CHAPTER 5

ENVIRONMENTAL IMPACT ASSESSMENT

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5.1 INTRODUCTION

5.1.1 Preamble

Allahabad city is strategically located at the confluence of Ganga River and Yamuna River. This confluence or 'Sangam' is one of the holiest spots of the Hindus and every year lakh of pilgrims bathe in its waters, hoping to attain salvation.

At present, about three fourths of the domestic waste waters of the Allahabad city gets discharged untreated into either the Yamuna or Ganga River upstream of the Sangam. Thus the city is currently polluting its most celebrated landmark. The steps required to remedy the situation include extension of the city's sewerage system and treatment of collected treated sewage before its discharge into the two mighty rivers.

In preparation of these steps, JICA Study Team has prepared the Master Plan for setting up the sewage collection and treatment facilities for the Allahabad city for the project horizon of 2030. The preparation of the Master Plan included an Initial Environmental Examination (IEE), which prepared a scoping matrix for possible environmental impacts of the project. This Rapid EIA studies further the areas identified in the matrix.

5.1.2 Objectives of and Need for the EIA Study

The purpose of this EIA study is to ensure that development options under consideration are environmentally sound and sustainable and that the environmental consequences of the project are recognized early and taken into account in the project design.

The major objectives of present study are to record the present environmental scenario, through field survey and secondary data, for various environmental parameters. The impacts of the proposed project on these various environmental parameters is then identified and a mitigation plan drawn up in order to make the project environmentally sound.

5.1.3 EIA Methodology

The major environmental parameters include air, noise, water, land use, ecology and socio-economics. The EIA study covers impacts of the project components with respect to these parameters.

The study is confined within existing policy, legal and administrative framework considering the applicable environmental legislations, regulations and guidelines.
The main scope of work thus includes the following:

1) Description of relevant aspects of natural environment specially flora, fauna and water
2) Description of socio-economic environment
3) Impact of project on the environment during implementation and operation phase
4) Recommend possible mitigation/abatement measures for significant impacts
5) Formulate a monitoring programme for significant environmental issues

The approach adopted for the present study has been depicted through flow chart (Figure 5.1).

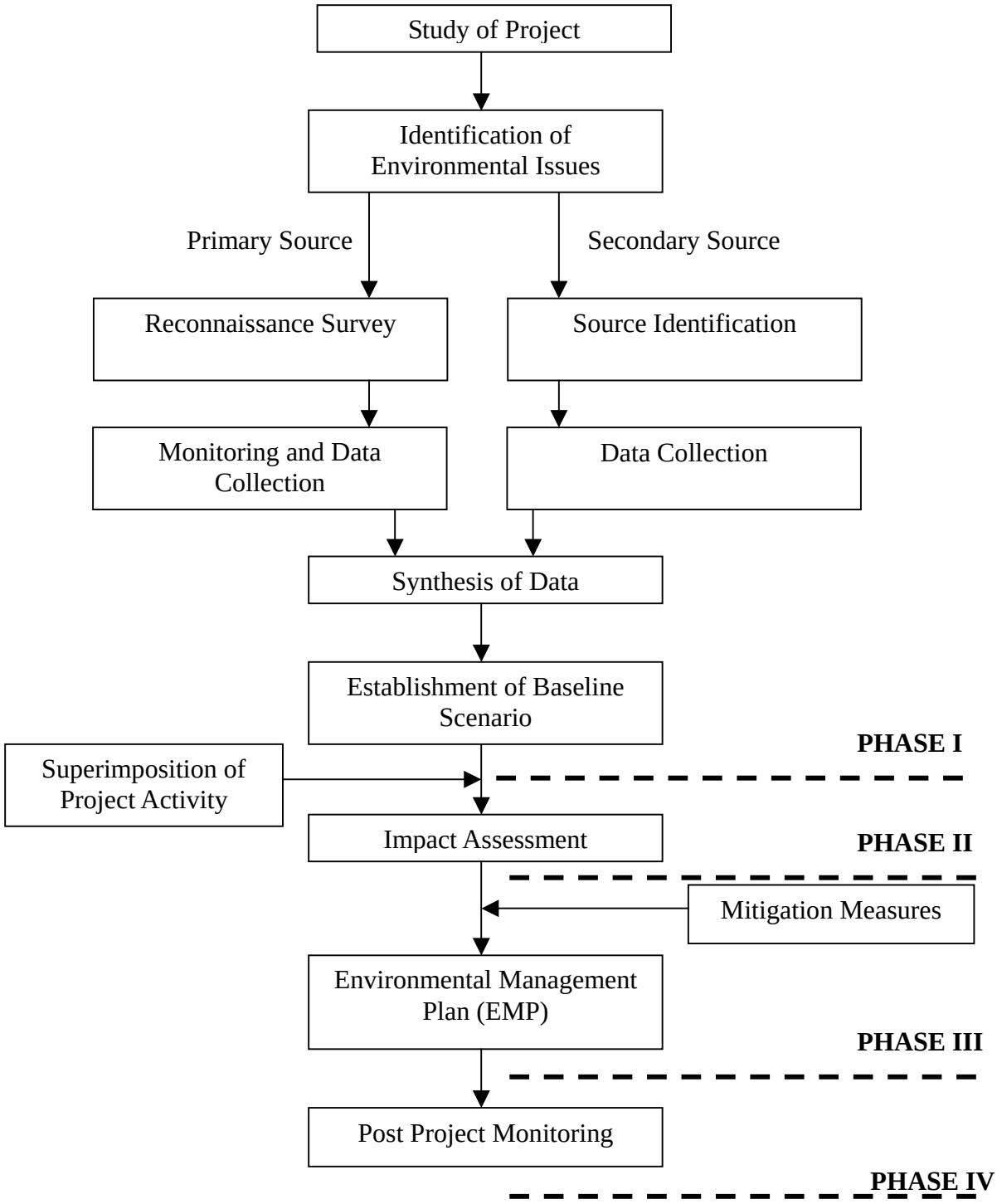


Figure 5.1 Approach for the EIA Study

A. Phase I – Establishment of the Baseline Environmental Scenario

"Baseline Environmental Scenario" is generally established through:

- Collection of secondary data through review of existing literature / data / information
- Generation / collection of primary data through survey and monitoring

The baseline environmental conditions of the study area have been established through survey and review of published literature and field studies / monitoring / survey. At the outset, the relevant secondary data has been collected, reviewed and analysed.

The secondary data collection incorporates collection of socio-economic data from local agencies as well as from the Department of Census. The data covers aspects like demography, literacy and social status, etc. Data concerning health and family planning has been collected from Directorate of Health Services, Lucknow.

The relevant details on water environment specially the ground water have been collected from the records of Central Pollution Control Board, Central Ground Water Board and Ministry of Water Resources, Govt. of India. Some information regarding the rise / fall of water table was obtained from the Ground Water Investigation Organisation, Government of UP, Allahabad. River discharge data of Ganga river was obtained from Central Water Commission. Water quality data and information regarding hydrogeological conditions were taken from the district reports of the Central Ground Water Board. The meteorological data has been obtained from the records of India Meteorological Department (IMD)

Site surveys carried out under the present study include study of the proposed STP sites. Rapid appraisal of proposed pumping sites was also made. Water samples from both surface and ground water sources were collected. Samples of raw sewage were also collected and analysed.

B. Phases II to IV Impact Assessment, Mitigation Planning and Monitoring Programming

Major project activities during the project construction and operation phases have been identified and impacts of these on the various environmental parameters have been studied.

Environmental Management Plan (EMP) is key to ensure a safe and clean environment. A project may have considered proper environmental protection measures; but without a management plan, to ensure their proper implementation and function, the desired results may not be obtained. The EMP envisages the plans for the proper implementation of mitigation measures to reduce the adverse impacts arising out of the project activities. The following issues have been addressed in the EMP:

- Mitigatory measures for abatement of the undesirable impacts caused by the proposed project.
- Institutional set up identified/ recommended for implementation of the EMP.
- Post project environmental monitoring programme including parameters, locations and frequency of monitoring and their implementation to be undertaken after commissioning of the project.
- Expenditures for environmental protection measures.

Table 5.1 Scoping Matrix for Environmental Impacts of Project Components

Environmental Elements / Development scheme		SOCIAL ENVIRONMENT								NATURAL ENVIRONMENT							POLLUTION							
		Resettlement	**Economic activity**	**Traffic/public facilities**	**Split of communities**	**Cultural properties**	**Water right/Right of Common**	**Public health condition**	**Solid waste**	**Hazard**	**Topography and geology**	**Soil erosion**	**Ground water**	**Hydrological situation**	**Coastal zone**	**Flora and fauna**	**Local meteorology**	**Landscape**	**Air pollution**	**Water pollution**	**Soil contamination**	**Noise and vibration**	**Ground subsidence**	**Odor**
Sewage treatment plant	C	X/Y	X/Y	Z					Z									Y				Z		
	O							Z					Z	Z						Y/Z	Y/Z	Z		Z
Pumping station	C	Z		Z																		Z		
	O							Z	Z													Z		
Installation of main trunk sewer	C		Z	Z																		Z		
	O																							
Rehabilitation of existing trunk sewer	C		Z	Z				Z												Z		Z		Z
	O																							

Remarks :
C : Indicates construction (rehabilitation) stage. **O** : Indicates operation stage
X : Indicates that the development scheme is foreseen to have strong impact on the environmental element
Y : Indicates that the development scheme is foreseen to have sound impact on the environmental element
Z : Indicates the impact is not quite sure and examination is required.

5.2 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

5.2.1 Policies and Legislative Framework

The National Water Policy of India adopted in 1987 and amended in 2002 states that:

- Water resources development projects should as far as possible be planned and developed as multipurpose projects. Provision for drinking water should be a primary consideration. The other uses being in priority order as the following: irrigation, flood control, hydropower, navigation, pisciculture and industrial and other uses, unless otherwise dictated by area-specific requirements;
- The integrated and coordinated development of surface and ground water and their conjunctive use should be envisaged at the project planning phase and should form an essential part of the project. There should be a close integration of water and land use policies;
- There should be an integrated and multi-disciplinary approach to the planning formulation, clearance and implementation of projects, including catchment management, environmental and ecological aspects, the rehabilitation of affected people and command area development.

The Water (Prevention and Control of Pollution) Act, 1974 and the Environment (Protection) Act, 1986 deal with the prevention and control of water pollution. The latter Act covers all aspects of the environment, under which the Central Government can take appropriate measures for:

- Protecting and improving the quality of the environment, and
- Preventing, controlling and abating environmental pollution.

The Pollution Control Boards (PCBs) established under the Water (Prevention & Control of Pollution) Act both at the Central Government and also at the State Government level for each State are responsible for enforcement of ambient water quality standards and effluent standards (including sewage) notified under the Environment (Protection) Act, 1986.

The sewerage project of Allahabad city will be executed by GoUP. GoUP will co-ordinate amongst different Government departments like UP Jal Nigam, Allahabad Nagar Nigam (ANN), Allahabad Jal Sansthan, Allahabad Development Authority, Revenue Department, Irrigation Department, State Pollution Control Board, etc. at various stages of the implementation of the project and also during the operation phase of the project.

During the construction phase mitigation measures will be taken in accordance with the Water (Prevention & Control of Pollution) Act, 1974, Air (Prevention and Control of Pollution) Act, 1981 and Environment (Protection) Act, 1986. Since the State Pollution Control Board is the enforcing agency for these Acts, the UPJN will seek their advice, whenever necessary.

5.2.2 Legal Instruments and Procedures (or, Laws / Regulations Applicable for the Project)

(1) Water (Prevention & Control of Pollution) Act, 1974 as Amended in 1988

The Central Pollution Control Board (CPCB) and the State Pollution Control Boards (SPCBs) are responsible for implementation of the Water (Prevention & Control of Pollution) Act 1974. The Water Act is applicable to all Union Territories and has been adopted by all the States, by resolution passed on that behalf under clause (I) of Article 252 of the Constitution. Under the provision of this Act, no discharge of wastewater can be made into the environment without obtaining prior consent from the concerned State Pollution Control Boards [from the Pollution Control Committees (PCCs), in case of Union Territories]. A consent prescribes the volume and quality of wastewater, in terms of

concentration of various pollutants, which is permitted for discharge into the environment. The Act allows both the Union Territories and the State Governments and their respective Pollution Control Boards, to make rules implementing the Act. In case of a conflict, the Union Government rules prevail.

(2) Air (Prevention & Control of Pollution) Act, 1981 as Amended in 1987

The Air (Prevention and Control of Pollution) Act, 1981 was formulated by the Central Government to regulate air pollution from various sources. Under this Act, the standards for various pollutants namely SO_2, NOx, suspended particulate matter, CO, hydrocarbons and several other air pollutants are stipulated by CPCB to protect the ambient air quality. The emissions from various stacks and other elevated sources are also simultaneously regulated as per recommended standards by the State Boards under the guidelines given by the Central Pollution Control Board. These standards are incorporated in the conditions of granting consent to establish and to operate the industry. The noise levels are also regulated by stipulating permissible ambient and source specific standards.

(3) Environment (Protection) Act, 1986

The Environment (Protection) Act, 1986 is an umbrella legislation covering various aspects of environment including pollution control, protection of wildlife, forest conservation and natural resources management. The Act empowers the Union Government to make rules providing standards in excess of which environmental pollutants shall not be discharged or emitted into the environment. It also empowers the Union Government to make rules regarding handling, storage, manufacture and import of hazardous substances including wastes. Violation of these rules constitutes a crime, which is punishable by imprisonment and / or fine.

(4) Hazardous Wastes (Management and Handling) Rules, as amended in 2003

Under the Environment (Protection) Act, 1986, rules for hazardous waste handling have been defined, under which the State Pollution Control Boards grant authorization to the industry for safe disposal of such wastes.

(5) Notifications for Environmental Impact Assessment

Environmental clearance on the basis of environmental impact assessment is mandatory for various development projects in India. Environmental clearance for 30 categories of projects (Appendix A5.1) was made mandatory by the Environmental Impact Assessment (EIA) Notification issued in January, 1994 under the Environment (Protection) Act, 1986. Later this notification was amended from time to time. The categories of projects requiring EIA was increased to 31 by extending the requirement of EIA and environmental clearance to commercial complexes and human settlements as per the rules modified in July 2004. However, Waste Water Collection and Treatment projects are not in the list. The procedure for environmental clearance is given in Appendix A5.2.

The Ministry of Environment & Forests (MoEF) enforced the EIA notification for conducting Environmental Impact Assessment (EIA) studies which are obligatory for the establishment of certain categories of activities. The Environmental Appraisal Committees (EACs) comprising experts, Government officials and non-government organisation (NGOs) have been set up by the MoEF to scrutinize the EIA reports based on recommendation of the Appraisal Committees. The MoEF takes decision for environmental clearance of specific projects.

(6) Land Acquisition Act (as amended in 1984)

Land is normally acquired under the provisions of the Land Acquisition Act, 1894 which is general and basic law in the country for the acquisition of land for public purposes and companies. This Act

was comprehensively amended in the year 1984, taking into consideration the recommendations of the Law Commission, the Land Acquisition Review Committee, headed by Justice A.N. Mulla, as well as suggestions from the State Governments and other quarters.

The Conference of the Revenue Secretaries of States (July, 1989) have also made recommendations that all land should be acquired under the provisions of the Land Acquisition Act, 1894 and other laws repugnant thereto should be brought in line with it or repealed altogether. However, these efforts have not met with success and a large number of laws, having different procedures and norms of compensation, continue to operate.

In view of the acknowledged superiority of the Land Acquisition Act, 1894 land is acquired under the provisions of this Act. The underlying principle governing the acquisition of land under the Land Acquisition Act, 1894 is that compensation alone is payable in lieu of deprivation. However, there is a provision under Section 31(3) in the Land Acquisition Act for grant of land in lieu of money compensation (Refer Appendix A5.3).

5.2.3 Environmental Standards

(1) Water Pollution

1) River Water Quality Standards

The classification of water bodies has been based on the concept of 'Designated Best Use' (DBU). According to this concept, out of various purposes for which the water body is used, the one that requires highest quality of water is taken as the benchmark and classified as 'Designated Best Use'. Using these criteria, water bodies are divided in five categories viz.:

Class A: Drinking water source without conventional treatment, but with chlorination
Class B: Outdoor bathing
Class C: Drinking water source with conventional treatment
Class D: Propagation of wildlife and fisheries
Class E: Irrigation, industrial cooling and controlled waste disposal

The DBU criteria are defined by a set of parameters such as pH, Dissolved Oxygen, Biochemical Oxygen Demand, Coliform, etc. For instance, specified limits for DO, BOD and coliform for Class A are 6 mg/l, 2 mg/l and 50/100 ml, respectively. For lower category such as Class D, specified values for these indicators are 4 mg/l, 6 mg/l and 5,000/100 ml, respectively. A detailed parameter-wise criteria is presented in Appendix A5.4.

