STATUS PAPER ON RIVER GANGA

State of Environment and Water Quality

National River Conservation Directorate
Ministry of Environment and Forests

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National River Conservation Directorate
Ministry of Environment and Forests
Government of India

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Alternate Hydro Energy Centre
Indian Institute of Technology Roorkee

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1.0 INTRODUCTION

India is endowed with rich water resources. Approximately 45,000 km long riverine systems criss-cross the length and breadth of the country. India has 12 major river basins, 46 medium river basins and 14 minor and desert river basins. Ganga river basin is the largest of these, extending over the states of Uttarakhand, Uttar Pradesh, Haryana, Himachal Pradesh, Delhi, Bihar, Jharkhand, Rajasthan, Madhya Pradesh, Chhattisgarh and West Bengal.

Rapidly increasing population, rising standards of living and exponential growth of industrialization and urbanisation have exposed the water resources, in general, and rivers, in particular, to various forms of degradation. Many Indian rivers, including the Ganga in several stretches, particularly during lean flows, have become unfit even for bathing. Realising that the rivers of the country were in a serious state of degradation, a beginning towards their restoration was made with the launching of the Ganga Action Plan (GAP) in 1985.

2.0 GANGA BASIN

Ganga drains a basin of extraordinary variation in altitude, climate, land use and cropping pattern. Ganga has been a cradle of human civilization since time immemorial. It is one of the most sacred rivers in the world and is deeply revered by the people of this country.

The Ganga basin lies between East longitudes 73°30 and 89° 0 and North latitudes of 22°30 and 31°30, covering an area of 1,086,000 sq km, extending over India, Nepal and Bangladesh. It has a catchment area of 8,61,404 sq. km in India, constituting 26% of the country's land mass and supporting about 43% of population (448.3 million as per 2001 census).

Ganga has many tributaries, both in the Himalayan region before it enters the plains at Haridwar and further downstream before its confluence with the Bay of Bengal. December-May are the lean flow months. The surface water resource potential of Ganga has been assessed as 525 billion cubic meters (BCM). Substantial abstraction of water for various purposes including irrigation, power generation and drinking water has impacted the quantity of flows in the river, particularly in the stretch between Kannauj and Allahbad.

3.0 GANGA ACTION PLAN (GAP)

The Ganga Action Plan was launched in 1985 with the objective of pollution abatement to improve the water quality in the river. The programme included 261 schemes spread over 25 Class I towns of U.P., Bihar and West Bengal. The main focus of the Plan was on Interception & Diversion and treatment of sewage generated from these identified towns. 34 Sewage Treatment Plants (STPs) with a treatment capacity of 869 mld have been set up under the Plan. GAP I was completed in March 2000 at a cost of Rs. 452 crores.

GAP II was started in 1993. It covers 59 towns located along the river in the five states of Uttarakhand, U.P, Jharkhand, Bihar and West Bengal. 319 schemes have been taken up under the Plan, out of which 200 have been completed. An expenditure of Rs. 370.40 crore has been incurred so far and sewage treatment capacity of 130 mld has been created.

GAP II was expanded in 1996 into the National River Conservation Plan (NRCP), which presently covers polluted stretches of 36 rivers in 20 States in the country.

4.0 STATUS OF WATER QUALITY OF GANGA RIVER

The Ganga river water quality evaluated on the basis of pollution indicators (DO, BOD and coliform) indicates that dissolved oxygen levels have improved in the main stem of Ganga. The values are mostly above the recommended value of 5.0 mg/l, except in the stretch between Kannauj and Kanpur where values below 5.0 mg /l have been noticed on several occasions. BOD values are also within stipulated limits in the upper and lower reaches of the Ganga but tend to be higher than 5.0 mg /l in the middle stretch from Kannauj to Varanasi. This can be described as the critical stretch.

The faecal coliform remains the only parameter on which the observed values exceed the permissible limits of 2500 MPN/100 ml at most places except in the upper reaches up to Haridwar.

Despite the problems of operation and maintenance, the river water quality shows discernible improvement (in terms of DO and BOD) over the pre-GAP period. This should be seen in the background of a steep increase in population with concomitant increase in organic pollution load.

5.0 CRITICAL ANALYSIS OF GAP

The success of GAP has been in preventing further deterioration of water quality, generally maintaining it and improving it in some places, even though the pollution load draining into the river has substantially increased due to population growth, rapid industrialization and urbanization. It can be inferred that if the pollution abatement programme had not been implemented there would have been an inevitable deterioration in the quality of river water posing threat to public health and ecology. A positive outcome of the programme has been an increased public awareness of the need to protect our rivers.

6.0 FUTURE COURSE OF ACTION

Recognising the need to revamp the river conservation strategy, the Central Government has given Ganga the status of a 'National River' and has set up the National Ganga River Basin Authority (NGRBA) on 20th February 2009. It is an empowered planning, financing, monitoring and coordinating Authority for effective abatement of pollution and conservation of the river. The Authority would adopt a comprehensive and holistic approach for conserving the river Ganga with river basin as the unit of planning. The Authority would seek to maintain minimum ecological flows besides implementing pollution abatement activities.

01 Introduction

India is endowed with rich water resources. Approximately 45,000 km long riverine systems criss-cross the length and breadth of the country. These rivers include Himalayan snow fed rivers, peninsular rain fed rivers and coastal short rapids.

The total geographical area of 3.29 millon square km of the country has been divided in to 12 major river basins, 46 medium river basins and 14 minor and desert river basins. The major river basins account for 78% of total surface area and serve 80% of the population. The Ganga river basin is the largest of these, extending over the states of Uttarakhand, Uttar Pradesh, Haryana, Himachal Pradesh, Delhi, Bihar, Jharkhand, Rajasthan, Madhya Pradesh, Chhattisgarh and West Bengal.

Rapidly increasing population, rising standards of living and exponential growth of industrialisation and urbanisation have exposed the water resources, in general, and rivers, in particular, to various forms of degradation. The deterioration in the water quality of the river impacts the people immediately. Many Indian rivers, including the Ganga in some stretches, particularly during lean flows, have become unfit even for bathing.

Realising that the rivers of the country were in a serious state of degradation, a beginning towards their restoration was made with the launching of the Ganga Action Plan in 1985. It was envisaged as a comprehensive programme of river conservation with the objective of improving the water quality. It was visualised that in due course, the programme would be enlarged to cover other major rivers of the country.

In order to prepare such a major programme, an exhaustive study titled “Assessment and Development Study of River Basin Series” (ADSORBS) of the Ganga Basin was carried out by the Central Pollution Control Board (CPCB). The study covered all aspects of rivers in the Ganga basin including water quality. The study pointed out that besides pollution from municipal and industrial wastes, non-point sources like run off from rural settlements, pesticides from agricultural fields, open defecation, dumping of carcasses and disposal of dead bodies significantly contribute to pollution of the river and render the water unsuitable for its intended use.

Equally important is the issue of flow in the River. Dams and barrages for storing and diverting water for irrigation, domestic consumption and industry, affect the flow, particularly during dry months. This has serious implications for water quality and aquatic life in the river.

The Ganga Action Plan Phase I (GAP I) was started in 1985 to improve the water quality of river Ganga to acceptable standards by preventing the pollution load reaching the river. The main focus of the Plan was on interception, diversion and treatment of municipal sewage draining into the river, which accounted for about 75% of river pollution. Treatment capacity of 869 million liters per day (MLD) was created in 25 Class-I towns in the three States of Uttar Pradesh, Bihar and West Bengal. In addition to the core works relating to sewerage and sewage treatment, certain non-core works like afforestation, crematoria, low cost sanitation and river front development, were also taken up.

