil (fig 9.5b).

The compost heap as above can also be covered with black plastic sheet which allows composting to proceed under anaerobic or semi-anaerobic condition (fig 9.5c).

The compost prepared as above can be collected by some agencies and sold in the market for agricultural purposes to get revenue.