Recently, primary quality for class B regarding coliform number has been revised as follows; faecal coliform: <500 MPN/100ml (Desirable), <2,500 MPN/100ml (Maximum permissible).

As of now, the DBU criteria are followed by various agencies responsible for management and control of water quality in the country including the two ongoing programmes viz. the National River Conservation Plan and the National Lake Conservation Plan.

However, in the current context of increased pollution loads and concerns for long-term ecological sustainability, it is felt that the criteria have certain fundamental limitations. Some of these are listed below:

- DBU criteria consider only human requirements and exclude ecological aspects and their relation to the human beings. In certain cases, ecological violations are not identified while the desired criteria may be satisfied.

- It recognizes only organised uses and ignores the requirements of large rural community.
- Two decades back when the criteria were developed, concerns on non-domestic sources of pollution were not pronounced.
- In case of large water bodies and rivers, adhering to one particular class of water is practically difficult and has high costs associated with any technical intervention.
- There is inherent inconsistency with regard to the set of parameters applicable to higher and lower classes. For instance, the category on 'irrigation, industrial cooling and controlled waste disposal" specified limits for TDS, sodium absorption ration etc. but does not cover BOD, coliform, helminth, toxicants.

Recognising these limitations, the Central Pollution Control Board has proposed a new criteria for classification of water bodies. The new approach is based on the premise of maintaining and restoring 'wholesomeness' of water for the health of ecosystem and environment in general; and protecting the designated organised uses of water by human beings and involving community for water quality management. The term 'Wholesomeness' here pertains to taking an ecosystem approach to aquatic environment and including socio-cultural aspects into consideration.

The new classification system proposes three categories or tiers of indicators of water quality depending on the ease or complexity involved in their determination with regard to knowledge, skills, and equipment. Secondly, it classifies water bodies into three broad categories viz. :

Class A: Excellent (long term goal)
Class B: Desirable level of wholesomeness (medium term goal)
Class C: Minimum acceptable level (Short term goal)

The three key parameters typically used for assessment are given in Table 5.2 and the salient features are described in the paragraphs that follow. (Water quality criteria and goals, CPCB, February 2002).

Table 5.2 Key Indicators of Inland Surface Water Quality under the Revised Criteria Proposed by CPCB

Indicator	Unit	A-Excellent	B-Desirable	C-Acceptable
DO	(% saturation)	90-110	80-120	60-140
BOD	(mg/l)	<2	<5	<8
Faecal Coliform	MPN/100 ml	<20	<200	<2,000

It is assumed that efforts being put in to restore and manage the quality of various water bodies will move them from Class C to Class A over a period of time. First tier of parameters pertain to visual and sensual observations and includes among others, ecological indicators such as presence of fish and insects. The second tier of parameters includes typical chemical and biological indicators, which can be measured by skilled chemists in a water quality laboratory.

The third tier of parameters is recommended only for detailed investigations and it includes among others, nutrients, phenols, pesticides, and heavy metals.

2) Effluent Discharge Standards

Effluent discharge standards are specified with reference to the type of industry, process or operations and in relation to the receiving environment or water body such as inland surface water, sewers, land or sea. While the Environment (Protection) Act has laid down discharge standards for a range of industries keeping in view the manufacturing processes, raw materials, technological feasibility, etc., it has also laid down vide Schedule VI of The Environment (Protection) Rules, 1986 general discharge standards which are applicable across the board. The Schedule specifies applicability of these general standards to discharge of sewage. These standards are given in Table 5.3.

Table 5.3 Discharge Standards

Indicator	Inland surface water	Public sewers	Land for irrigation	Marine outfall
Suspended solids	100	600	200	100
Oil and grease	10	20	10	20
BOD	30	350	100	100

Note : All values are in mg/l and are the maximum permissible levels.
Source : Pollution control acts, rules and notifications issued hereunder, CPCB, September, 2001.

The general BOD limit specified for discharge of wastewater from typical industrial sources or domestic wastewater is same at 100 mg/l. However, the rules specify that the discharge limits can be made further stringent if the concerned pollution control authority finds it appropriate depending on the condition of the receiving environment and severity of the discharges from various sources.

With regard to application of sewage for land farming the 'Manual on Sewerage and Sewage Treatment', CPHEEO, Ministry of Urban Development, Govt. of India, provides guidelines on characteristics of irrigation waters. These include conductivity/ salinity, sodium absorption ratio, chlorides, boron, etc. In addition, the manual provides maximum permissible concentrations of toxic heavy metal etc. Constituent wise values are given in Appendix A5.5. However, it is noted that while salinity and toxicity aspects have been addressed in these standards and guidelines, the issue of infection to agriculture workers and consumers of cultivated products due to bacterial population in sewage has not been addressed here.

The upper limits of important parameters for treated sewage to be used for irrigation are given in Table 5.4.

Table 5.4 Treated Water Quality for Irrigation

Parameter	Unit	Limits
BOD	mg/I	100
Suspended Solids	mg/I	200
Dissolved Solids	mg/l	2,100
pH		5.5-9.0
Oil & Grease	mg/l	10
Arsenic	mg/l	0.2
Boron	mg/l	2.0
Cyanide	mg/l	0.2
Chloride	mg/l	600
Sulphate	mg/l	1,000

Source: CPCB, Standards for discharge of Industrial/Domestic wastewater

In addition to the standards prescribed by the CPCB, the project proposes to take into account the WHO guidelines for wastewater reuse for irrigation of level B (cereals, industrial and fodder crops, pasture and trees). These guidelines were elaborated by WHO after reviewing epidemiological studies of untreated wastewater reuse. This review led to the conclusion that the danger of infection is:

- High with intestinal nematodes;
- Moderate with bacteriological infections and diarrheas;
- Minimal with viral infections and diarrhoeas, and hepatitis A; and
- High to non-existent with trematode and cestode infections, schistosomiasis, clonorchiasis, and taeniasis, depending on local practices and circumstances.

The WHO guidelines are given in Table 5.5.

Table 5.5 Recommended Microbiological Quality Guidelines for Wastewater Use in Agriculture

Category	Reuse conditions	Group exposed	Intestinal nematodes (arithmetic mean no of eggs/liter)	Faecal coliforms (geometric mean no. /100 ml)	Waste water treatment expected to achieve required micro-biological quality
A	Irrigation of crops likely to be eaten uncooked; sports fields, public parks	Workers, consumers, public	≤ 1	$\leq 1{,}000$	Series of stabilization ponds designed to achieve the micro-biological quality indicated, or equivalent treatment
B	Irrigation of cereal crops, industrial and fodder crops, and pasture and trees.	Workers	≤ 1	No standard recommended	Retention in stabilization ponds for 8-10 days for equivalent helminth and faecal coliform removal
C	Localized irrigation of crops in category B if exposure of workers and the public does not occur	None	Not applicable	Not applicable	Pretreatment as required by irrigation technology, but not less than primary sedimentation

Source: *Health Guidelines for the use of wastewater in agriculture and aquaculture. Technical Report No. 778. WHO, Geneva, 1989*

3) Drinking water quality standards

Water quality standards for drinking purpose are given in Appendix A5.5.

4) Air quality

It will be necessary of the project execution agency to maintain air quality within mentioned limits for various parameters. The detailed ambient air quality standards are given in Appendix A5.6.

5) Noise

The noise levels at project sites and residential areas nearby should be as per stipulated standards given in Appendix A5.7.

5.2.4 Administrative Framework

(1) Pollution Control Boards

To monitor and control the growing environmental pollution, the Pollution Control Boards were constituted both at National and State levels under Water (Prevention and Control of Pollution) Act, 1974.

The Central Pollution Control Board was formulated as an Apex Body and was empowered to set up the standards for the environmental components namely water, air and noise. The CPCB functions under the Chairman, who is the administrative head of the CPCB. The member Secretary of the CPCB is the technical head for day to day functioning of the Board. The State Boards are working in a similar fashion to that adopted by the CPCB.

The Public Liability Insurance Act is also given for enforcement to the Boards. Under the legal framework, the Pollution Control Boards can prosecute the concerned industry or establishment, which violate the provisions of the above Act, and if the Courts permit, the industry can be asked to stop their entire business. The NGOs or any individual can also approach the Court for this purpose.

The environmental protection set-up in India is given in Figure 5.2.

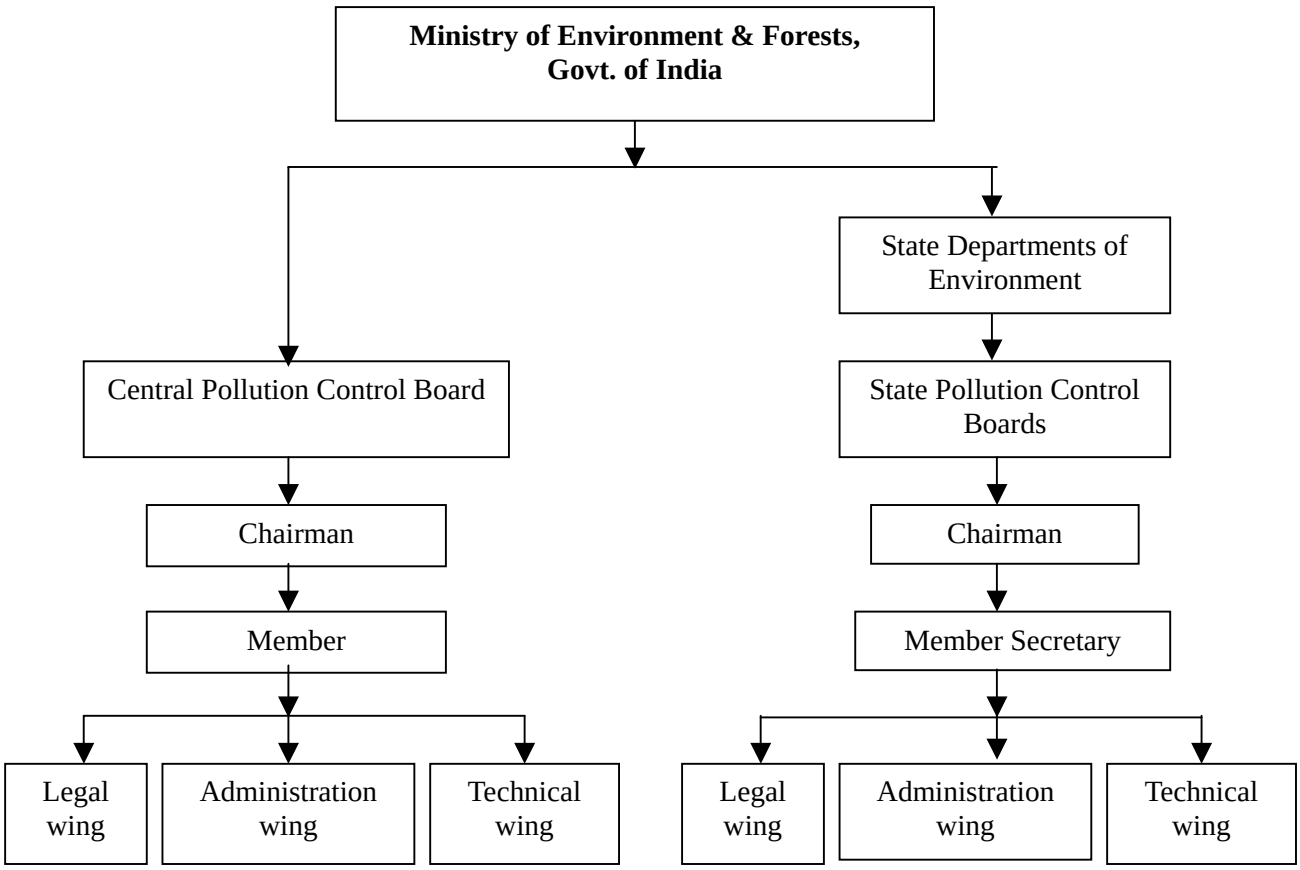


Figure 5.2 Environmental Protection Set-up in India

(2) Uttar Pradesh Pollution Control Board (UP PCB)

The Uttar Pradesh Pollution Control Board was constituted in 1975 under Section Four of the Water (Prevention and Control of Pollution) Act, 1974. Its original objective was the prevention and control of water pollution but, later, it was also entrusted with the prevention and control of air pollution.

(3) Uttar Pradesh Jal Nigam (UPJN)

UPJN is a Corporation of the State Govt. of UP. It was created in 1975 under the provisions of UP Water Supply and Sewerage Act, 1975 by converting the State Local Self Government Engineering Department into UP Jal Nigam. The UPJN is entrusted with the job of development of water supply and sewerage sector in the State. It has also been designated as the implementing agency for the NRCP and NLCP in the State of UP.

The Ganga Pollution Control Unit in Allahabad was basically formed to undertake the construction and execution of the assets that were created under the Ganga Action Plan - Phase I. Under this, different pumping stations and one sewage treatment plant were built to take care of the sewage and effluent flowing into Ganga and Yamuna rivers. Since then, it has been a primary body also responsible for the operation and maintenance of these assets. As per the order from the Central Government, the operation and maintenance of these assets were supposed to be transferred to the local body. However, they have not been transferred so far.

(4) Allahabad Nagar Nigam (ANN)

The Allahabad Nagar Nigam was formed in 1960 with the objective to provide all the necessary basic civic facilities to the residents and visitors of the Allahabad City. These services include the cleaning of drains and gutters, solid waste management, maintenance of roads, lighting, etc.

Historically, Allahabad is a Holy City located close to confluence (Sangam) of two rivers named Ganga and Yamuna and attracts a large floating population in the form of pilgrims, which entail additional burden on the existing civic facilities especially during Kumbh and Magh Mela (Religious Festivals).

Allahabad Nagar Nigam has been divided into 90 wards (70 wards of Municipal Corporation + 7 wards of Allahabad Cantonment Board (CB) + 13 other wards) for administrative and management purposes. The Sanitation aspect of the city is taken care by the Health and Sanitation Department, which has Health Officers, Additional Health Officers, Zonal Health Officers and Sanitary Inspectors.

On a broad level, the Nagar Nigam handles the following responsibilities like Health and Sanitation, Primary Education, Solid Waste Management, plantation, slaughterhouses, cleaning of roads, Maintenance of Ghats, etc.

With special reference to the surface and underground drainage system, Allahabad Nagar Nigam is involved in:

- Cleaning of surface drains and desilting of deep drains
- Construction and maintenance of surface drains, deep drains along the road and lanes within municipal maintenance

Additionally, Allahabad Nagar Nigam is responsible only for the maintenance of the branch sewers and some portion of main sewers in the city. The laterals and the branch sewers since they are small in size and form the most initial components of the sewer network and are easier to maintain. This kind of maintenance does not require heavy mechanical equipment and is generally done manually. Allahabad Nagar Nigam is currently managing this with their staffs that are not formally trained but have gained experience over the years. Generally, in case of complex problems where mechanically aided cleaning is required Jal Sansthan is approached for help.

(5) Jal Sansthan, Allahabad

Till 1975, the Municipal Corporation (Now Nagar Nigam) was a single organisation that looked after all the operation and maintenance of the infrastructure including water supply and sewerage and the Local Self Government, Engineering Department of the UP Government undertook the planning and construction of the capital works. However, with the arrival of the International Monetary Fund, it was decided that two separate entities would be required. One will be responsible for construction and execution while the other one will be mainly into operation and maintenance of these structures. Accordingly, under the water supply and sewage Act, 1975 Jal Nigam was established for capital works and Jal Sansthans were created for operation and maintenance. Allahabad Jal Sansthan came into existence in 1976 under the UP Water and Sewerage Act 1975. It was entrusted with the work of cleaning and maintaining the trunk and main sewers. The production and distribution of clean potable drinking water is also looked after by the Jal Sansthan.

Allahabad Jal Sansthan is responsible mainly for the cleaning and maintenance of the main and trunk sewers. The cleaning is mostly done through use of mechanical equipments.

5.2.5 EIA Guidelines

The general guidelines for the preparation of EIA reports for different types of projects have been formulated by the Ministry of Environment and Forests, Government of India. A copy of the guidelines is given in Appendix A5.8.