Under GAP I, only a part of the pollution load of river Ganga was addressed. Therefore, the Plan was extended to GAP II, which was approved in stages between 1993 and 1996. Besides Ganga, GAP II included its major tributaries viz. Yamuna, Gomti and Damodar. Subsequently, Mahananda was also added. 59 towns along the main stem of river Ganga in the 5 States of Uttarakhand, UP, Bihar, Jharkhand and West Bengal are covered under GAP II. A sewage treatment capacity of 130 MLD has been created under the Plan.

In response to demands from many States, the Ganga Action Plan was expanded in 1996 to the National River Conservation Plan (NRCP) to include other rivers in the country. Presently polluted stretches of 36 rivers in 20 States are covered under NRCP.

02 Ganga Basin

2.1 BACKGROUND

The Himalayas are the source of three major Indian rivers namely the Indus, the Ganga and the Brahmaputra. Ganga drains a basin of extraordinary variation in altitude, climate, land use, flora and fauna, social and cultural life.

Ganga has been a cradle of human civilization since time immemorial. Millions depend on this great river for physical and spiritual sustenance. People have immense faith in the powers of healing and regeneration of the Ganga. It is one of the most sacred rivers in the world and is deeply revered by the people of this country. The River plays a vital role in religious ceremonies and rituals. To bathe in Ganga is a lifelong ambition of many who congregate in large numbers for several river centered festivals such as Kumbh Mela and numerous Snan (bath) festivals.

2.2 LOCATION

Ganga basin is the largest river basin in India in terms of catchment area, constituting 26% of the country's land mass (8,61,404 Sq. km) and supporting about 43% of its population (448.3 million as per 2001 census). The basin lies between East longitudes 73°30 and 89° 0 and North latitudes of 22°30 and 31°30, covering an area of 1,086,000 sq km, extending over India, Nepal and Bangladesh. About 79% area of Ganga basin is in India. The basin covers 11 states viz., Uttarakhand, U.P., M.P., Rajasthan, Haryana, Himachal Pradesh, Chhattisgarh, Jharkhand, Bihar, West Bengal and Delhi. The drainage area in each state is given in Table 2.1.

Table 2.1: State Wise Distribution of Drainage Area of the Ganga River in India

(Source: CWC publication no. 50/89 “Major River Basins of India - An Overview” - April 1989)

State	Drainage area (km^2)
Uttarakhand and Uttar Pradesh	294,364
Madhya Pradesh and Chhattisgarh	198,962
Bihar and Jharkhand	143,961
Rajasthan	112,490
West Bengal	71,485
Haryana	34,341
Himachal Pradesh	4,317
Delhi	1,484
Total	**861,404**

2.3 CLIMATE

The annual average rainfall in the basin varies between 39 cm to 200 cm, with an average of 110 cm. Eighty percent of the rainfall occurs during the monsoon months i.e. between June and October. Because of large temporal variations in precipitation over the year, there is wide fluctuation in the flow characteristics of the river.

2.4 COURSE OF GANGA

Bhagirathi is the source stream of Ganga. It emanates from Gangotri Glacier at Gaumukh at an elevation of 3,892 m (12,770 feet). Many small streams comprise the headwaters of Ganga. The important among these are Alaknanda, Dhauliganga, Pindar, Mandakini and Bhilangana. At Devprayag, where Alaknanda joins Bhagirathi, the river acquires the name Ganga. It traverses a course of 2525 km before flowing into the Bay of Bengal. It has a large number of tributaries joining it during this journey (Figure 1).

In Uttarakhand, near Tehri, a dam, has been built on Bhagirathi for hydropower generation resulting in regulated additional water during the dry months. At Haridwar, Ganga opens to the Gangetic Plains, where a barrage diverts a large quantity of its waters into the Upper Ganga Canal, to provide water for irrigation. At Bijnore, another barrage diverts water into the Madhya Ganga Canal but only during monsoon months. At Narora, there is further diversion of water into the Lower Ganga Canal.

Further down, River Ramganga joins Ganga near Kannauj, adding additional water to the river. Yamuna confluences Ganga at the Sangam in Allahabad, making a major contribution to the river flow. Beyond Allahabad, Ganga is joined by several tributaries, most of which are from the north and a few from the south. In the stretch between Allahabad in U.P. and Malda in West Bengal, Ganga, therefore, has considerable flow. The Farakka barrage in West Bengal regulates the flow of the river, diverting some of the water into a feeder canal linking Hooghly to keep it relatively silt-free. Downstream of this barrage, River Ganga splits into two, Bhagirathi (Hooghly) on the right and Padma on the left. Bhagirathi (Hooghly) meets the Bay of Bengal about 150 km downstream of Kolkata. Padma enters Bangladesh and meets river Brahmputra and Meghna before finally joining the Bay of Bengal.

2.5 HYDROLOGY OF GANGA BASIN

Rainfall, subsurface flows and snow melt from glaciers are the main sources of water in river Ganga. Surface water resources of Ganga have been assessed at 525 billion cubic meter (BCM). Catchment area, annual yield of water and mean flow of tributaries of Ganga are given in *Annexure-I*. Out of its 17 main tributaries, Yamuna, Sone, Ghagra and Kosi contribute over half of the annual water yield of the Ganga. These tributaries meet the Ganga at Allahabad and further downstream. The river has a problem of low flows between the Haridwar - Allahabad stretch, as may be seen from Figures 2 and 3.

December to May are the months of lean flow in the Ganga. The lean flow during these months, at some important towns along the river Ganga, is shown in Figure 4.