5.2.6 JBIC and JICA Guidelines

The present project is under the Infrastructure Sector and would be listed as Category 'B' project as per JBIC's environmental guidelines, which describe the principles for the procedures and methodologies employed by JBIC to confirm environmental considerations are integrated in every project financed. The project could be classified as Category 'B' project under the JICA guidelines as it would have less adverse environmental impacts, which would be of temporary nature, during the construction phase only.

In fulfilment of JBIC requirements, an EIA statement has been prepared even though it is not essential as per the existing Indian guidelines. The Environmental Checklist for Waste Disposal projects (a sub-category of Infrastructure projects has been consulted while preparing the EIA statement.

5.3 DESCRIPTION OF THE PROPOSED PROJECT

5.3.1 Introduction

JICA's Master Plan has divided the city of Allahabad into seven sewerage districts. The long term goals of the Master Plan are total possible reduction in pollutant loads on the environment and to improve the living conditions of the residents of Allahabad. However, in view of the large gap between the existing and the required infrastructure, certain priority projects have been identified for implementation before year 2015 i.e. within 1 to 5 years of adopting the Master Plan.

These priority projects are listed in Table 5.6 and form the scope of the present techno-economic feasibility study. The priority projects fall in four of the seven sewerage districts namely District A, B, D and E.

Table 5.6 Priority Projects

District
District A **Projects** • Augmentation of Naini STP from 60 to 80 mld • Rehabilitation of Gaughat PS and Chachar Nala PS • Rehabilitation / Replacement of existing trunk sewers and installation of new trunk sewers
District B **Projects** • Rehabilitation of Lukerganj SPS • Construction of Ghaghar Nala SPS • Construction of Sasur Khaderi SPS • Construction of Numaya Dahi STP • Installation of new trunk sewers • Installation of rising main to STP
District D **Projects** • Construction of Rajapur STP

• Rehabilitation of Alopibagh SPS • Reconstruction of Morigate SPS • Reconstruction of Mumfordganj SPS • Rehabilitation of Allahpur SPS • Rehabilitation of Daraganj SPS • Rehabilitation / Replacement of existing trunk sewers and installation of new trunk sewers and rising mains • Construction of Rajapur Nala tapping facility
District E **Projects** • Construction of Kodara STP and tapping facility • Construction of Ponghat STP and tapping facility

Technical Details of these project components are listed in Table 5.7 to Table 5.10.

Table 5.7 Summary - STP

Sr.	Location of STP	District	Capacity in mld (2015/2030)	Type of process used	Land Acquisition Requirement
1	Naini (Augmentation)	G	20 (Existing 60 mld)	Activated Sludge Process + Chlorination	N/A
2	Numaya Dahi	B	50/50	Waste Stabilisation Ponds	75.8 ha.
3	Ponghat STP	E	10/10	Waste Stabilisation Ponds	19.3 ha.
4	Kodara STP	E	15/30	USAB + Aerated Lagoons	12.1 ha.
5	Rajapur STP	D	65/80	USAB + Aerated Lagoons	25 ha.

Table 5.8 Summary - Proposed Rising Mains

Sr.	Dist.	Corridor/Area	Node Id	Size (mm)	Material	Peak Flow in 2030 (lps)	Length of Pipe (m)
1	B	Ghaghar Nala to Numaya Dahi Sewage Treatment Plant	-	1000	PSC	1,090	7,700
2	B	Sasur Khaderi PS		600	CI	660	200
3	D	Morigate PS to Alopibagh PS		800	PSC	786 (2003) 281 (2030)	1,800
4	D	Alopibagh PS to Mumforganj PS	Alopi-17	1000	PSC	1,064 (2015) 1,031 (2030)	3,100
5	D	Mumforganj PS to Rajapur Sewage Treatment Plant		1100	PSC	1,420	2,650

Table 5.9 Summary -Proposed Sewerage System (Trunk Sewer)

S. No.	District	Corridor/Area	Node Identification	Size	Peak Flow in 2030	Length of Pipe for Different Depth			Length	No. of Manholes for depth range		Total no. of Manholes
				mm	lps	1 m - 4 m	4 m - 6 m	6 m - 9 m	m	2.5 m - 7 m	7 m - 10 m	
1	A	GT Road	4-5	500		574	334	90	998			
2	A	GT Road	5-7	700		646	307	224	1,177			
Total									**2,175**	46	6	**52**
3	A	Salik ganj Road	8-15(Gaughat)	600		505	634	0	1,139			
Total									**1,139**	34	0	**34**
4	A	S K Dey Marg	11-12(Shaukat Ali Marg)	500		377	211	104	692			
Total									**692**	18	0	**18**
5	B	Sasur Khaderi-Karamat Chowki	-	900		325	278	110	713			
Total									**713**	14	2	**16**
6	B	Lukerganj-Ghaghar	-	450		1,496	377	0	1,873			
7	B	Lukerganj-Ghaghar	-	1000		78	555	526	1,159			
Total									**3,032**	68	12	**80**
8	B	Interceptor at Ghaghar (nala 1C-1B)	7-7C	350		482	0	0	482			
9	B	Interceptor at Ghaghar (nala 1B-1A)	7C-7A	375		181	0	0	181			
10	B	Interceptor at Ghaghar (nala 1A)	7B-7A	450		77	0	0	77			
11	B	Interceptor at Ghaghar (nala 1A-Ghaghar PS)	7A-6	800		436	0	0	436			
Total									**1,176**	39		**39**

S. No.	District	Corridor/Area	Node Identification	Size	Peak Flow in 2030	Length of Pipe for Different Depth			Length	No. of Manholes for depth range		Total no. of Manholes
12	D	Muir Road	3-4	500		1,306	453	206	1,965			
Total									**1,965**	43	4	**47**
13	D	Thornhill Road	1-2	450		703	884	0	1,587			
14	D	Thornhill Road	2-4	600		180	635	77	892			
15	D	Thornhill Road	4-18 (Mum PS)	700		0	249	877	1,126			
Total									**3,605**	52	16	**68**
16	D	Alopi-Mum	18-Mum PS	1200		1,392	264	0	1,656			
Total									**1,656**	39	0	**39**
17	D	Interceptor at Rajapur	20-STP	150		108	0	0	108			
18	D	Interceptor at Rajapur	20-STP	200		646	0	0	646			
19	D	Interceptor at Rajapur	20-STP	500		405	0	0	405			
20	D	Interceptor at Rajapur	20-STP	600		175	0	0	175			
Total									**1,334**	28	0	**28**
Grand Total						10,092	5181	2,214	**17,487**			**421**

Table 5.10 Summary of Existing Sewerage System

Pipe Line No.	Node No.	Road	Structural Condition of sewer	Existing Sewer										Design Dis-charge in 2030 (mld)	Proposed		
				Dia/Size (M)	Length (m)	Material	Slope			Silting (%)			Avg. Discharge Capacity (mld)		Proposal	Dia/ Size (M)	Slope
							Min	Max	Avg.	Min	Max	Avg.					
District A																	
EA1	1-1A	Mahatma Gandhi Marg	Poor	0.30	1591.38	Concrete	1 in 985.05	1 in 98.33	1 in 265.27	11	57	43	3.83	15.81	Replace	0.60	1 in 265.27
	1A-2	Mahatma Gandhi Marg	Poor	0.50	541.65	Concrete	1 in (-ve) 498.62	1 in 768.43	1 in 485.78	21	44	30	11.05	15.81	Replace	0.60	1 in 485.78
	2-2A	Mahatma Gandhi Marg	Poor	0.60	916.61	Brick Masonry	1 in 1910.24	1 in 52.24	1 in 164.71	9	37	16	30.86	20.22	Replace	0.60	1 in 164.71
	2A-3	Lala Sitaram Road	Poor	0.60	649.44	Brick Masonry	1 in 5041	1 in 140.89	1 in 662.69	22	50.00	35	15.38	20.22	Replace	0.70	1 in 662.69
EA2	6-7	GT Road	Poor	1.0x1.15	1504	Brick Masonry	1 in 10706	1 in 76.9	1 in 1915.92	18	69	37	50.39	16.85	Desilting + CCTV	-	-
	7-Gaugh at PS	Lauder Road	Poor	1.0x1.15	791.84	Brick Masonry	1 in 4368.57	1 in 137.66	1 in 891.71	15	37	27	115	74.48	Desilting + CCTV	-	-
EA3	3-7	Lala Sitaram Road	Poor	0.70	784.32	Brick Masonry	1 in 7491.82	1 in 166.4	1 in 392.75	15	83	46	30.14	24.54	Replace	0.70	1 in 392.75
EA4	14-15	SL& ML Bhargava Road	Poor	0.9x0.6	1036	Brick Masonry	1 in 3129.5	1 in 399	1 in 800.62	9	70	36	29.32	17.53	Desilting + CCTV	-	-
EA5	10-12	Shaukat Ali Marg	Poor	0.9x0.6	496.99	Brick Masonry	1 in 3029.35	1 in 182.23	1 in 581.96	16	37	28	32.33	33.26	Replace	0.80	1 in 581.96
	12-12A	Shaukat Ali Marg	Poor	0.9x1.2	386.39	Brick Masonry	1 in 27645	1 in 331.9	1 in 1174.44	12	42	27	58.73	50.72	Replace	1.20	1 in 1174.4 4
	12A-13	Shaukat Ali Marg	Poor	0.9x1.2	649.59	Brick Masonry	1 in 2444.80	1 in 94.66	1 in 280.36	8	44	18	119.19	50.72	Replace	1.2	1 in 280.36
	13-PS	Yamuna Bank Road	Poor	1.2x1.4	871.65	Brick Masonry	1 in 4550.4	1 in 41.97	1 in 549.94	5	29	17	155.67	72.14	Replace	1.2	1 in 549.94

Pipe Line No.	Node No.	Road	Structural Condition of sewer	Existing Sewer										Design Dis-charge in 2030 (mld)	Proposed		
				Dia/Size (M)	Length (m)	Material	Slope			Silting (%)			Avg. Discharge Capacity (mld)		Proposal	Dia/ Size (M)	Slope
							Min	Max	Avg.	Min	Max	Avg.					
EA6	9-10	Nurullah Road	Poor	0.9x0.6	732.23	Brick Masonry	1 in 1353.14	1 in 29.43	1 in 234.54	14	100	85	54.17	4.92	Desilting + CCTV	-	-
District D																	
ED1	5-8-11A	Jawahar Lal Nehru Road	Poor	1.1x1.3	1267.95	Brick Masonry	1 in 4806.86	1 in 60.81	1 in 212.53	12	16	13	201.73	13.65	Desilting + CCTV	-	-
	11A-11 B	Jawahar Lal Nehru Road	Poor	1.1x1.3	747.61	Brick Masonry	1 in 1388	1 in 152.25	1 in 281.16	15	35	25	175.39	22.55	Desilting + CCTV	-	-
	11B-Alo pibagh PS	-	Poor	1.1x1.3	85.49	Brick Masonry	1 in 339.08	1 in 113.8	1 in 222.05	13	16	14	197.36	54.76	Desilting + CCTV	-	-
ED2	10-10A	Chintam ani Marg	Poor	0.30	516.44	Concrete	1 in 373.56	1 in 26.84	1 in 49.70	17	83	31	8.85	11.06	Replace	0.40	1 in 49.70
	10A-11	Chintam ani Marg	Poor	0.60	767.61	Brick Masonry	1 in 1766.67	1 in 91.26	1 in 451	26	57	43	18.65	19.61	Replace	0.70	1 in 451
	11-11B	Jawahar Lal Nehru Road	Poor	0.99	777.63	Brick Masonry	1 in 3513.6	1 in 277.96	1 in 668.64	15	40	27	58.22	31.71	Desilting + CCTV	-	-
ED3	6-7	Kamla Nehru Marg	Poor	0.30	328.14	Concrete	1 in 848.67	1 in 77	1 in 260.43	73	100	100	3.86	5.96	Replace	0.40	1 in 260.43
	7-7A	Maharshi Dayanan d Marg	Poor	0.50	1124.67	Concrete	1 in 1305.06	1 in 63.55	1 in 67.73	24	76	36	30.0	8.55	Desilting + CCTV	-	-
	7A-7B	Maharshi Dayanan d Marg	Poor	0.50	343.51	Concrete	1 in (-ve) 956.27	1 in 56.29	1 in 379.57	30	100	72	12.8	8.55	Replace	0.50	1 in 379.57

Pipe Line No.	Node No.	Road	Structural Condition of sewer	Existing Sewer										Design Dis-charge in 2030 (mld)	Proposed		
				Dia/Size (M)	Length (m)	Material	Slope			Silting (%)			Avg. Discharge Capacity (mld)		Proposal	Dia/ Size (M)	Slope
							Min	Max	Avg.	Min	Max	Avg.					
	7B-10A	-	Poor	0.50	309.04	Concrete	1 in 527.50	1 in 234.07	1 in 386.78	20	52	28	12.68	8.55	Desilting + CCTV	-	-
ED4	9-11	LIC Road	Poor	0.30	304.28	Brick Masonry	1 in (-ve) 1044.22	1 in 156.10	1 in 330.74	52	83	69	3.43	12.10	Replace	0.50	1 in 330.74
		LIC Road	Poor	0.50	1208.56	Brick Masonry	1 in 5076.66	1 in 58.03	1 in 439.80	34	100	91	11.61	12.10	Replace	0.60	1 in 439.80
		LIC Road	Poor	0.60	324.33	Brick Masonry	1 in (-ve) 6759	1 in 1203.9 2	1 in 1287.02	23	56	46	11.04	12.10	Replace	0.60	1 in 1287.0 2
ED5	13-15	Allahpur Road	Poor	0.70	272.24	Brick Masonry	1 in 2770.67	1 in 263.43	1 in 760.45	48	72	33	21.66	18.06	Desilting + CCTV	-	-
	15-Alop ibagh	Allahpur Road	Poor	1.0	889.5	Brick Masonry	1 in 7710.91	1 in 403.23	1 in 1051.42	18	45	42	47.69	36.98	Desilting + CCTV	-	-

5.3.2 Shortfalls of the Existing Sewerage System

(1) Data regarding the Existing Sewer System in Allahabad is presented below:

1) Total length of sewerage network – 495 km
2) Coverage in terms of area – 38% of the municipal extents
3) Coverage in terms of population – 36% of 2003 population
4) Material of drains – Brick masonry / RCC

The inadequacies of the system are as follows: -

1) Inadequate population and area coverage
2) Silting of sewers – All the existing lines have heavy silt deposition.
3) Choking of sewers due to ingress of solid waste – The solid waste of the city is finding its way into the sewers, choking the pipelines and manholes.
4) Poor maintenance – The present measures for cleaning the sewers of the debris and deposited silt are totally inadequate. Maintenance practices are reactive rather than proactive.
5) Variations in existing slopes – Sewer lines show large variation in constructed slopes probably as a result of errors during construction. This has resulted in reduced capacities and hence, siltation in certain stretches.
6) Old infrastructure – Some of the pipe stretches are more than 70 years old and need replacement / augmentation.
7) Structural damage – Some of the old sewers are damaged due to corrosion. In certain places, sewer overflows have been solved by diverting the flows into surface drains.

(2) Sewage Pumping Stations

Allahabad city has eight existing pumping stations. The current operational problems of these pumping stations are briefly described below: -

- **Gaughat Pumping Station**

The SPS receives flows from Chachar Nala SPS and Lukerganj in dist A & B, Allahpur, Mumforganj & Daraganj via Alopibagh in dist. D and from various trunk sewers of the city. It pumps the received flows to Naini STP. The alignment of the pumping unit needs to be corrected. There is tremendous vibration on the pumping sets. Mechanical Bar Screens and conveyor system provided are not functional and need immediate replacement.

The standby DG sets are provided but there is no diesel to operate these in the event of a power failure. Hence, the system remains surcharged resulting in backflow. The sewers are hydraulically over loaded resulting in settlement. The wet sump is inadequate for the ultimate discharge. Though electrical system is working satisfactorily, but it has outlived its life hence needs replacement.

- **Mumfordganj Pumping Station**

The discharge from Mumfordganj Katra and Naya Katra Areas is discharged into the wet sump. Simultaneously, the Mumfordganj nala is also tapped. There is neither mechanical nor manual bar screen provided in the system.