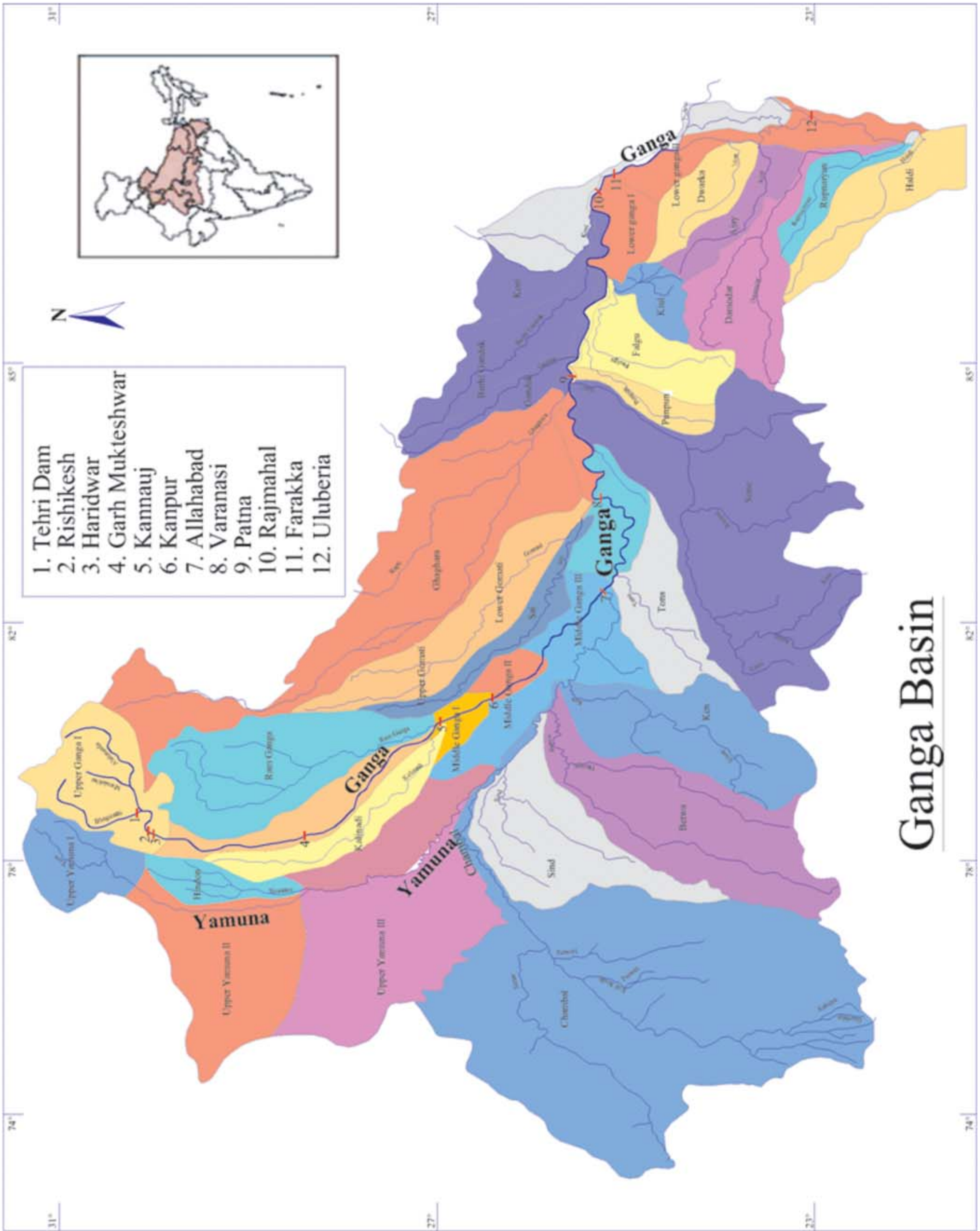


Fig. 1: Ganga Basin

Fig. 2 : Mean Discharge Seasonal

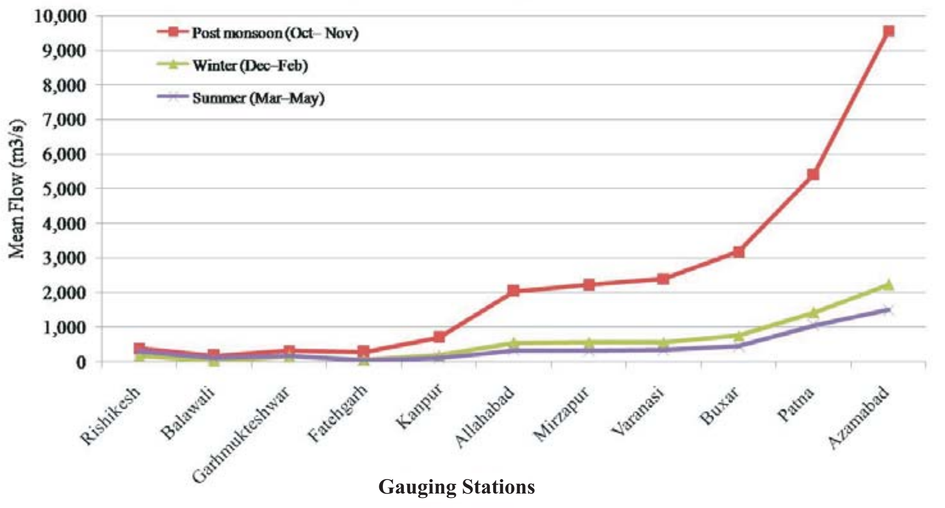


Fig. 3 : Seasonal Flow Variation

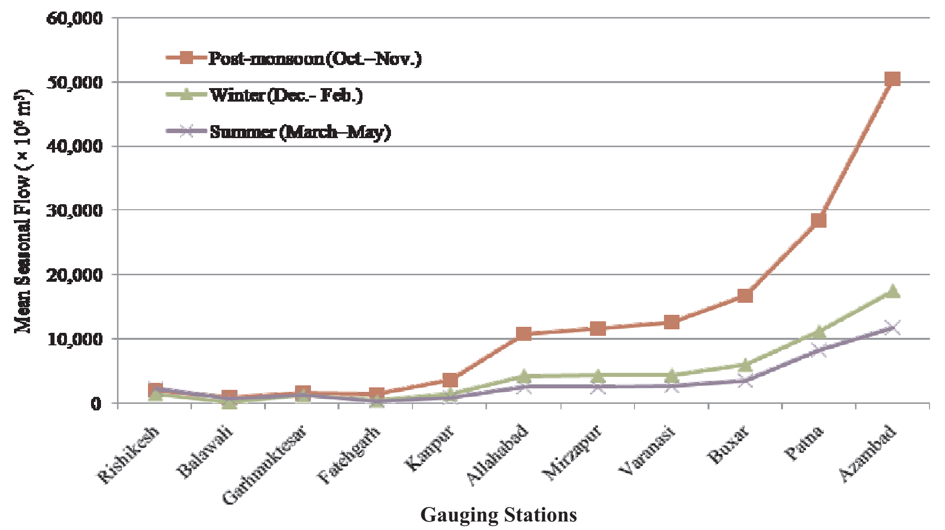
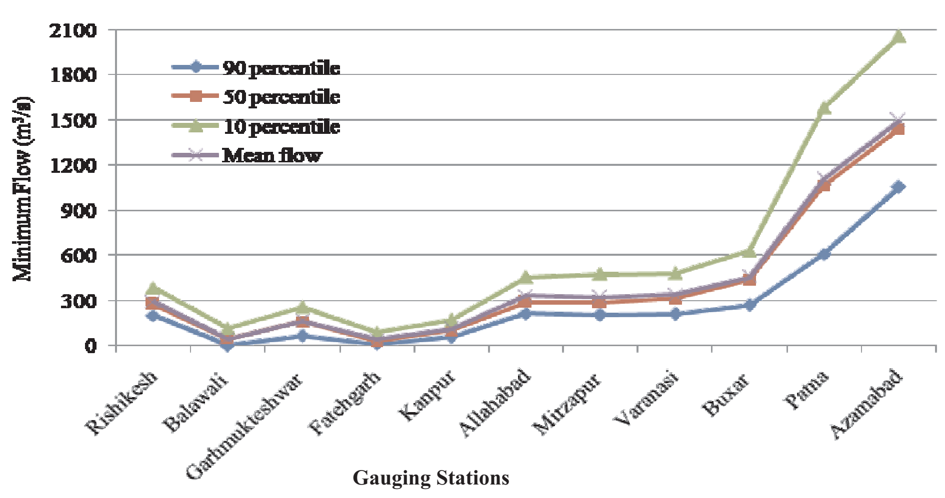


Fig. 4 : Lean Flow in Ganga during summers



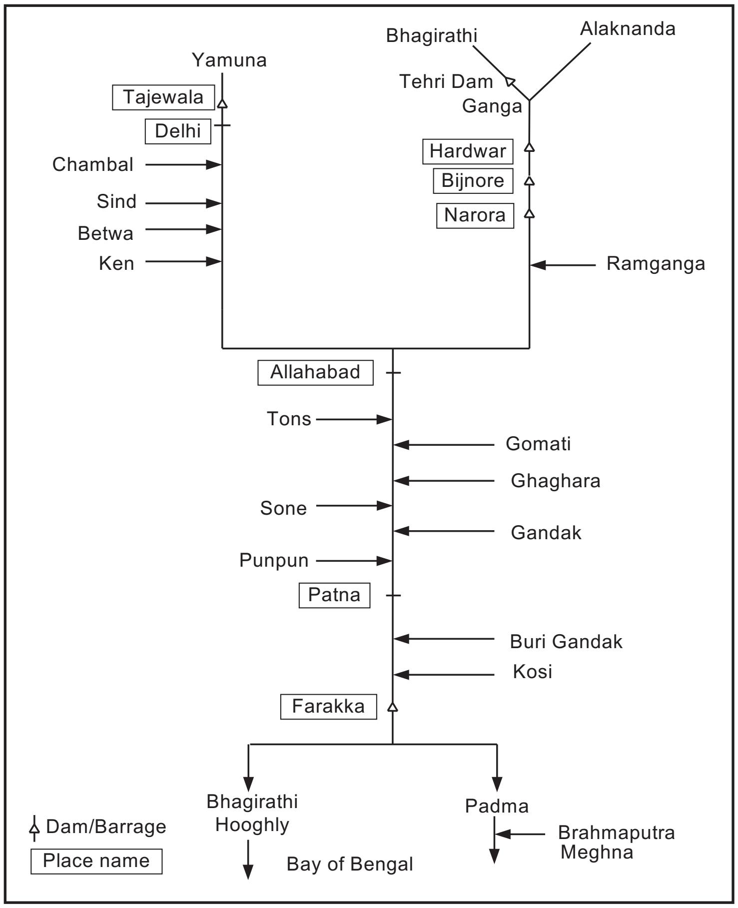


Fig. 5: Line diagram of Ganga with its major tributaries and water management structures

The average annual flow at various gauging stations and in major tributaries is shown in the line diagram in Fig. 5. The tributaries joining Ganga from the south are shown on the left of the diagram and those joining it from the north are shown on the right side.

On an average, each square km of the Ganga basin receives a million cubic meter (MCM) of water as rainfall. 30% of this is lost as evaporation, 20% seeps to the subsurface and the remaining 50% is available as surface runoff. The deep channel of the river bounded by high banks facilitates the passage of ground water as base flow. Annual flooding is the characteristic of all rivers in the Ganga basin. The Ganga rises during the monsoon but the high banks restrict the flood water from spreading. The flood plain is usually 0.5 to 2 km wide. This active flood plain is flooded every year. There are many structures on the Ganga which divert its discharge. Major Water Resources Development Projects on the river are given in *Annexure-II*.

2.6 PHYSIOGRAPHIC ASPECTS OF GANGA BASIN

Structurally, the Ganga basin comprises of three large divisions of the Indian subcontinent, namely: the Himalayan fold mountains and the Central Indian highlands, the Peninsular shield, and the Gangetic plain. The Himalayan Fold Mountains include numerous snow peaks rising above 7000 meters. Each of these peaks is surrounded by snow fields and glaciers. All the tributaries are characterised by well regulated flows and assured supply of water throughout the year. The Gangetic plain, in which the main stem of Ganga lies, consists of alluvial formation and is a vast flat depositional surface at an elevation below 300 meters.

2.7 SOIL CHARACTERISTICS OF GANGA BASIN

The Ganga basin consists of a wide variety of soils. While soils of the high Himalayas in the north are subject to continuous erosion, the Gangetic plain provides a huge receptacle into which thousands of meters of thick layers of sediments have been deposited to form a wide valley plain. The Deccan plateau in the south has a mantle of residual soils of varying thickness arising out of weathering of ancient rocks of the peninsular shield. Some of the soils are highly susceptible to erosion. Mountain soils, submontane soils and alluvial soils, covering 58 % of the basin area, have very high erodibility; red soils covering 12% of the basin area have high erodibility, red & yellow soils and mixed red and black soils covering an area of 8% have moderate erodibility, and deep black soils and medium black soils covering an area of 14% have low erodibility. Shallow black soils and lateritic soils covering an area of 6% have very low erodibility.

Broadly, it can be said that soils in Haryana, Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal, through which the main stem of Ganga and all its tributaries flow, have very high erodibility.

2.8 DEMOGRAPHY OF GANGA BASIN

Demography has an important bearing on the state of the river as it is significantly affected by the population living within the basin. Average population density in the Ganga basin is 520 persons per square km as against 312 for the entire country (2001 census). Major cities of Delhi, Kolkata, Kanpur, Lucknow, Patna, Agra, Meerut, Varanasi and Allahabad are situated in the basin. The cities in the basin have large and growing populations and a rapidly expanding industrial base. The summary of urban population in the basin is given in Table 2.2. It can be seen that between 1991 and 2001, urban population increased by 32%. This trend is likely to continue. The pollution load is also expected to increase correspondingly.

Table 2.2: State-wise Number of Cities/Towns and Estimated Population

S. No	State	No of towns/ cities	Urban population 1991	Urban population 2001
1.	Bihar (including Jharkhand)	130	6,715,096	8,681,800
2.	Haryana	106	4,054,744	6,115,304
3.	Himachal Pradesh	57	449,196	595,581
4.	Madhya Pradesh (including Chhattisgarh)	394	12,152,967	15,967,145
5.	Rajasthan	222	10,077,371	13,200,000
6.	Uttar Pradesh	704	27,544,233	34,539,582
7.	Uttarakhand	86		2,179,074
8.	West Bengal	373	18,707,601	22,427,251
9.	Delhi	1	8,471,625	12,905,780
	Total	2073	88,172,833	116,611,517

03 Ganga Action Plan

To prevent the pollution of river Ganga and to improve its water quality, an Action Plan known as Ganga Action Plan was formulated in the year 1984 on the basis of a comprehensive survey of the Ganga Basin carried out by the Central Pollution Control Board under "Assessment and Development Study of River Basin Series (ADSORB)".

3.1 OBJECTIVES OF GANGA ACTION PLAN (GAP)

The objective, at the time of launching the Ganga Action Plan in 1985, was to improve the water quality of Ganga to acceptable standards by preventing the pollution load from reaching the river. Later, in 1987, on the recommendations of the Monitoring Committee of GAP, the objective of the Plan was modified to restoring the river water quality to the Designated Best Use class of Ganga, which is "Bathing Class" (Class B). The standards of water quality for Class B are given in the following box.

The classification of designated best use of inland surface water as stipulated by CPCB is given in Table 3.1.

3.2 APPROACH OF GANGA ACTION PLAN (GAP)

Studies undertaken before the formulation of the Ganga Action Plan indicated that a large proportion of pollution load in the river came from the municipal wastewater generated in 25 Class I towns located on the banks of the Ganga, each with a population exceeding one lakh. Therefore, the emphasis under the Plan was on interception and diversion of wastewater and its treatment in Sewage Treatment Plants, before discharge into river or on land. In addition, works were also undertaken to prevent pollution of the river from non-point sources, improving aesthetics, and promoting public participation. The various types of schemes taken up under GAP are categorized into core and non-core schemes.