The rising main is passing through the flood control pumping station for pumping of sewage to Alopibagh. There is a single Panel 11 kV HT feeder for pump house. There is one step down transformer as well. There is no standby feeder for HT supply from any other source.

However, 63 kVA Diesel generating (DG) set is provided for running the pumps during power failure, but there is no diesel oil for running the DG set.

As per the Master Plan, 92 mld (peak flow) sewage shall be supplied from Alopibagh Pump House by pumping and gravity. Since capacity of existing pump house is 15.7 mld (peak flow with 50% standby) and there is no space to provide additional pumps; hence, existing Pump House shall have to be abandoned and a new pump house shall have to be constructed.

- **Chachar Nala SPS**

The SPS taps the Chachar nala and pump the flow to Gaughat SPS. The present peak flow is more than the installed pumping capacity. The existing wet sump capacity is inadequate; hence additional wet sump shall be provided to cater to present demand. There are no mechanical / manual bar Screens provided before the wet sump. Diesel Generator has been provided but there is no diesel oil to operate it.

- **Lukerganj Pumping Station**

This pumping station is located in a congested area. The SPS is designed to receive flow from a 27 inch gravity sewer. However, as this line is choked, the SPS is not operated most of the time. There are no Bar Screens for removal of the floating matter and capacity of existing sump is inadequate. The pumping capacity is considered adequate for the present.

- **Daraganj Pumping Station**

The pumping station is located at the bank of Ganga river. Wastewater is fed to the pump house through a sewer main collecting wastewater from the Bakshi Bund area and partly from the Allahpur area. The incoming sewage is pumped to the Alopibagh SPS. There is no screening arrangement (either manual or mechanical) before the wet sump. Electrical supply is from the public distribution system from overhead main on LT. Neither dedicated feeder have been provided nor the SPS has a Diesel Generating Set for operation of pumps during the power failure.

The pumps along with control valves may have to be replaced due to age factor.

- **Allahpur Pumping Station**

The pump house is situated at Allahpur to cater to the disposal of sewage from Tagore Town, Allahpur and nearby areas. The SPS pumps the sewage to Alopibagh SPS. The existing network of sewers comes to the wet sump of the pump house. There are neither mechanical nor manual bar screens before the wet sump & after the collection chamber.

Electrical system is presently working satisfactorily, however, switchgear shall need to be replaced in future.

The pumps & controlling valves also require replacement as their useful life is over.

Diesel Generator set as standby power is available but it is not operated due to non-availability of diesel.

- **Morigate Pumping Station**

The SPS taps the flow of two nalas and pumps it to the Alopibagh SPS. The coarse bar screen is provided at upstream of the pump house at the tapping point of Mori nala. However,

the other nala coming from Daraganj area discharges into the pump house downstream of the coarse bar screens.

Mechanical bar screens have to be provided for removal of floatings.

Electrical system needs major replacement / augmentation. The connection is given through pole mounted step down transformer of UPPCL across the Bandh Road. The MCCB and other switchgears need to be replaced on priority, the wiring of the control panel needs to be replaced with measuring instruments.

The capacity of the sewage pump house is inadequate even for the present flow. Hence an additional pump house has been proposed on near by available defence land.

- **Alopibagh Pumping Station**

Alopibagh SPS receives flow from the Daraganj, Allahpur and Morigate SPS and from the gravity sewers in surrounding areas. The flow is pumped to Gaughat SPS. The capacity of the wet sump is not adequate for retention of 5 minutes. There is no mechanical bar screen. However, manual bar screens are provided in the wet sump, floatings are collected manually by the cleaning staff by physically entering into wet sump and picking the floating matter with their bare hands (Ref. picture).

There is only one source of power supply on 11 kV system. However, there should be a standby feeder from other source to take care of pumping in the event of failure of the first source.

The pumping capacity is not adequate for the discharge from the various trunk sewers and rising mains from other pumping stations.
The Diesel Generating Set of 160 kVA is provided but there is no diesel oil to operate.

Conclusion :
Except for the two SPS at Daraganj and Allahpur, raw sewage at all other SPS is overflowing untreated to the rivers Yamuna / Ganga due to design deficiencies and / or inadequate capacities.

The situation is worsened by the long power cuts in the city during this time Diesel Generating sets cannot be operated due to non-availability of diesel.

5.3.3 Existing Naini Sewage Treatment Plant

There is only one existing STP of 60 mld capacity at Naini. It receives raw water from the Gaughat Pumping Station located across the Yamuna. The plant is based on the Activated Sludge Process (ASP). The technical details are presented in another section of this report. A brief performance review is presented here:

1) CPCB has monitored the performance of Naini STP 22 times between July 1999 and March 2002. As per data published by CPCB, the treated effluent BOD showed significant variation (in excess of 10%) over the discharge requirement (30mg/l) in 5 out of the 22 samples. Similarly, SS values were significantly higher in 8 of the 22 samples collected and tested. The incidence of failure to meet discharge requirements is thus on the higher side.
2) As observed by the project team during their visits to the plant, screening arrangements are poorly maintained.
3) The solids handling line is grossly under loaded as the plant was designed for a very high influent SS value (600 mg/l) whereas the average influent value is almost half of this (335 mg/l).
4) Gas production is very less, possibly the main reason for this is very low influent SS, as explained above.
5) The equipment for production of power from sewage gas (DF engines, gas scrubbers etc.) are lying unused as diesel required for operating the DF engines is not available.

5.4 BASELINE ENVIRONMENTAL SCENARIO

5.4.1 Study Area

The present feasibility study covers four sewerage districts of the Municipal Corporation of Allahabad namely Districts A, B, D and E. The study area falls in Allahabad district of UP State. The Municipal Corporation of Allahabad encompasses an area of 79.5 km^2 and is thickly populated having an average population density of 15,700 per km^2. As Allahabad is one of the most important religious centers of the country, it has got a large floating population. There is no record available for the floating population. The Maha Kumbh (Religious Fair) attracts the largest floating population. Anticipated floating population during Magh Mela (Religious Fair) every year has been estimated as one lakh per day. This adds extra load to the sewage system of the city for which due provision is required. As festivals / Melas are routine features, therefore, a large area of the city has been earmarked as Mela ground.

5.4.2 Physical Environment

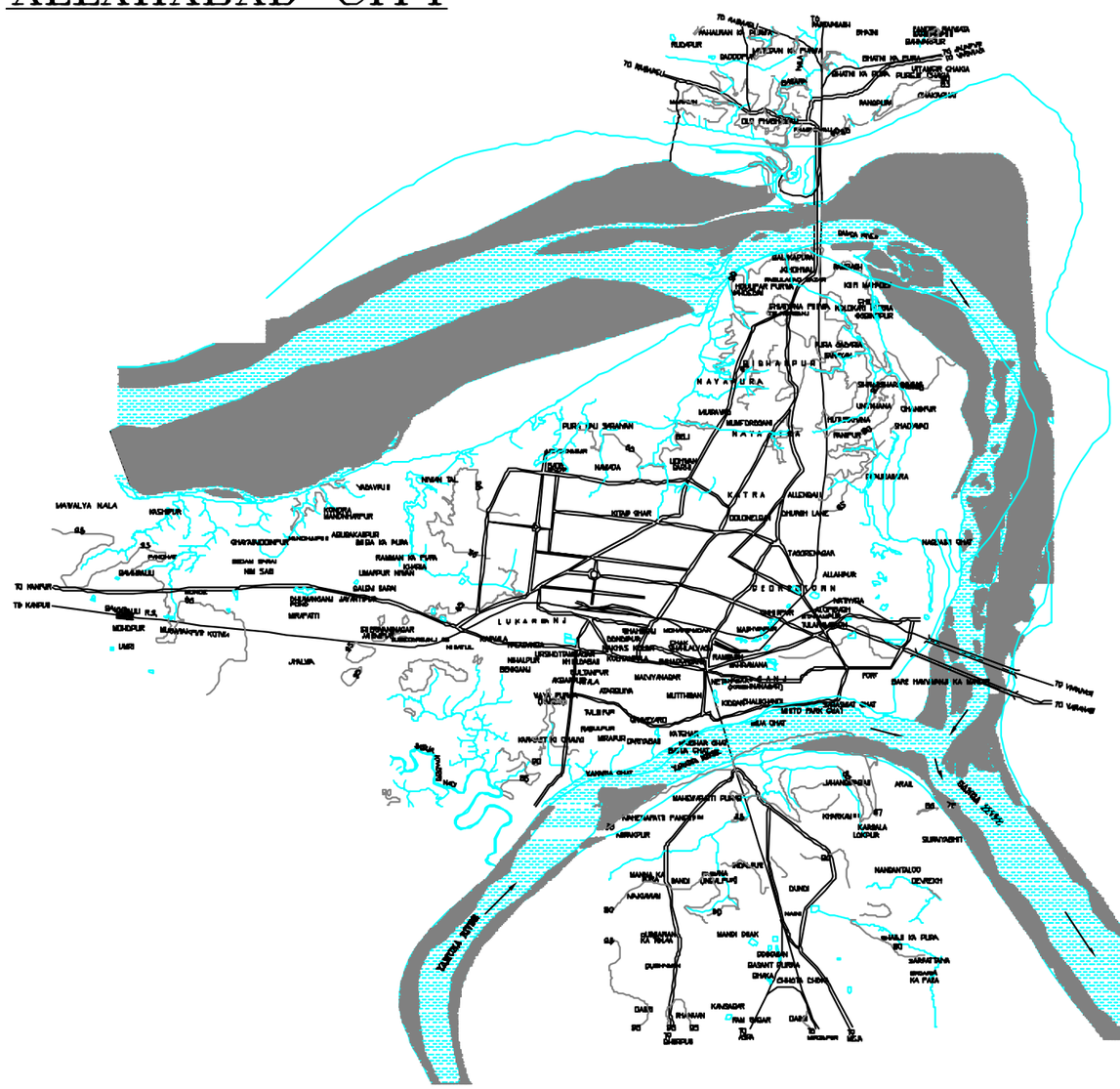
(1) Physiography and Drainage

The city in general occupies the interfluvial belt of Ganga River in the north and the Yamuna in the south. The confluence of the two rivers lies in the south east of the city. These rivers are perennial rivers, which carry huge volume of water during the rainy season. A seasonal river Sasur Khaderi flowing easterly, joins the left bank of the Yamuna River in the southern area of the Allahabad city. A number of small nalas originating from the central parts of the city form the natural drainage of the city. 39 major drains fall into Ganga River and eleven into Yamuna River. A list of the Nalas is attached in Appendix A5.9. Due to the absence of required sewerage infrastructure for the city, these Nalas carry domestic wastewater at present, thus convey the raw sewage / sullage direct into Ganga River and Yamuna River.

The average elevation of the city is around 95 m above MSL (Mean Sea Level). The general land slope is easterly. A surface water divide lies between Ganga River and Yamuna River having east west

strike. The alluvial plain forms the chief morphological feature. The land elevation drops inward from the high ridge to the central depression formed by Sasur Khaderi in the south western parts of the city as shown in Figure 5.3.

ALLAHABAD CITY



LEGEND

- RIVER / NALA
- SURFACE CONTOUR — 90
- ROADS
- RAILWAY LINE

INST.					
ELEC.					
MECH.					
STRU.					
CIVIL					
REV NO.	0	1	2	3	4

REV.	DESCRIPTION OF REVISIONS	DATE	CHECKED

CHECKED BY: A.Bhatnagar	CHECK	APPROVED BY: D.Sarkar	APPROVE
DRAWN	Surendra		
DESIGNED	R.Mittal	SCALE	1:100
SURVEYED	S.Sharma	DATE	

JICA

STUP CONSULTANTS LTD.

PROJECT:
THE STUDY ON
WATER QUALITY MANAGEMENT PLAN
FOR GANGA RIVER IN THE REPUBLIC OF INDIA
FEASIBILITY STUDY FOR ALLAHABAD CITY

CORRIDOR:
ALLAHABAD CITY

SHEET CONTENTS:
MAP SHOWING GENERAL LAND ELEVATION

DRAWING NO. FIGURE 5.3

SHT. NO 1

(2) Climate

The nearest meteorological station of Indian Meteorology Department, for which published long term data (climatological normals) are available, is at Allahabad. The climatological normals (based on about 30 years data 1951 to 1980) for this station has been presented in Appendix A5.10 as long term meteorological data for the project. Climatological Normals of various parameters have been presented in the following order:

Temperature, Humidity and Rainfall	Table 5.11
Special Weather Phenomena	Table 5.12

Temperature

It can be observed from Table 5.11 that the mean of monthly maximum temperature varies in the range between 23.6°C (January) and 42.3°C (May), and the mean of monthly minimum temperature in the range between 8.7°C (January) and 28.5°C (June). The mean of highest temperature in a month varies in the range between 27.9°C (January) and 45.9°C (May), and the lowest in a month in the range between 3.8°C (December) and 24.0°C (June).

Table 5.11 Climatological Normals of Temperature, Humidity and Rainfall at Allahabad

Month	Mean Air Temperature, °C				Humidity %		Rainfall	
	Daily Max	Daily Min	Highest in the Month	Lowest in the Month	0830 Hrs	1730 Hrs	Monthly Total mm	No. of Rainy days
January	23.6	8.7	27.9	4.5	78	53	19.2	1.6
February	27.2	11.2	32.4	6.1	66	40	15.5	1.4
March	33.6	16.5	39.0	10.9	46	25	9.2	0.9
April	39.4	22.5	43.5	17.3	32	18	5.7	0.5
May	42.3	26.7	45.9	22.5	36	36	9.9	0.7
June	40.1	28.5	45.2	24.0	55	41	85.4	4.4
July	34.1	26.4	39.3	23.5	80	71	300.1	12.8
August	32.7	25.7	36.5	23.6	85	77	307.6	14.4
September	33.2	24.7	36.2	22.3	80	71	189.8	8.7
October	33.1	20.5	35.8	15.9	69	55	40.1	2.2
November	29.7	13.8	32.7	9.6	65	49	11.7	0.5
December	24.8	9.3	28.4	5.3	75	56	3.4	0.5
Total/Mean	32.8	19.5	46.1	3.8	64	48	1,017.7	48.6
No. of years	30	30	30	30	30	30	29	29

Source: Climatological tables, 1951-1980; IMD Publication

Rainfall

The normal annual total rainfall at the station is reported as 1,017.7 mm (Table 5.12). August is the month with maximum precipitation (307.6 mm), followed closely by July (300.1 mm). The period from June to September (southwestern monsoon) accounts for about 87% of total rainfall. Winter rains occur mostly during the months of January and February, and account for about 1.6% of total rainfall.

Wind Direction and Speed

It can be observed from Appendix A5.11 that western, northwestern and southwestern winds are prevalent throughout the year except during the monsoon months. During the monsoon months, eastern and northeastern winds are prevalent. The mean of monthly average wind speed varies in the range between 2.4 km/h (November) and 8.0 km/h (June). Most of the times, winds are reported in the speed range between 1 km/h and 19 km/h.

Special weather Phenomena: The number of days with precipitation, hail, thunder, fog, dust storm and squall has been presented in Table 5.12. Almost 50% of days during monsoon months experience precipitation. Thunder is also prevalent during the months of July and August. Dust storms occur during May and June.

Table 5.12 Climatological Normals - Special Weather Phenomena at Allahabad

Month	No. of days with					
	Precipitation	**Hail**	**Thunder**	**Fog**	**Dust Storm**	**Squall**
January	3.0	0.2	1.3	4.5	0.1	0.1
February	2.8	0.1	2.3	1.3	0.0	0.2
March	1.7	0.0	2.9	0.1	0.4	0.7
April	1.0	0.1	2.3	0.0	0.9	0.4
May	1.3	0.0	2.7	0.0	1.5	0.5
June	6.5	0.0	8.0	0.0	2.7	1.1
July	16.8	0.0	12.0	0.0	0.2	0.4
August	18.2	0.0	12.0	0.0	0.5	0.4
September	11.5	0.0	8.4	0.1	0.0	0.6
October	3.5	0.0	2.7	0.4	0.1	0.2
November	0.8	0.0	0.2	0.4	0.0	0.0
December	0.9	0.0	0.4	3.7	0.0	0.0
Total	**68.0**	**0.4**	**55.2**	**10.5**	**6.4**	**4.6**

Source: Climatological tables, 1951-1980; IMD Publication

(3) Geology

The city of Allahabad occupies the interfluvial sediment of Ganga River & Yamuna River. These fluvial sediments attain significant thickness and comprise unconsolidated material. These sediments are essentially a sequence of clays, sands, and silts with interspread bands of Kankar having limited extent. These fluvial sediments may be divided into several groups based on energy sequence concept (stability of heavy mineral and grain size distribution). Broadly these fluvial sediments are grouped as younger and older alluvium. The younger alluvium is generally confined to a depth of 60 m below the ground and it occupies the present day flood plain area. The older alluvial sediments marginally differ in lithology from that of younger alluvium sediments, with presence of sandy clay and lenses of gravel/pebbles and Kankar. The older alluvium overlies the Siwalik group of formations, which in turn overlies the pre-Cambrian formation. The generalized stratigraphic sequence of the formations present in the study area is given in Table 5.13.