WATER QUALITY STANDARDS FOR OUT DOOR BATHING (CLASS B)

pH	:	6.5 – 8.5
Dissolved Oxygen (DO)	:	5 mg/l or more
Biochemical Oxygen Demand (BOD)	:	3 mg/l or less
Faecal Coliform	:	500 MPN / 100 ml (Desirable) 2500 MPN/100 ml (Max. Permissible)

Table 3.1 The Designated Best Use Classification of Inland Surface Water

Source: CPCB

Class	Designated Best Use (DBU)	CRITERIA	
A	Drinking Water Source without conventional treatment but after disinfection	pH Dissolved Oxygen (DO) Biochemical Oxygen Demand (BOD) Total Coliform	6.5 to 8.5 6 mg/l or more 2 mg/l or less 50 MPN/100 ml
B	Outdoor bathing (Organised)	pH Dissolved Oxygen (DO) Biochemical Oxygen Demand (BOD) Total Coliform	6.5 to 8.5 5 mg/l or more 3 mg/l or less 500 MPN/100 ml
C	Drinking Water Source with Conventional treatment followed by disinfection	pH Dissolved Oxygen (DO) Biochemical Oxygen Demand (BOD) Total Coliform	6.5 to 8.5 4 mg/l or more 3 mg/l or less 5000 MPN/100 ml
D	Propagation of wild life and fisheries	pH Dissolved Oxygen (DO) Free Ammonia	6.5 to 8.5 4 mg/l or more 1.2 mg/l
E	Irrigation, industrial cooling and controlled waste disposal	pH Electrical Conductivity Sodium absorption ratio Boron	6.5 to 8.5 2250 mhos/cm 26 2 mg/l

Core Schemes :

- Interception and diversion (I&D) of sewage, reaching the Ganga river.
- Installing treatment facilities to treat the intercepted sewage.

Non Core Schemes :

- Providing facilities of Low Cost Sanitation (LCS) at community and individual levels at identified locations.
- Installation of Crematoria (electric as well as wood based improved crematoria).
- River Front Development (RFD) including bathing ghats.
- Afforestation
- Public awareness and participation.

3.3 INSTITUTIONAL ARRANGEMENTS

An apex body, namely the Central Ganga Authority, (CGA) was set up under the Chairmanship of the Prime Minister to finalize the policy framework and to coordinate and oversee the implementation of the Action Plan.

A Steering Committee was constituted with Secretary, Ministry of Environment and Forests as Chairman to consider approval of schemes, allocation of funds and to review progress. A Monitoring Committee was also constituted to monitor progress of implementation of schemes.

The Ganga Project Directorate (GPD), with the necessary financial and administrative powers, was set up as a part of the Ministry of Environment and Forests to implement the Action Plan.

GAP II was merged with the National River Conservation Plan (NRCP) in 1996. The NRCP presently covers polluted stretches of 36 rivers spread over 165 towns in 20 States.

3.4 GANGA ACTION PLAN PHASE I (GAP I)

Under GAP I, pollution abatement schemes were taken up in 25 Class-I towns in three States of U.P., Bihar and West Bengal. GAP I was declared complete on 31.03.2000 with an expenditure of Rs. 452 crore. The details are given below:

States Covered	:	3 (UP, Bihar and West Bengal)
Towns Covered	:	25 (UP-6, Bihar-4 and West Bengal-15)
Schemes Sanctioned	:	261
Schemes Completed	:	260
Interception and Diversion	:	88
Sewage Treatment Plants	:	34
Low Cost Sanitation	:	43
Crematoria	:	28
River Front Development	:	35
Others (afforestation)	:	32
Sewage Treatment Capacity to be Created	:	882 MLD (35 STPs)
Sewage Treatment Capacity Created	:	869 MLD (34 STPs)
Total expenditure incurred	:	Rs. 452 Crores.

3.5 GANGA ACTION PLAN PHASE II (GAP II)

As GAP I addressed only a part of the pollution load of Ganga, GAP II was launched in stages between 1993 and 1996. 59 towns along the main stem of river Ganga in five States of Uttarakhand, U.P., Jharkhand, Bihar and West Bengal are covered under the Plan. The salient features of the Plan are as under:

States Covered	:	5 (Uttarakhand, UP, Bihar, Jharkhand and West Bengal)
Towns Covered	:	59 (Uttarakhand-10, UP-12, Bihar-13, Jharkhand-1, West Bengal-23)
Schemes Sanctioned	:	319
Schemes Completed	:	200
Sewage Treatment Capacity to be Created	:	277.28 MLD (37 STPs)
Sewage Treatment Capacity Created	:	129.77 MLD (18 STPs)

3.6 INDUSTRIAL POLLUTION

Though industrial pollution constitutes around 20% of the total pollution load by volume, its contribution to polluting the river Ganga is much greater, due to the higher concentration of pollutants. This problem was sought to be addressed by focusing on Grossly Polluting Industries. Any industrial unit, discharging into the river effluent having BOD load of 100 kg/day or more, and/or is involved in the manufacture and use of hazardous substances, is classified as grossly polluting. Such units were identified and asked to install Effluent Treatment Plants.

Presently, 154 grossly polluting industrial units are identified on the main stem of River Ganga. Of these, 94 units have Effluent Treatment Plants (ETPs) operating satisfactorily, 22 have ETPs but they do not operate satisfactorily and 38 Units have closed down. The total number of grossly polluting units along river Ganga and its tributaries is 478. Of these, 335 units have ETPs operating satisfactorily, while in 64 units ETPs do not operate satisfactorily and 79 units have been closed down.

04

Water Quality Status of Ganga River

Water quality monitoring is undertaken with the objective of defining the status of water quality. It also provides an idea of the trend in water quality. It is a long term and standardized assessment. The primary uses considered for such characterization relate to drinking water, safety of human contact and health of ecosystems.

Before the launching of GAP, a comprehensive study of water quality in Ganga River Basin was undertaken by CPCB (at 39 stations between Rishikesh and Diamond Harbour). Under GAP, Water Quality Monitoring is a regular activity. This is being done at 27 Monitoring Stations. Though 21 water quality parameters were identified by NRCD, the emphasis is on parameters which indicate the quality criteria for Designated Best Use viz. pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and indictor bacteria coliform (faecal coliform).

This monitoring is being carried out through reputed scientific institutes/universities situated along the river and having the necessary infrastructure and capability to undertake this work. Nine core parameters and site specific heavy metals are monitored on a monthly basis. Performance monitoring of sewage treatment plants is also undertaken. A 'Protocol for Water Quality Monitoring' notified by the Water Quality Assessment Authority is being followed for achieving uniformity in monitoring of surface & ground water by all agencies in the country.

The authenticity and reliability of water quality data is ensured through an exercise of Analytical Quality Control (AQC) with the help of Central Pollution Control Board. A water quality monitoring bulletin is published at regular intervals for information and corrective measures.

4.1 PRE-GAP STATUS

4.1.1 Dissolved Oxygen (DO)

During the pre-GAP period, DO values exhibited a more or less stable pattern in Ganga. The average values ranged between 6.8-7.2 mg/l. The values were generally above 4.0 mg/l. Higher values were recorded in winters at Haridwar, Allahabad, Varanasi and Patna. There were only minor fluctuations.