Table 5.13 Generalised Stratigraphic Sequence

Time unit	Time rock unit	Rock unit	Thickness m
Recent to 0.01 m year	Newer Alluvium	Sand & Clay	60-100
Holocene <1 m year	Older Alluvium	Sand, clay, pebble, gravel and Kankar	100-200
----------Unconformity----------			
Pleistocene & Pleocene	Siwalik	Conglomerate, sandstone shale etc.	Above 350 m
----------Unconformity----------			
Pre Cambrian	Vindhyan	Sand stone, Limestone	Not known
----------Unconformity----------			
Archean	Bundelkhand massit	Granite	Basement

To depict the sub surface geology the borehole data of two exploratory boreholes namely Daraganj and Sulem Sarai have been given in Appendix A5.12.

(4) Water Environment

1) Hydrogeological Scenario

Mode of occurrence

The ground water in the area occurs within the primary porosity of unconsolidated alluvial sediment, which has considerable thickness as evident from the borehole data. The ground water generally occurs in unconfined state within the first shallow aquifer within 50 m from the ground while in deeper aquifer it occurs in semi confined to confined conditions.

Depth to water table

To evaluate the behaviour of water table over the area the long term data of three permanent hydrograph stations being monitored by Central Ground Water Board have been collected and is presented in Appendix A5.13 and Figure 5.4. Analysis of data indicates that the depth to water table over the city ranges between 3.5 to 20 m below the ground, during pre monsoon season and between 2 to 19 m below the ground during post monsoon season. Pre and post water level status have been shown in Figure 5.5. The long term average water levels of the three locations of Allahabad vary between 3.64 to 17.14 m (Table 5.14).

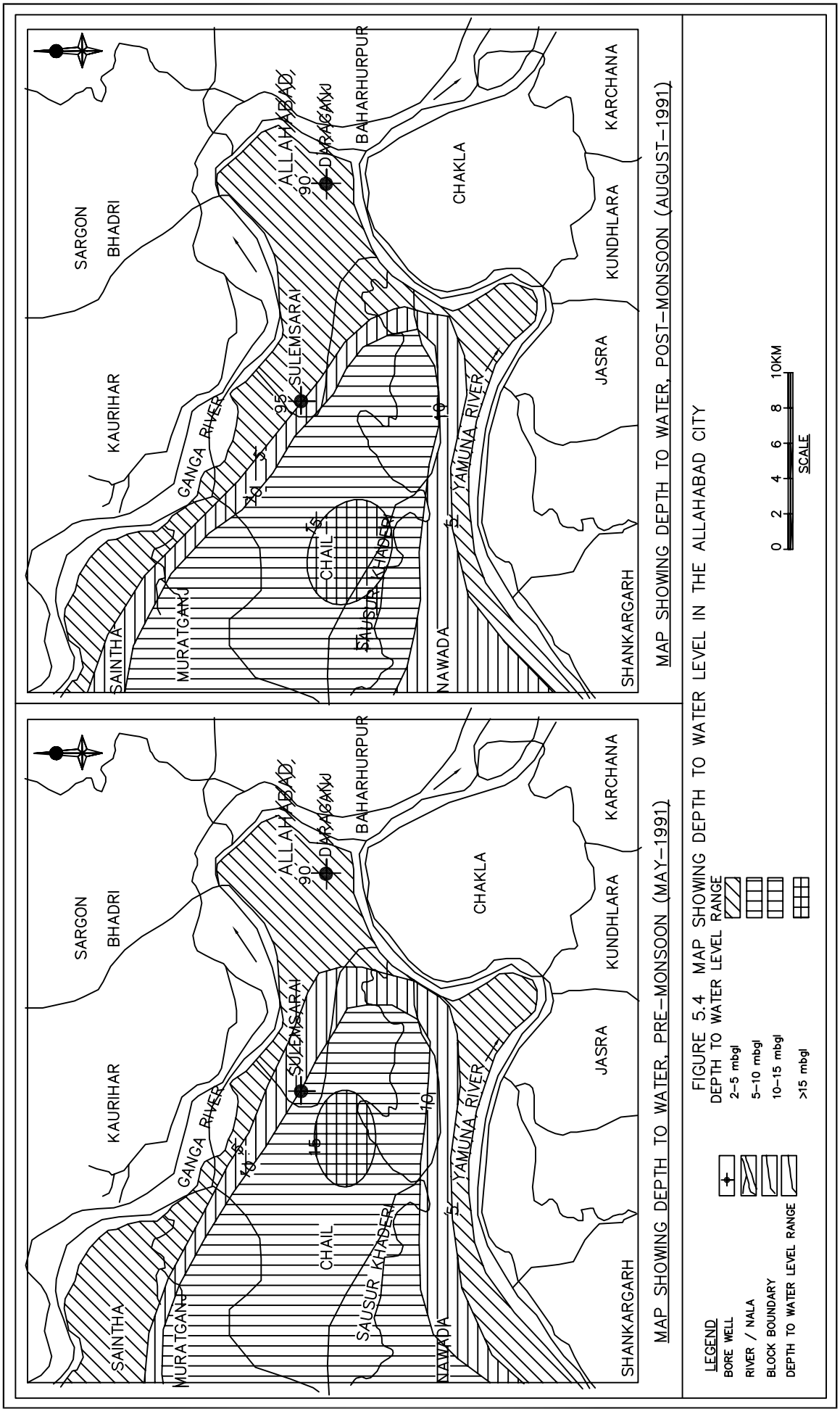


FIGURE 5.4 MAP SHOWING DEPTH TO WATER LEVEL IN THE ALLAHABAD CITY
DEPTH TO WATER LEVEL RANGE

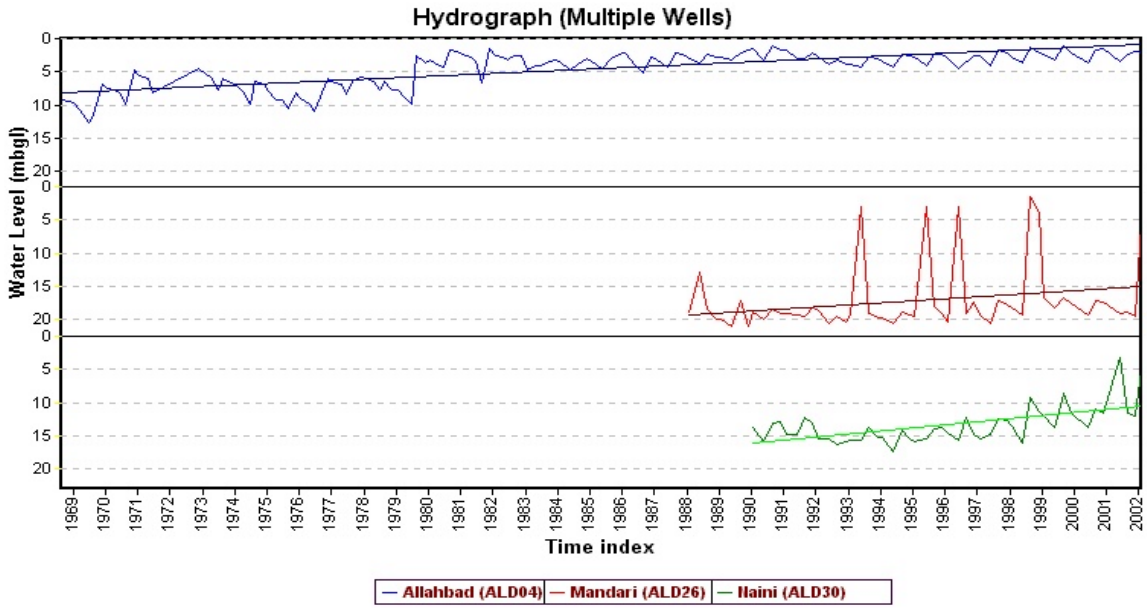


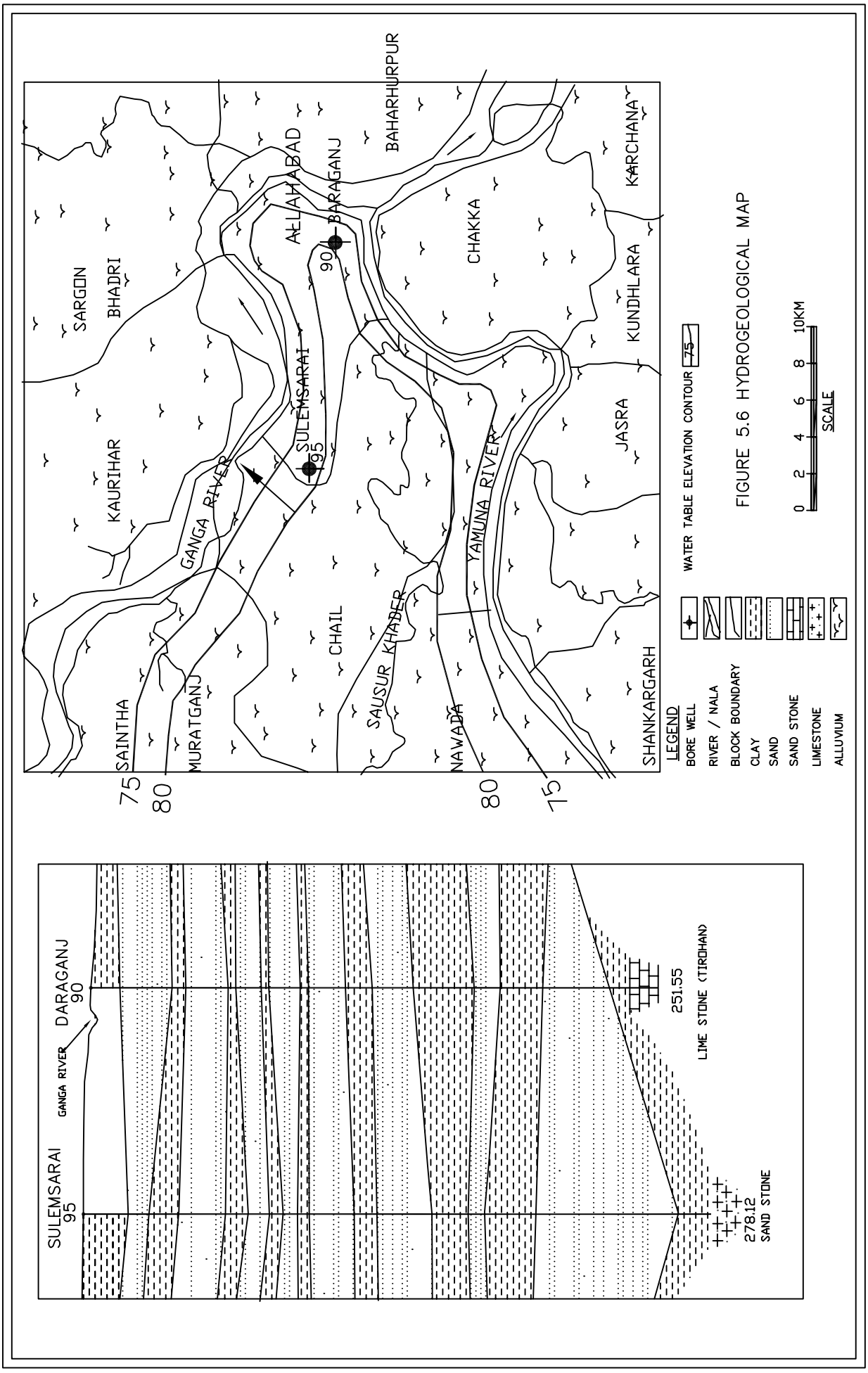
Figure 5.5 Hydrograph (Multiple Wells)

Table 5.14 Minimum, Maximum and Average Water Levels

Location	Well No.	Period	Minimum	Maximum	Average
Allahabad	ALD04	1969-2003	1.00	12.58	4.64
Mandari	ALD26	1989-2003	1.48	21.00	17.14
Naini	ALD30	1991-2003	3.30	17.30	13.42

Ground water flow regime

The water table follows the morphology. The city occupies the Doab zone (surrounding area before confluence of two rivers) of the Ganga River in north and east and Yamuna in south. The general land slope is towards east. The surface water divide roughly follows west-east strike. Therefore, ground water slopes both toward Ganga River as well as toward Yamuna in conformity to local topography. The ground water flow regime has been depicted in Figure 5.6.


SULEMSARAI
95
GANGA RIVER
DARAGANJ
90
251.55
LIME STONE (TIRDHAN)
278.12
SAND STONE
SAINTHA
MURATGANJ
KAURIHAR
SARGON
BHADRI
GANGA RIVER
SULEMSARAI
95
ALLAHABAD
90
BARAGANJ
BAHARHURPUR
CHAKKA
KARCHANA
KUNDHLARA
JASRA
CHAIL
SAUSUR KHADER
YAMUNA RIVER
NAWADA
SHANKARGARH
75
80
80
75
LEGEND
BORE WELL
RIVER / NALA
BLOCK BOUNDARY
CLAY
SAND
SAND STONE
LIMESTONE
ALLUVIUM
WATER TABLE ELEVATION CONTOUR 75
0 2 4 6 8 10KM
SCALE
FIGURE 5.6 HYDROGEOLOGICAL MAP

Water level trend

The water level trend analysis has been carried out for the three stations having long term water level data. The trend analysis is given in Table 5.15.

Table 5.15 Water Level Trend

Location	Well No.	Period	Pre-monsoon		Post monsoon	
			Rise (m/yr)	Fall (m/yr)	Rise (m/yr)	Fall (m/yr)
Allahabad	ALD04	1969-2003	0.216	-	0.167	-
Mandari	ALD26	1989-2003	-	0.063	0.396	-
Naini	ALD30	1991-2003	0.578	-	0.277	-

From the above table it is evident that the post monsoon levels show a general rising trend in the area which is of the order of 16 to 30 cm per year while the pre-monsoon trend at Mandari shows a decline of the order of 6 cm/year while Allahabad and Naini show a rise of 21 cm/year and 37 cm/year, respectively. The annual water level trend of the above mentioned locations are shown in Figure 5.6.

2) Surface Water

The important surface water system of the city is easterly flowing Yamuna river which lies south of the main city. The Ganga is second important source of surface water which flows easterly and then turns abruptly south wards close to eastern end of city and finally meets Yamuna river close to celebrated temple of lord Hanuman in Sangam area of the city. The discharge of the two rivers combined is quite high as evident from the available data given in Table 5.16. During the monsoon season these rivers carry huge volume of water, flooding their banks.

3) Water Quality

- **Secondary Data**

Secondary data regarding water quality of both surface and underground water sources in and around the project study has been collected from CGWB (Central Ground Water Board) and CPCB (Central Pollution Control Board). In addition, 10 surface water and 10 ground water samples have been collected and tested in an MoEF approved laboratory (certificate of approval attached in Appendix A5.14.

- **Ground Water Quality**

Central Ground Water Board has collected water samples from exploratory tube wells and open wells from time to time. The analytical results have been compiled from the reports of Central Ground Water Board and have been presented in Table 5.17.

From the above data it is observed that the ground water, both from shallow and deep aquifers is mildly alkaline in nature. The water from the deeper aquifers within the city have a conductivity between 1,115 to 1,681 micro seimen/cm while phreatic aquifer has got conductivity less than 1,000 micro seimen/cm. The ground water of the area is fresh and potable with all the parameters within the permissible limits of human utilisation.