4.1.2 Biochemical Oxygen Demand (BOD)

BOD depicts the pollution status of a stream and is measured as oxygen equivalent of organic matter. The values exhibited higher pollution level during post monsoon months than in summers and winters. The BOD levels were higher at Kannauj and downstream upto Varanasi. The pattern of variation, spatial and temporal, was not smooth. Maximum values were recorded at Kanpur downstream [15.5 mg/l, 14.15 mg/l, 16.39 mg/l (post-monsoon, winter and summers)]. Minimum values of less than 3 mg/l were recorded in the hilly stretches and downstream of Patna, except at Diamond Harbour where value of 15.58 mg/l was recorded in summer.

4.1.3 Coliform

The variation in total coliforms was 48333, 916667 and 835333 MPN/100 ml (post monsoon, winter and summer) at Uluberia with minimum levels at Haridwar (43, 2400, 2400). As expected, the counts were higher in summers compared to those in post-monsoon and winter seasons.

The data at 16 monitoring stations during the pre-GAP period is given in *Annexure-III.* The graphic representation is given in Figure 6.

The pre GAP status of ambient water quality along different zones of the River Ganga as per CPCB's classification of 'Designated Best use' is summarized in Table 4.1 and Table 4.2.

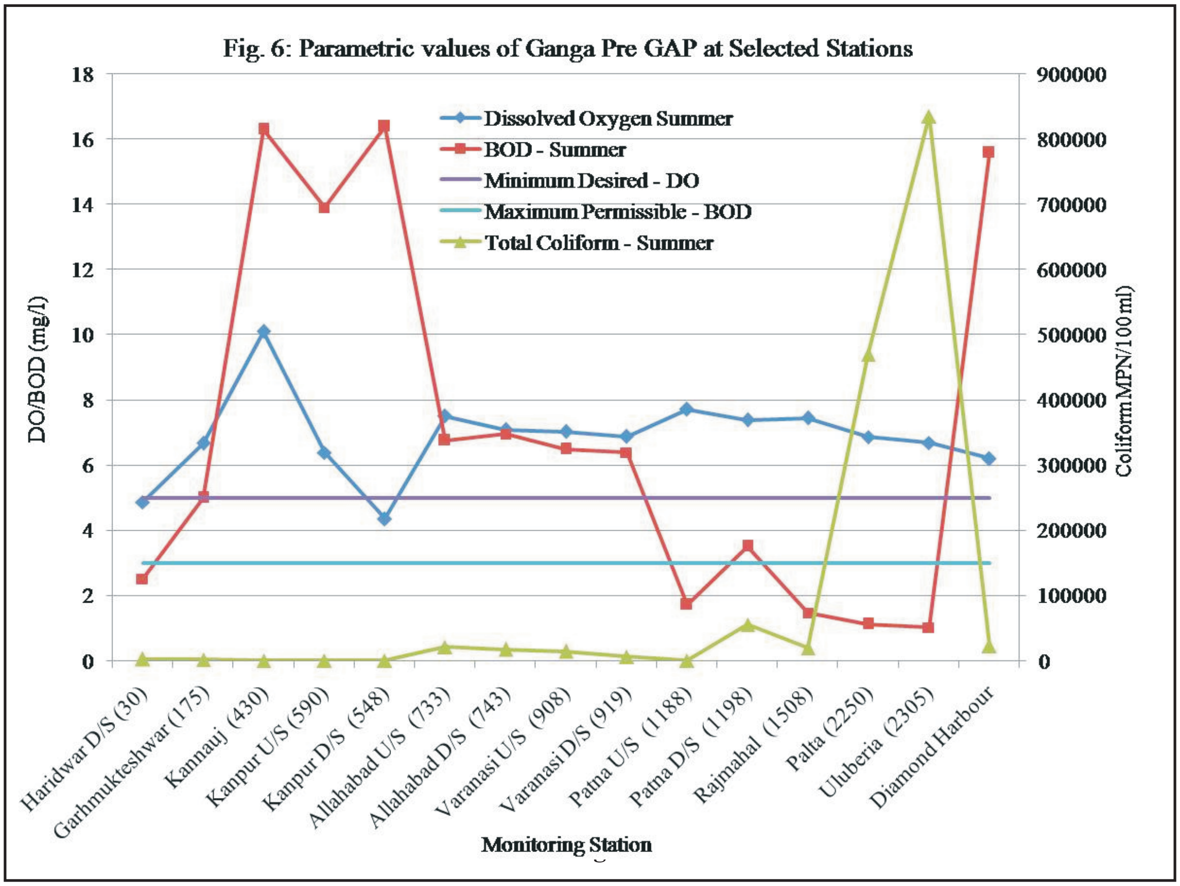


Table 4.1 Status of Ambient Water Quality Along Different Zones of the Ganga

Monitoring Stations		Total Coliform	DO Status	BOD Status	Over all water quality
Uttarakhand	Rishikesh	C	B	B	B
	Haridwar	C	C	D	C
UP	Garhmukteswar	C	C	D	C
	Kannauj	D	B	D	C
	Kanpur u/s	D	C	D	D
	Kanpur d/s	D	D	D	D
	Allahabad u/s	D	A	D	D
	Allahabad d/s	D	A	D	D
	Mirzapur	D	A	D	D
	Varanasi u/s	D	A	D	D
	Varanasi d/s	D	A	D	D
Bihar	Buxar	D	A	B	C
	Patna u/s	D	A	C	C
	Patna d/s	D	A	B	C
	Munger	D	B	C	C
	Bhagalpur	D	A	B	C
	Rajmahal	D	A	B	C
West Bengal	Farakka	D	A	A	C
	Nabadwip	D	A	A	C
	Kalyani	D	B	D	D
	Palta	D	A	B	D
	Uluberia	D	B	D	D
	Diamond Harbour	D	A	D	D

u/s -: upstream d/s -: downstream

Table 4.2 Zoning and Water Quality Classification of the Ganga

S. No.	Zone	Length (km)	Ambient Water quality class	Designated Best Use	Critical parameter
1.	Source to Rishikesh	250	B	A	Total Coliform
2.	Rishikesh to Kannauj	420	C	B	Total Coliform and BOD
3.	Kannauj to d/s Varanasi (Trighat)	730	B	A	Total Coliform
4.	Trighat to Kalyani	950	C	B	Total Coliform
5.	Kalyani to Diamond Harbour	100	D	B	Total Coliform

(Source: CPCB)

4.2 POST-GAP QUALITY

4.2.1 Dissolved Oxygen

A perusal of the results (*Annexure IV*) indicates that in 22 years of monitoring at 16 stations, the value of DO below 5.0 mg/l was recorded only in 2.6% cases. In these cases, the values were between 3.2 and 4.9 mg/l. These were observed between Kannauj and Kanpur. A comparison of results with pre-GAP period shows that there is a marginal increase in DO values indicating improvement in water quality.

4.2.2 Biochemical Oxygen Demand

The variation in BOD values is much higher as compared to DO. Values exceeding 3.0 mg/l or more were recorded in 27% samples. These values were observed mostly in the stretch between Kannauj and Kanpur and sometimes at Allahabad. Detailed perusal, station wise and year wise, reveals that the values exceeded the acceptable standard (3.0 mg/l) at Rishikesh and Haridwar only once and twice respectively whereas between Kannauj and Kanpur the values exceeded the acceptable level frequently. Higher values of BOD were also recorded at Allahabad and Varanasi. The most critical stretch is between Kannauj and Allahabad downstream. The highest value of BOD (65.8 mg/l) was recorded at Kanpur during lean flow. The graphic representation is in Figure 8.

Fig. 7: Water quality data for river ganga (summer average i.e. March-June)

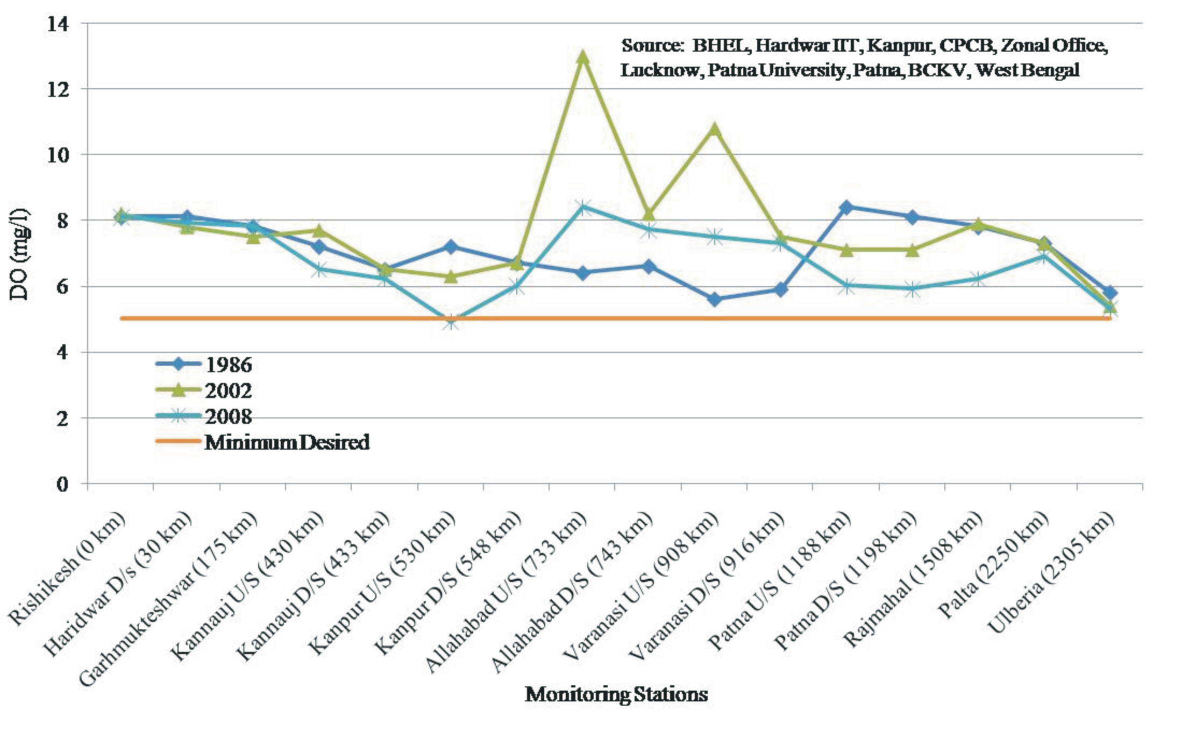
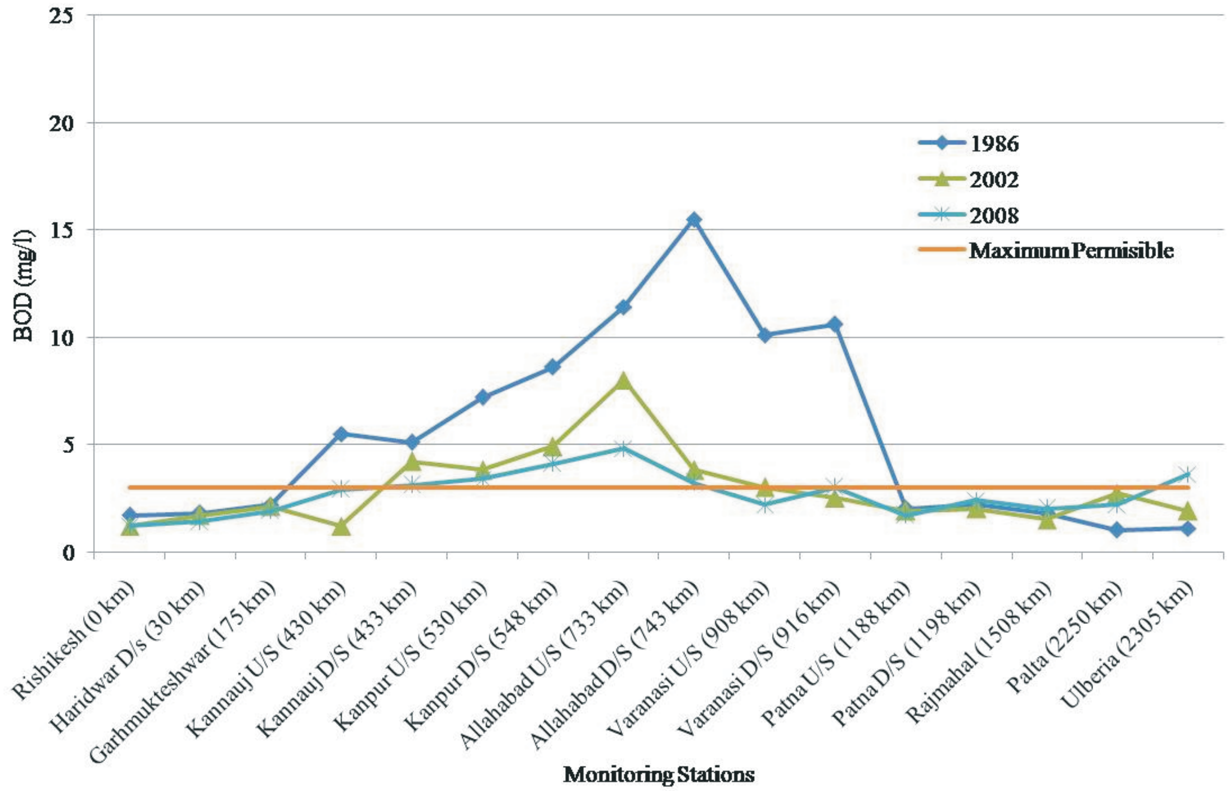


Fig. 8: Water Quality data for River Ganga (summer average i.e. March-June)



4.2.3 Total Coliform and Fecal Coliform

The fecal coliform counts frequently exceeded the stipulated limit at Kannauj, Kanpur, Allahabad and Varanasi. It is also observed that standards for coliforms are exceeded more frequently than for BOD and DO. Thus coliform and BOD emerge as the most critical parameters of river pollution.

4.3 IMPACT OF RIVER ACTION PLAN ON RIVER QUALITY

- The results of water quality monitoring for the period 1986-2008 are given in Figure 7 & Figure 8 for DO and BOD. This graphical representation is based on data given in *Annexure -IV*.
- The desired class of water (according to the Designated Best Use of the Ganga water) at various locations and the class actually found in various years is given in *Annexure - V*. The classification is based on the measured values of DO, BOD and Coliform (CF). The parameters on which water is below the desired class, is indicated in italics in the table.
- It is observed that in 1986, Bio-chemical Oxygen Demand (BOD), ranged from 5.5 to 15.5 mg/l in the critical stretch from Kannauj to Varanasi. As against this, BOD values in 2008 in the stretch from Kannauj to Kanpur and Allahabad to Varanasi are 2.9-4.1mg/l and 2.2-4.8 mg/l respectively, indicating improvement.