Table 5.16 Discharge of the Ganga at Allahabad (Sangam) (In m^3/s)

Year	Jan	Feb	Mar	Apr.	May	June	July	Aug	Sept.	Oct.	Nov.	Dec.
1972	401.38	433.61	294.13	288.22	362.67	230.12	2609.37	6664.86	13253.85	2065.60	644.51	489.48
1973	389.03	347.81	283.07	225.23	221.70	478.79	13783.95	21527.10	28809.04	4651.25	1073.44	598.22
1974	507.35	384.54	325.14	267.79	307.61	260.77	9149.19	19693.12	3915.68	1100.98	691.88	488.52
1975	462.97	303.01	265.96	270.39	189.88	572.22	9742.86	18209.47	15767.68	4366.54	1303.98	724.01
1976	669.83	557.91	420.13	420.78	383.05	1117.08	3359.80	18221.71	16142.34	1893.42	553.63	482.89
1977	335.10	327.90	270.71	394.99	373.86	332.77	9115.64	17417.39	14236.34	3051.76	1124.82	750.47
1978	707.07	623.33	740.88	707.16	556.80	1077.63	7994.05	29786.23	22399.45	3980.05	1346.27	964.36
1979	924.76	1123.35	1217.99	678.51	582.70	474.02	4357.59	5701.17	1476.75	598.01	318.43	518.45
1980	380.91	288.71	224.58	151.84	123.71	406.30	6804.97	21670.89	11438.90	1441.81	684.11	443.14
1981	430.99	439.37	337.12	329.04	314.16	303.28	5841.30	11214.96	3259.22	2337.97	674.15	507.81
1982	476.17	741.79	645.68	689.06	624.22	626.40	1779.81	28824.31	16981.02	1398.27	763.93	616.34
1983	565.77	552.64	357.87	312.95	499.11	503.91	3738.99	12823.00	22159.27	7019.81	1522.83	767.78
1984	721.53	551.58	486.94	367.11	279.16	575.60	2261.22	10243.38	11080.78	1237.75	571.11	400.81
1985	433.23	323.99	238.99	262.01	237.49	257.07	1827.61	15588.59	10073.87	12078.49	2174.33	745.18
1986	588.76	736.23	554.26	372.11	309.60	382.35	11078.10	17831.97	4199.39	1539.24	740.38	519.89
1987	497.74	399.46	334.12	271.71	238.36	247.44	1116.56	3277.58	12471.41	1968.60	589.38	366.13
1988	327.21	279.35	261.20	216.16	173.64	165.69	5489.87	16483.92	4730.56	4060.86	9520.2	476.83

Table 5.17 Chemical Analysis Result of Groundwater Samples

Sr.	Well	Well Type	pH	E.C. MS/cm	HCO_3	CO_3	Cl	SO_4	NO_3	F	Ca	Mg	TH	Na	K	SiO_2
1	Allahabad	DW	8.3	736	284	Tr.	59	59	35	0.84	8.4	27	195	86	4.6	16
2	Naini	DW	8.4	712	257	24	87	33	8.8	0.83	35	62	113	135	7.2	33
3	Daraganj	EW	8.1	1596	378	Nd	223	188	Nd	0.83	128	58	568	116	6.5	Nd
4	Sulem Sarai	EW	7.5	978	415	Nd	186	144	Nd	0.84	83	63	468	69	3.9	Nd
5	Daraganj	EW	8.8	1681	258	Nd	287	Nd	Nd	Nd	128	71	593	128	6.5	Nd
6	Daraganj IV	STW	7.7	1312	378	Nd	189	Nd	Nd	Nd	188	37	424	68	2.5	Nd
7	Daraganj II	STW	7.6	1518	323	Nd	287	Nd	Nd	Nd	119	77	614	94	5.6	Nd
8	Daraganj VIII	STW	7.8	1115	336	Nd	135	Nd	Nd	Nd	86	54	435	78	5	Nd

Source: Central Ground Water Board
DW- Dug Well, EW – Exploratory Well of CGWB, STW – State Tube Well

- **Surface Water Quality**

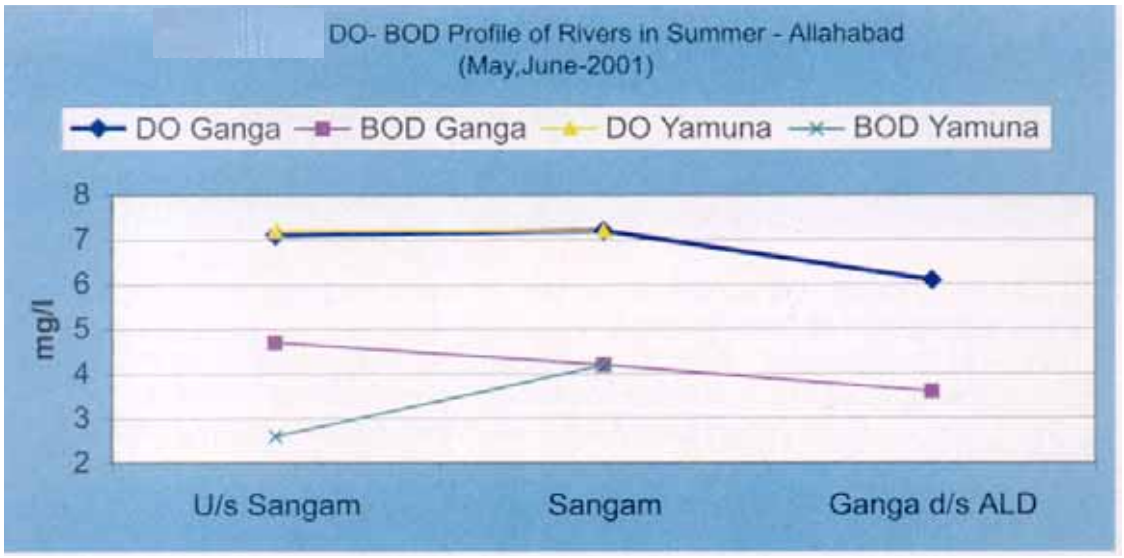
Monitoring of rivers Ganga and Yamuna was conducted by the Zonal Office of CPCB during 1999-2002, under the NRCD programme to assess the quality at the upstream and downstream of the city and also at the Sangam, where millions of people take the holy bath every year. The locations are as follows:

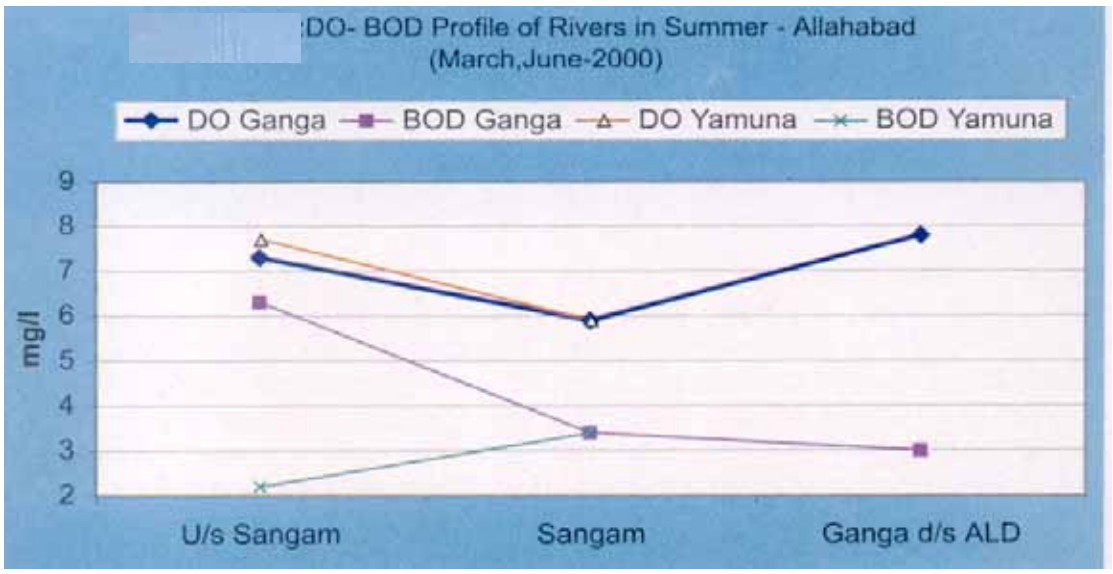
(i) Ganga River at Phaphamau bridge (1/3 from left bank) – The point may be taken as u/s of the city / Sangam.
(ii) Yamuna River before Sangam
(iii) River at the Sangam
(iv) Ganga River at the downstream of the city at Sirsa Ghat. This point is around 30 kms. from the city.

Following methodology was adopted to represent the data:

(i) The monitoring results were arranged year-wise / season-wise viz. summer, rainy and winter season and average values were calculated.
(ii) Based on these average values, the BOD-DO profiles were plotted.
(iii) In a similar way Total Coliforms and Faecal Coliforms values were represented year-wise / season-wise.

The monitoring results are presented in Figure 5.7 to Figure 5.11.





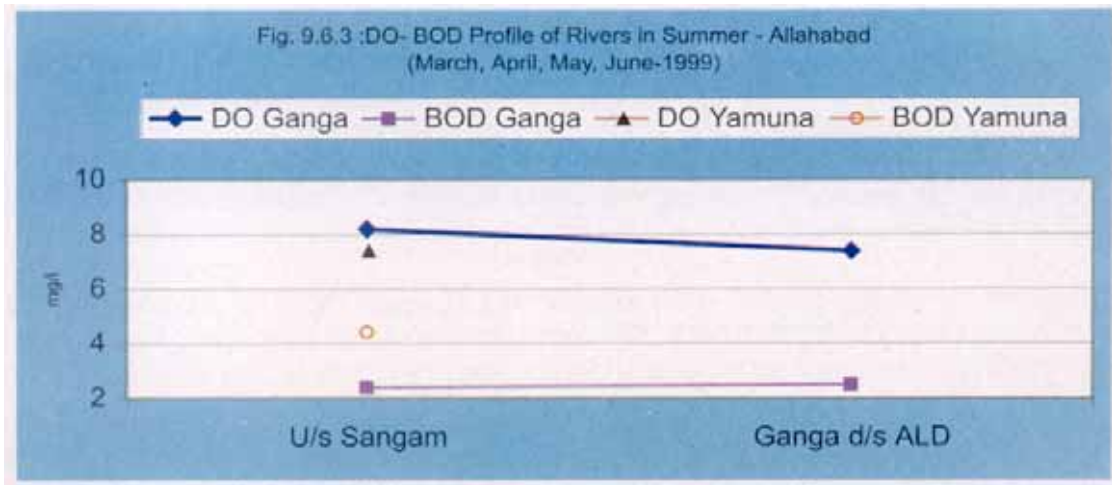


Figure 5.7 Monitoring Results for River Water Quality of the Ganga and the Yamuna (1999-2001) (1/5)

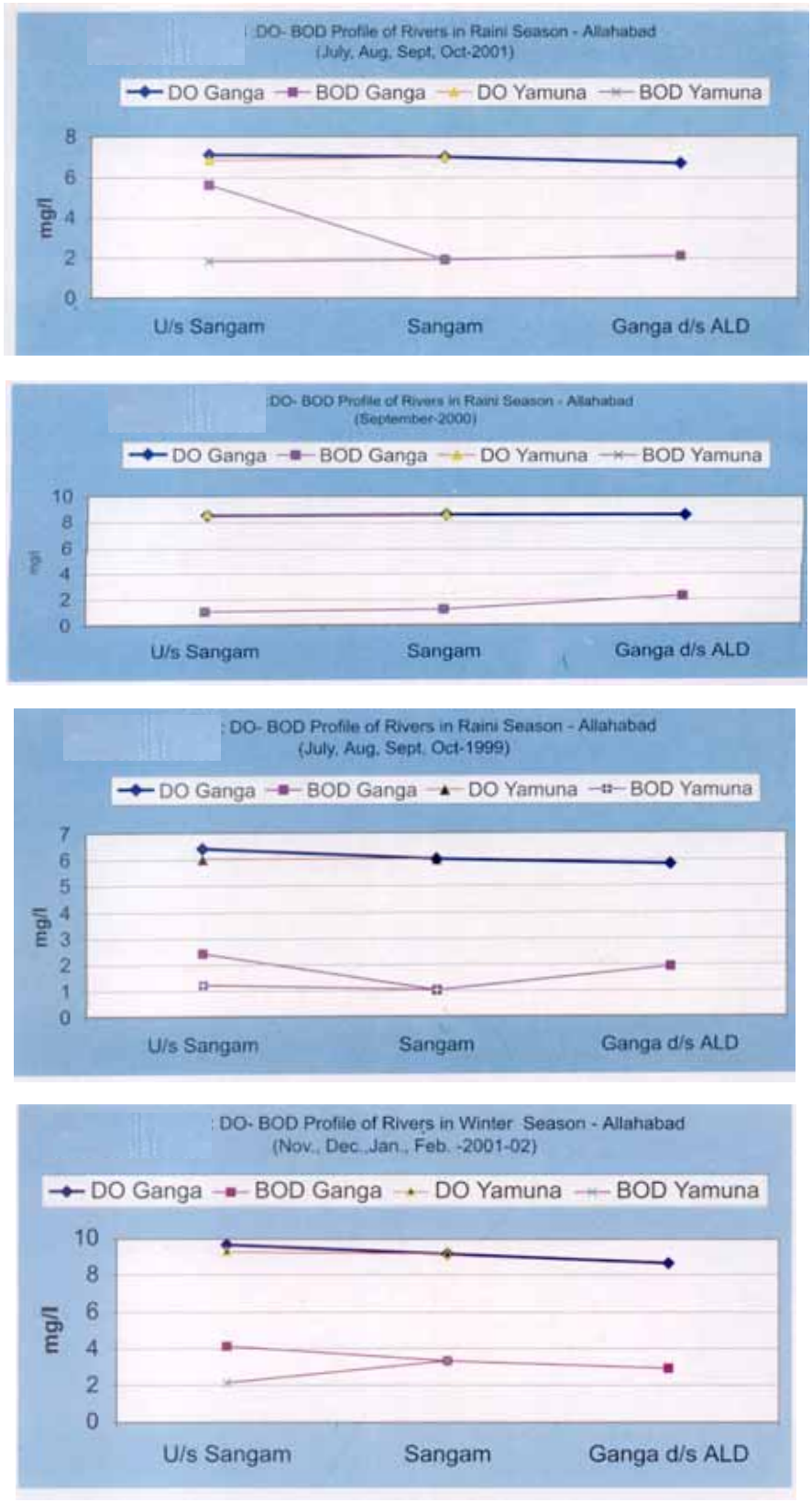
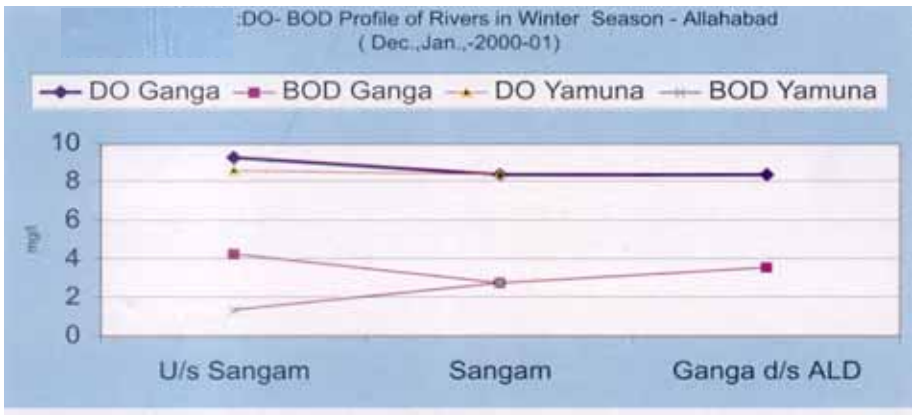
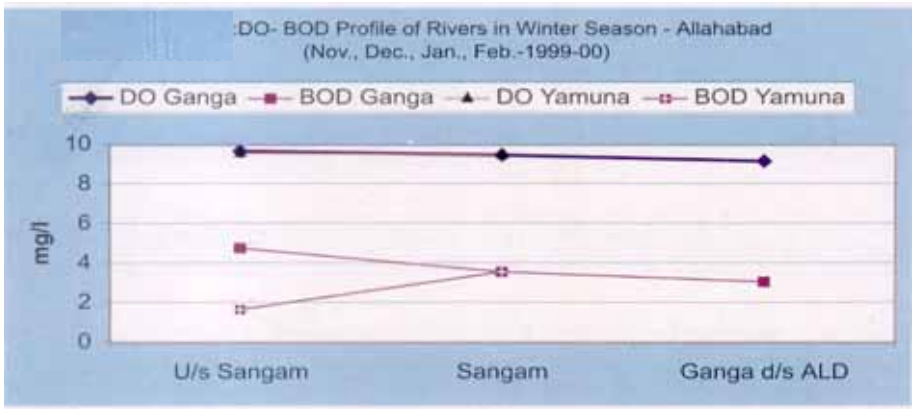
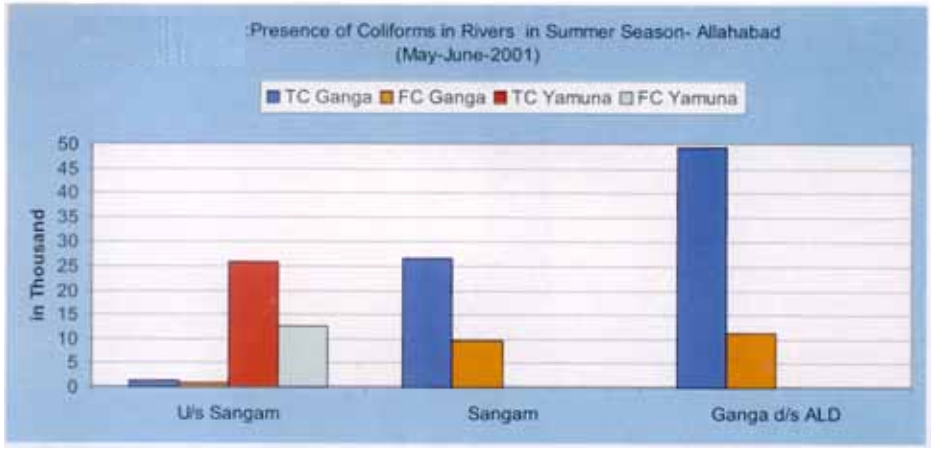


Figure 5.8 Monitoring Results for River Water Quality of the Ganga and the Yamuna (1999-2001) (2/5)







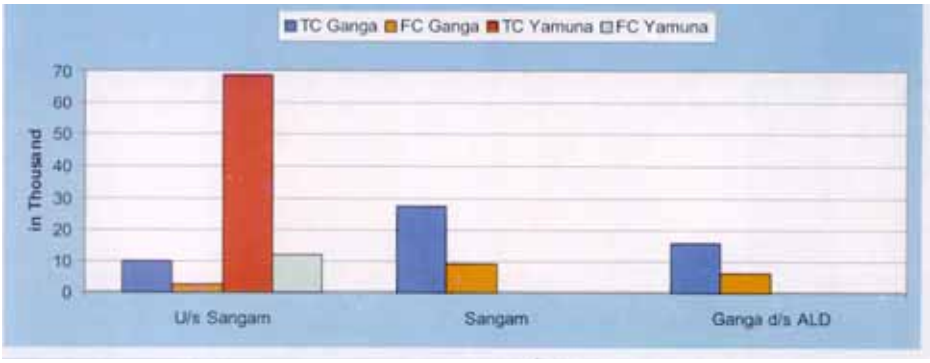
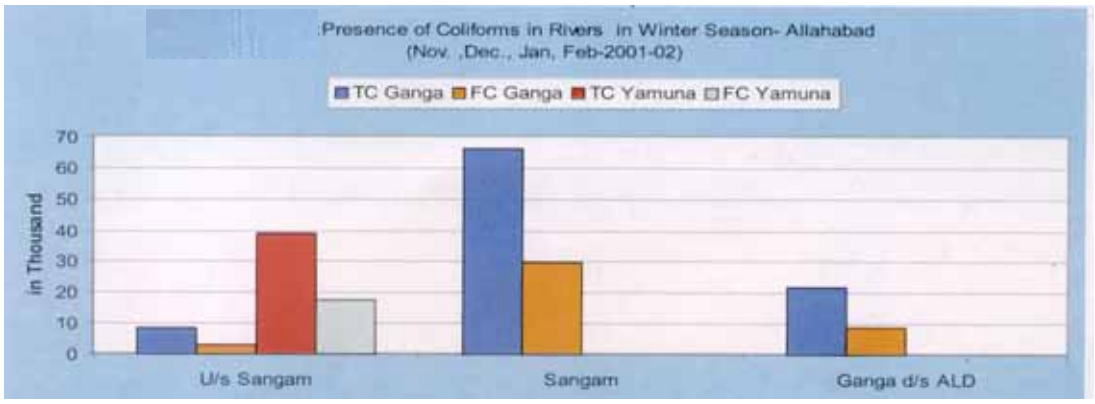
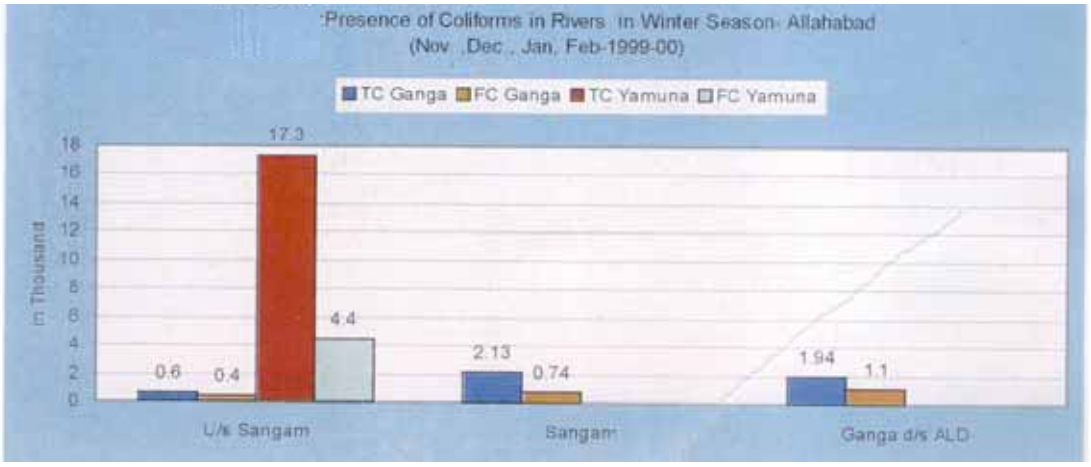
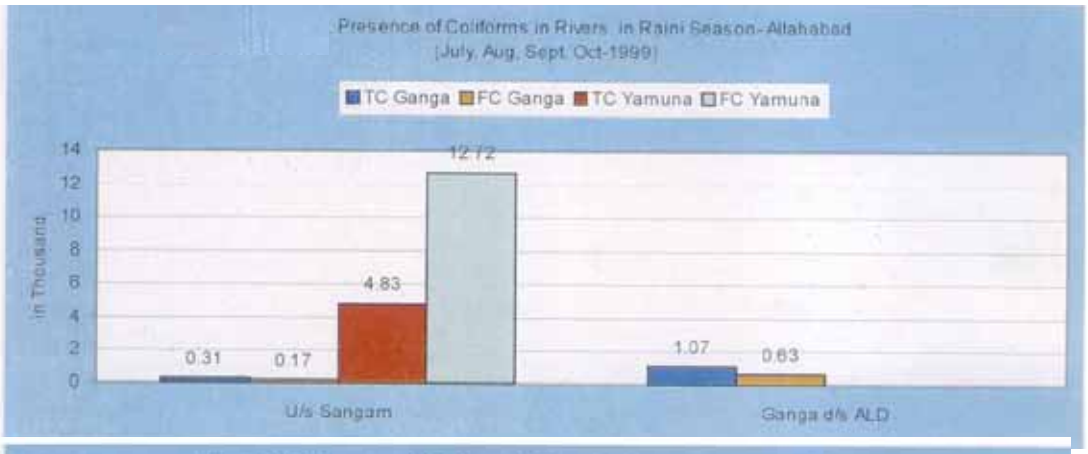


Figure 5.9 Monitoring Results for River Water Quality of the Ganga and the Yamuna (1999-2001) (3/5)







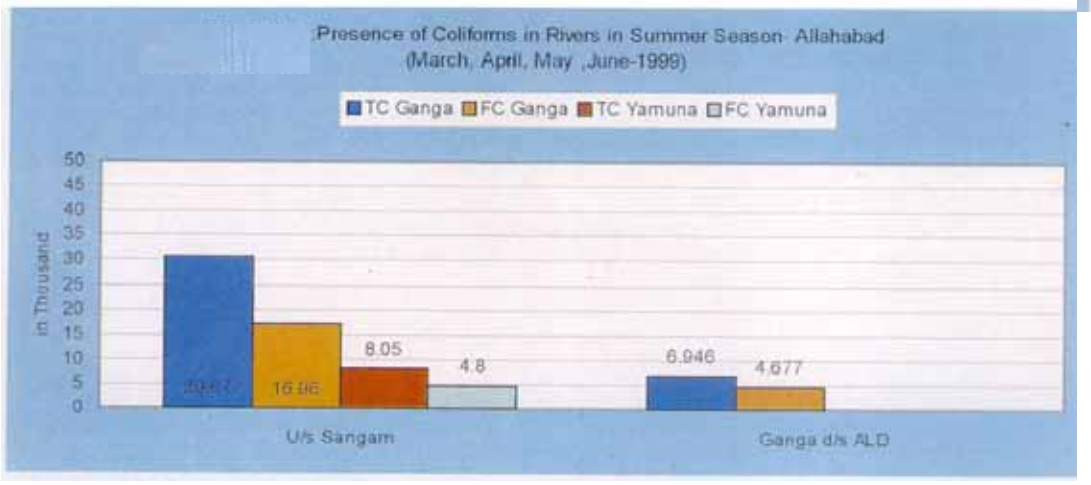


Figure 5.10 Monitoring Results for River Water Quality of the Ganga and the Yamuna (1999-2001) (4/5)

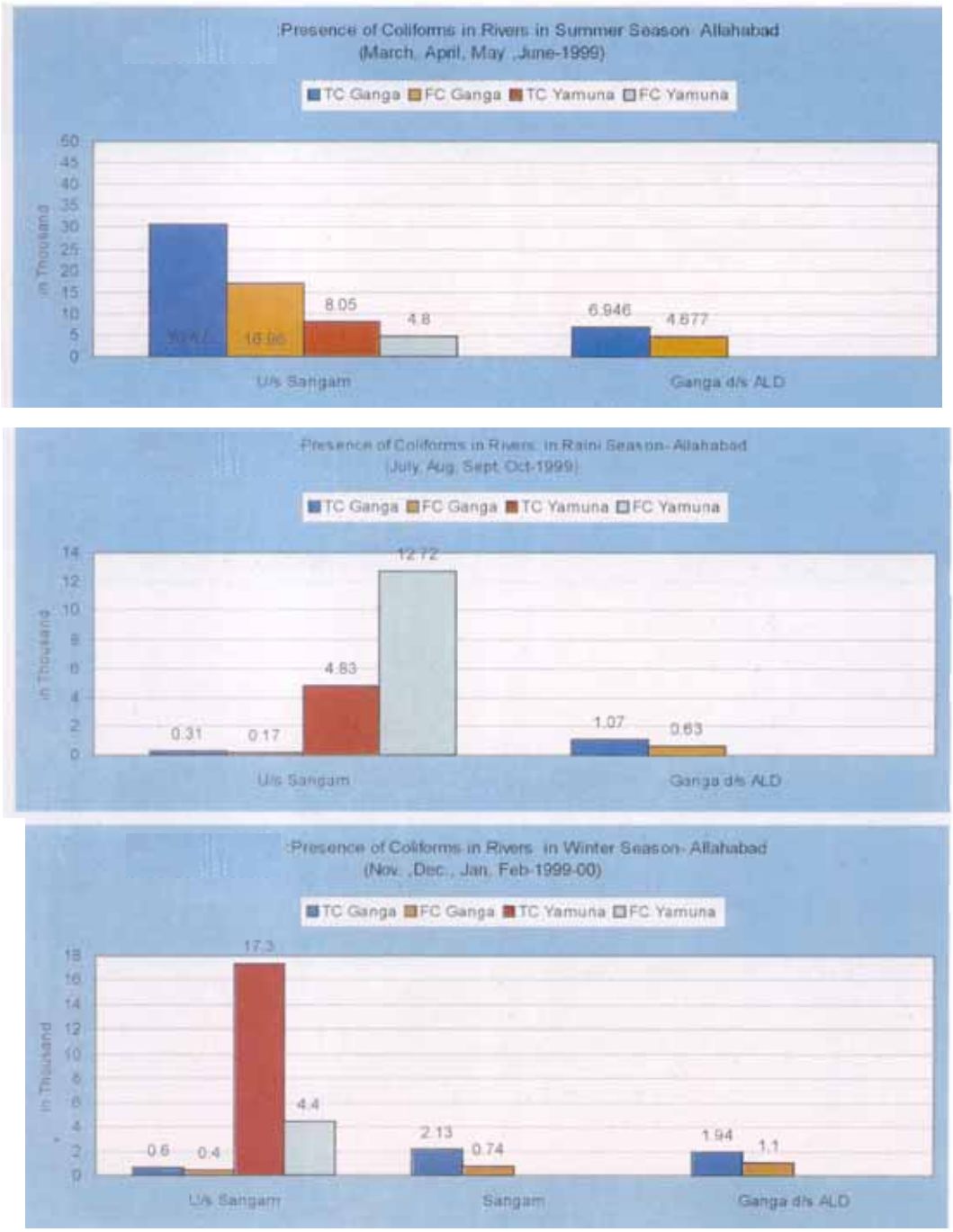


Figure 5.11 Monitoring Results for River Water Quality of the Ganga and the Yamuna (1999-2001) (5/5)

After going through the data following observations may be made.

(i) Dissolved oxygen in both the rivers is less during summer season. However it increases gradually and reaches the peak during winter season. This is obvious because during summer the river flow reduces and at increased temperature the bacterial activities increases to oxidize the organic matter discharged into it from various domestic and industrial sources. On the other hand during winter, the re-oxygenation capacity increases and also the river flow is comparatively more.

(ii) DO in both the rivers at the u/s of city is more and decreases gradually towards

downstream side as a result of discharges of huge quantities of waste-waters into it along the city-side.

(iii) During rainy season due to availability of gigantic quantities of dilution water, the DO level in the u/s and d/s of the city does not vary much and remains almost constant. The DO-profile is in the form of straight line.

(iv) The impact of discharges from domestic and industrial sources at Kanpur into Ganga River can be seen at Allahabad also. The BOD of Ganga in the u/s of Allahabad is more as compared to river Yamuna. It may be stated that river is more polluted and another river is serving as source of dilution.

(v) The BOD level at Sangam is in between the values observed in respect of the two rivers at its upstream. However, it also depends upon the activities going at this place like mass bathing and other religious offerings, which increase organic and coliform loadings.

(vi) The BOD level after Sangam, in the down stream of the city at Sirsa ghat, may increase slightly due to discharges at Naini from STP and Mawaiya and Makhiya industrial drains. In general, the average BOD level in the d/s of the city is to the tune of 3 mg/l.

The characteristics of the rivers with respect to the presence of coliforms are highly variable. However, following points may be observed:

(i) In general, Coliform content of river Yamuna is on higher side as compared to Ganga River.

(ii) At Sangam also, significant population of coliforms is observed, which may be attributed as a result of mass bathing and related activities.

(iii) The coliform population of the river water after Sangam decreases slowly as a result of self-purification capacity of the river.

- **Heavy Metals in River Waters:**

The heavy metals were monitored at 5 locations at u/s and d/s of Allahabad and the results are presented in Table 5.18. A close scrutiny of the data reveals that the concentration of chromium in the Ganga River is significant. One of the most probable reasons may be due to discharges of chromium bearing wastewater from the defaulter tanneries at Kanpur. The concentration of iron in the same river was observed at the alarming level. The concentration of chromium and iron were found as high as 3.23 mg/l and 97.92 mg/l, respectively, which must be a matter of concern. Other metals were found either as Not Traceable or within the limits prescribed for drinking water standard.

Table 5.18 Heavy Metals in Rivers at Allahabad – (2000-01)

Sampling Locations	Phase	Cd (mg/l)	Cr (mg/l)	Cu (mg/l)	Fe (mg/l)	Ni (mg/l)	Pb (mg/l)	Zn (mg/l)
Ganga at Phaphamau Bridge	June-00	NT	0.01	0.01	4.59	0.01	NT	0.03
	Sept -00	NT	0.37	0.07	97.92	0.05	NT	0.14
	Dec.-00	NT	NT	0.01	5.14	0.02	NT	0.09
	Feb. –Mar 01	NT	0.05	0.02	0.50	NT	NT	0.05
Yamuna b/c Ganga	June-00	NT	NT	NT	NT	NT	NT	0.12
	Sept -00	NT	NT	0.01	7.90	NT	NT	NT
	Dec.-00	NT	NT	NT	0.55	0.01	NT	0.02
	Feb. –Mar 01	NT	0.03	NT	NT	NT	NT	0.10
Sangam	June-00	NT	0.01	0.01	4.83	0.02	NT	NT
	Sept -00	NT	0.19	0.03	35.54	NT	NT	0.06
	Dec.-00	NT	0.12	0.01	6.12	0.01	NT	0.02

	Feb. –Mar 01	NT	0.03	0.02	3.75	NT	NT	0.07
Ganga at Sirsa Ghat d/s-1/4	June-00	NT	0.02	0.01	3.16	0.01	NT	0.06
	Sept -00	NT	0.03	0.03	35.67	0.02	NT	0.07
	Dec.-00	NT	0.02	0.02	11.87	0.03	NT	0.06
	Feb. –Mar 01	NT	0.38	0.02	5.88	NT	NT	0.08
Ganga at Sirsa Ghat d/s-1/2	June-00	NT	NT	0.01	2.90	NT	NT	0.05
	Sept -00	-	-	-	-	-	-	-
	Dec.-00	NT	0.02	0.03	8.99	0.01	NT	0.11
	Feb. –Mar 01	NT	3.23	0.02	21.00	0.02	NT	0.06
Maximum of all		0	3.23	0.07	97.92	0.05	0	0.14
Minimum of all		0	0.01	0.01	0.50	0.01	0	0.02

- **Latest Status of Overall Quality of River Waters:**

During the in-depth study conducted by UPPCB (UP Pollution Control Board) in January 2002, attempts were made to assess the impact of the pollution being discharged into the rivers at Allahabad. With this view, following locations were covered:

(i) Ganga River near village Murhoo-Malakha: This point is located about 3 kms u/s of Rasoolabad Ghat along the left bank. Before this point, there is no discharge of sewage or other wastewater from Allahabad. This point represents truly the characteristics of river water before entering the city.
(ii) Ganga River at Pontoon bridge before Sangam. This point reflects the impact of wastewater from a number of drains.
(iii) Yamuna River upstream of the city (about 1 km. upstream of Balua-ghat). This point represents the characteristics of river water before entering the city.
(iv) Yamuna River before Sangam near the under-construction bridge near Minto park. This point reflects the impact of discharge of city sewage into it.
(v) River at Sangam.
(vi) Ganga River at Sirsa-ghat (30 km. d/s of the city). The point shows the final quality of river water after confluence and discharges of all types of drains, STP treated wastewater and industrial drains.

The results are expressed in Table 5.19 and expressed graphically also in Figure 5.12 and 5.13. A close scrutiny of the data confirms the observations made in the previous parameters, in respect of DO, BOD, TC, FC and heavy metals. In respect of physico-chemical properties as presented in Table 5.19, the quality of river water is confirming even the norms prescribed for drinking water.

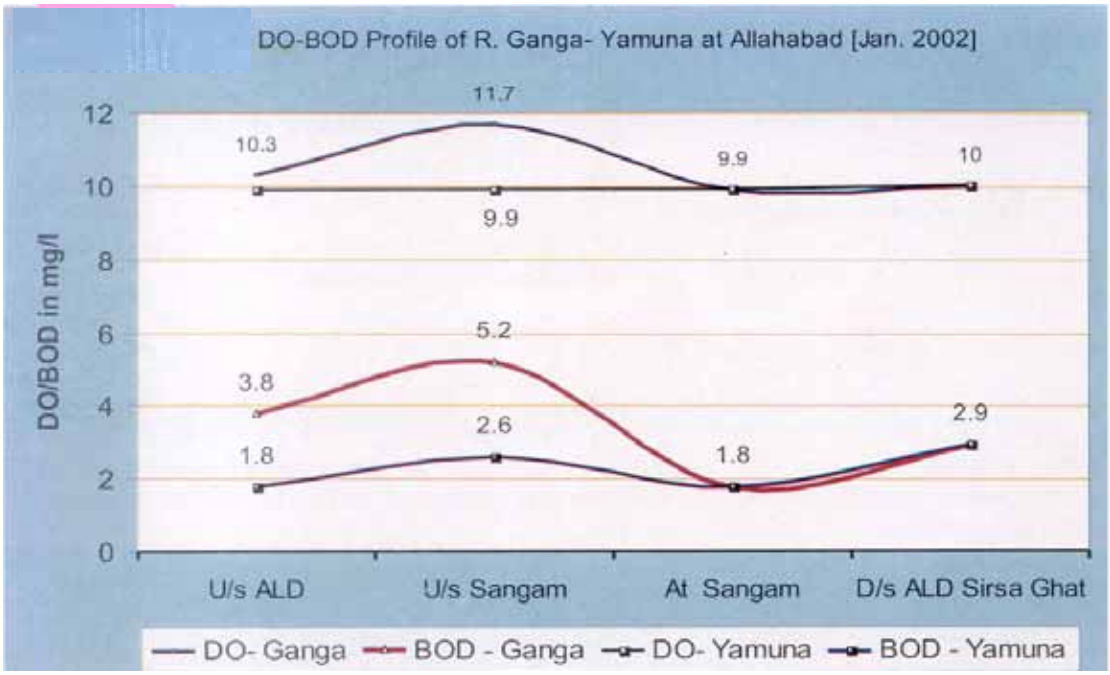


Figure 5.12 DO-BOD Profile of R. Ganga and Yamuna at Allahabad (Jan. 2002)

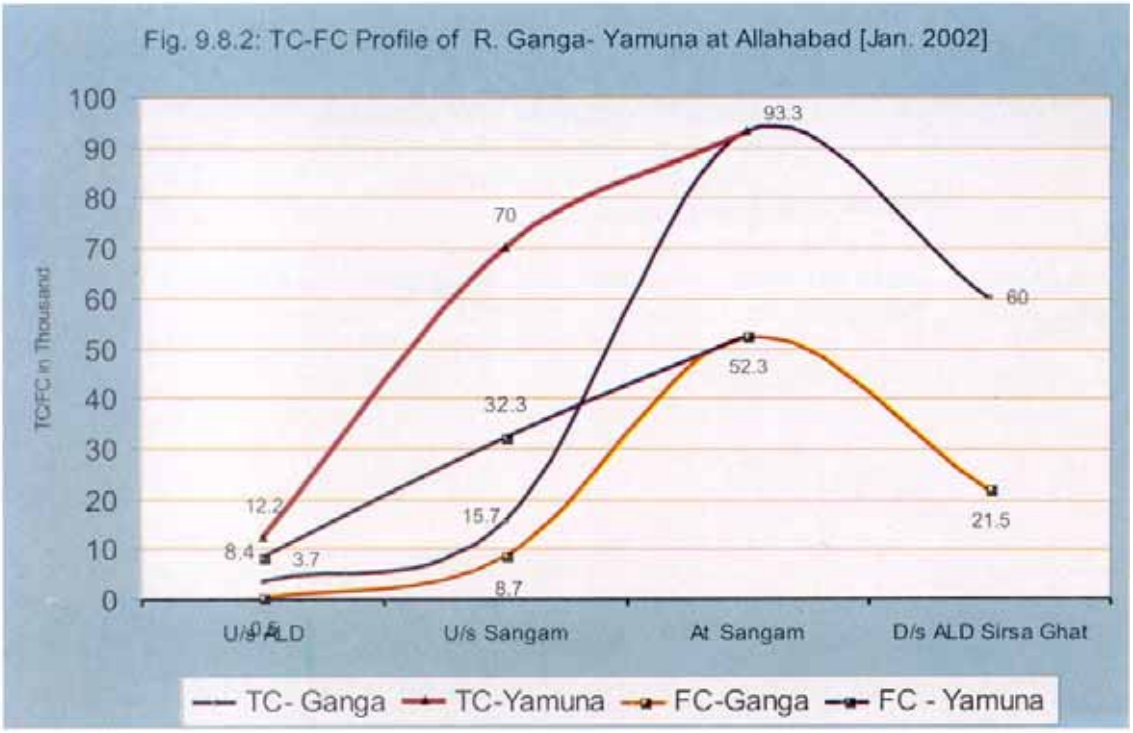


Figure 5.13 TC-FC Profile of Ganga and Yamuna River at Allahabad (Jan. 2002)

Table 5.19 Quality of River Water – Allahabad (January 2002) (1/3)

S. No.	Location		pH	Turb. NTU	Cond µmhos /cm	TDS m/l	SS m/l	Chlo m/l	Alk. m/l	T. Hard m/l	Ca++ m/l	Fluorides m/l	Sulph. m/l	Phos. m/l	NO_3-N m/l	NO_2-N m/l	TKN mg/
1	Ganga River u/s of Allahabad city	1/3rd from left Bank (LB)	8.25	3.5	336	350	31	23	212	186	49	0.31	49	0.15	3.17	0.09	0.30
		mid.	8.13	3.2	380	327	23	21	218	184	47	0.31	47	0.15	2.75	0.09	2.11
		1/3rd from Right Bank (RB)	8.11	3.3	340	330	22	20	216	182	43	0.31	47	0.18	2.74	0.08	1.51
2	Ganga River d/s of Allahabad city and u/s of Sangam	1/3rd from left Bank (LB)	8.06	7.8	348	330	76	21	210	178	48	0.31	50	0.19	2.87	0.08	0.90
		mid.	8.31	7.4	328	350	83	21	210	188	38	0.31	46	0.21	2.87	0.08	0.60
		1/3rd from Right Bank (RB)	7.95	8.2	321	350	70	20	208	178	43	0.30	44	0.19	2.77	0.08	6.03
3	Yamuna River u/s of Allahabad city	1/3rd from left Bank (LB)	8.14	2.3	444	409	7	43	260	204	43	0.35	52	0.12	1.54	0.05	1.51
		mid.	8.18	1.6	405	358	6	45	232	184	45	0.34	53	0.13	2.00	NT	1.21
		1/3rd from Right Bank (RB)	7.95	1.7	437	389	6	43	244	190	45	0.35	48	0.09	1.30	NT	0.30
4	Yamuna River d/s of Allahabad city and u/s of Sangam (just u/s of under –construction bridge)	1/3rd from left Bank (LB)	7.84	2.6	481	401	13	43	254	194	43	0.34	52	0.13	1.52	0.01	0.90
		mid.	7.83	2.2	448	417	12	45	244	192	45	0.35	52	0.08	1.3	0.01	0.30
		1/3rd from Right Bank (RB)	7.85	2.1	455	360	10	44	250	188	45	0.34	52	0.04	NT	0.01	0.60
5	Ganga River-Yamuna at Sangam	mid.	8.18	8.4	354	346	116	22	214	188	46	0.31	50	0.19	NT	0.08	0.60
6	Ganga River d/s of Allahabad city at Sirsa Ghat (approx. 30 kms away from Sangam)	1/3rd from left Bank (LB)	8.40	5.1	320	328	46	27	210	172	28	0.31	43	0.02	NT	0.02	3.62
		mid.	8.43	6.0	338	350	10	29	210	176	27	0.31	51	0.03	NT	0.03	4.22
		1/3rd from Right Bank (RB)	8.46	6.1	353	346	32	31	222	184	30	0.31	44	0.03	NT	0.03	6.63

Note : *(i) Turb. – Turbidity (i) Cond. – Conductivity (iii) TDS – Total Dissolved Solids (iv) SS – Suspended Solids (V) Chlo. – Chlorides (vi) Alk. – Alkalinity (vii) Sulph. – Sulphates (viii) Phos. – Phosphates*

Source : CPCB

Table 5.20 Quality of River Water – Allahabad (January 2002) (2/3)

S. No.	Location		DO mg/l	COD mg/l	BOD mg/l	TC MPN/100 ml	FC MPN / 100ml
1	Ganga River u/s of Allahabad city	1/3rd from left Bank (LB)	10.6	8	3.4	1.3×10^3	0.4×10^3
		mid.	10.0	8	4.0	8.0×10^3	0.3×10^3
		1/3rd from Right Bank (RB)	10.2	12	4.0	1.7×10^3	0.8×10^3
2	River Ganga d/s of Allahabad city and u/s of Sangam	1/3rd from left Bank (LB)	11.9	16	5.1	2.2×10^4	1.3×10^4
		mid.	11.5	12	5.1	8.0×10^3	5.0×10^3
		1/3rd from Right Bank (RB)	11.8	36	5.4	1.7×10^4	8.0×10^3
3	Yamuna River u/s of Allahabad city	1/3rd from left Bank (LB)	10.7	8	2.3	3.0×10^4	2.2×10^4
		mid.	9.4	8	1.7	5.0×10^3	2.3×10^3
		1/3rd from Right Bank (RB)	9.5	8	1.3	1.7×10^3	0.8×10^3
4	Yamuna River d/s of Allahabad city and u/s of Sangam (just u/s of under construction) bridge	1/3rd from left Bank (LB)	11.1	8	3.1	9.0×10^4	3.0×10^4
		mid.	9.4	44	2.3	9.0×10^4	5.0×10^4
		1/3rd from Right Bank (RB)	9.6	8	2.3	3.0×10^4	1.7×10^4
5	Ganga River-Yamuna at Sangam	mid stream	10.6	36	4.9	1.6×10^5	9.0×10^4
6	Ganga River d/s of Allahabad city at Sirsa Ghat (approx. 30 kms away from Sangam)	1/3rd from left Bank (LB)	10.0	15	2.7	2.4×10^4	9.3×10^3
		mid.	1.0	19	3.3	1.10×10^5	4.6×10^4
		1/3rd from Right Bank (RB)	**	15	2.7	4.6×10^4	9.3×10^3

Source : CPCB

Table 5.21 Quality of River Water – Allahabad (January 2002) (3/3)

S. No	Location		Cadmium mg/l	Chromium mg/l	Copper mg/l	Iron mg/l	Nickel mg/l	Lead mg/l	Zinc mg/l
1	Ganga River u/s of Allahabad city	1/3rd from left Bank (LB)	NT	NT	0.05	5.28	NT	NT	0.20
		mid.	NT	NT	0.08	4.85	NT	NT	0.13
		1/3rd from Right Bank (RB)	NT	NT	0.08	4.80	NT	NT	0.25
2	Ganga River d/s of Allahabad city and u/s of Sangam	1/3rd from left Bank (LB)	NT	NT	0.08	2.05	NT	NT	0.33
		mid.	NT	NT	0.08	23.25	NT	NT	0.45
		1/3rd from Right Bank (RB)	NT	NT	0.08	22.90	NT	NT	0.30
3	Yamuna River u/s of Allahabad city	1/3rd from left Bank (LB)	NT	NT	0.08	2.35	NT	NT	0.25
		mid.	NT	NT	0.05	2.60	NT	NT	0.23
		1/3rd from Right Bank (RB)	NT	NT	0.05	2.65	NT	NT	0.28
4	Yamuna River d/s of Allahabad city and u/s of Sangam (just u/s of under –construction bridge)	1/3rd from left Bank (LB)	NT	NT	0.05	3.25	NT	NT	0.33
		mid.	NT	NT	0.05	0.23	NT	NT	0.18
		1/3rd from Right Bank (RB)	NT	NT	0.03	2.25	NT	NT	0.18
5	Ganga River-Yamuna at Sangam	mid.	NT	NT	0.08	27.15	NT	NT	0.30
6	Ganga River d/s of Allahabad city at Sirsa Ghat (approx. 30 kms away from Sangam)	1/3rd from left Bank (LB)	NT	NT	0.08	10.88	NT	NT	0.53
		mid.	NT	NT	0.13	15.1	NT	NT	1173
		1/3rd from Right Bank (RB)	NT	NT	0.08	11.83	NT	NT	0.60

Note : (i) Turb. – Turbidity (i) Cond. – Conductivity (iii) TDS – Total Dissolved Solids (iv) SS – Suspended Solids (v) Chlo. – Chlorides (vi) Alk. – Alkalinity (vii) Sulph. – Sulphates (viii) Phos. – Phosphates
Source : CPCB

(5) Primary Data Collection

Water Sampling Location

Representative samples of groundwater as well surface water were collected from within the study area and analysed. At present, the sewage of the city is flowing into the Ganga and Yamuna Rivers through unlined natural drains. This arrangement is polluting the surface waters and in addition, is also likely to have adverse impacts on the underground water reserves. Regarding the underground waters, the shallow aquifer is most prone to contamination. Therefore, water samples from shallow wells and