- Dissolved Oxygen (DO) levels (in the Allahabad-Varanasi stretch) were in the range of 5.9 to 6.6 mg/l in 1986. In 2008, the range had improved to 7.3 to 8.4 mg/l. These values of BOD and DO are averages for the critical months of March to June, when temperatures are high and the flows in the river are low.

4.4 SUMMARY

Despite the problems of operation and maintenance, river water quality has shown discernible improvement (in terms of DO and BOD) over the pre-GAP period. This has to be seen in the background of a steep increase in population with concomitant increase in organic pollution load. In the absence of Ganga Action Plan, there would have been further deterioration in these parameters. This conclusion has also been corroborated by several independent studies (Markandya & Murthy, 2004).

The high BOD values in some of the towns are attributed to increased population and partial interception and diversion under GAP schemes. The water quality of the river is likely to improve when all the ongoing works are completed and the entire waste water being generated is tackled.

A comparison of pre-GAP and post-GAP values of the three critical parameters, namely DO, BOD and Coliforms reveals the following:

- Dissolved Oxygen is largely within acceptable limits.
- In the upper Ganga, from origin to Haridwar, the water quality is more or less of Bathing Standards (Class B).
- Higher levels of coliform are present almost throughout Ganga. GAP has not been able to adequately address the issue of coliforms.
- The stretch from Kannauj to Kanpur and Allahabad to Varanasi remains critical and needs focused attention. Apart from higher levels of coliforms, the norms for BOD indicating organic pollution are also exceeded in this stretch.
- A study on development of scenarios on comparison of river water quality with and without GAP (Markandya & Murthy, 2004) showed that a stretch of about 740 km (out of total 1520 km) between Rishikesh and Rajmahal would have violated the BOD limit of 3 mg/l without GAP. The study also indicated that a stretch of about 437 km had a BOD level above the permissible limit of 3 mg/l after GAP I.

05 Critical Analysis of GAP

The implementation of GAP has been successful in preventing further deterioration of water quality in the river Ganga, and in fact improving it in a few places, even though the pollution load has increased substantially with time. It would be safe to infer that if the pollution abatement programme had not been taken up there would have been an inevitable and sharp deterioration in the quality of water, posing a serious threat to public health and ecology. Another positive impact of the programme has been an increased public awareness of the need to protect our rivers and other sources of surface water from degradation.

In view of the fact that water quality has not yet reached the prescribed standards for bathing, especially in the stretch from Kannauj to Varanasi, there has been criticism of the GAP in the media and civil society. A very significant factor in this regard is the inadequate flow in the river due to abstraction of water for various purposes including irrigation, drinking water and power generation. A sizeable proportion of water is diverted into the Upper and Lower Ganga canals resulting in reduced flow in the main river.

On the other hand, there have been independent studies by academic institutions which have concluded that the programme has produced positive results. The Cost Benefit Analysis of GAP-I carried out jointly by the University of Bath and Metroeconomica, UK in collaboration with several Indian institutions also endorsed the positive outcomes of the Plan.

Another indicator of the positive impact of GAP I is that several States demanded that the river conservation programme be extended to other rivers. As a result, the National River Conservation Plan (NRCP) was launched in 1995, as a country-wide river conservation programme. It presently covers polluted stretches of 36 rivers in 20 States.

5.1 LIMITED SCOPE OF GAP

GAP suffered from the following limitations;

- Only a part of the pollution load of the river could be tackled.
- GAP concentrated on improving the water quality of Ganga, mainly in terms of organic pollution and dissolved oxygen.
- Only the wastewater of towns flowing through the drains to the river was targeted. Connections of household toilets to the sewer system, solid waste management, and some other vital aspects of municipal activities, which impinge on the water quality were not addressed.
- The issue of ensuring environmental flows in the river was not attended to. This has become increasingly important in view of the competing demands on the Ganga water for drinking, irrigation and power generation. Adopting more efficient water conservation practices could have reduced the need for abstraction of water from Ganga.

- Tree cover in the Ganga basin has reduced considerably and land use pattern has changed, leading to soil erosion. Sediment yield and its deposit on the river bed were also not monitored.
- Pollution load from non-point sources was addressed marginally.
- No attention was paid to run-off from agricultural fields, which brings non-biodegradable pesticides into the river.
- Measures necessary for the prevention of pollution of the river water while planning new settlements or expansion of the present ones were not considered.
- Watershed development as well as groundwater and surface water interaction were not covered.
- Only Class-I towns on the banks of rivers were taken up. Thus a large number of urban settlements remained outside the purview of the Plan.
- Pollution from rural sector was not addressed.
- Several parameters such as heavy metals, pesticides, nitrogen and phosphorous were not monitored. These parameters have become important with increased industrialisation and urbanisation.

5.2 FORMULATION OF SCHEMES

There was little sense of ownership among the stakeholders due to their limited participation in formulating schemes and in implementation. In public perception, the Plan continues to be seen as a Government scheme.

In the initial stages, schemes of I&D and STP were implemented with limited knowledge of actual wastewater generation and treatment technology options. This was due to lack of indigenous experience in pollution abatement works. An attempt has been made to address this shortcoming in the next stage (GAP II), with various technologies being evaluated to select the most appropriate option for a particular location.

Initially, no provision was made for supply of stand-by power. Treatment plants & pumping stations, therefore, were operated with frequent interruptions. Subsequently, dedicated power line and/or diesel generator sets have been installed to ensure uninterrupted power supply to these facilities. However, O&M continues to be a major problem.

In the absence of a fast track mechanism, there were delays in preparing and sanctioning schemes.

5.3 IMPLEMENTATION

Problems of land acquisition, court cases, contractual issues and inadequate capacities in the local bodies/implementing agencies came in the way of speedy implementation.

In some cases, essential components of schemes were not foreseen and estimates had to be revised. This caused cost over-runs and delays.

5.4 OPERATION AND MAINTENANCE (O&M)

While seeking approval of schemes under the GAP, the State Governments had committed to ensuring proper O&M of the river conservation assets being created. However, most of the states could not provide adequate financial resources for O&M,

steady and uninterrupted electricity and experienced manpower. The Municipal Corporations had problems in raising the required financial and human resources to ensure proper operation and maintenance of pollution abatment infrastructure created under GAP. Consequently, O&M of these assets suffered resulting in continued pollution of the river.

Under-utilization of STPs, in some instances due to non-conveyance of the sewage to the STPs, particularly in the absence of upstream systems such as branch sewer and house connections is also a serious constraint.

5.5 TECHNOLOGICAL ISSUES

Decentralized approach was adopted only in a few places under the Plan. The schemes generally relied on centralised systems, which meant that sewage was transported to the periphery of the town for treatment before its final disposal. This resulted in long sewer systems, involving pumping and treatment, which were capital and energy intensive.

A variety of treatment technologies have been adopted under GAP. At places where adequate land was available, waste stabilization pond technology was used. In most other places, technologies like the Activated Sludge Process (ASP), which is a tried and tested technology, as well as Upflow Anaerobic Sludge Blanket (UASB), which is a new technology, were adopted. While ASP is an energy intensive technology, the UASB is less energy intensive but its effluent needs to be polished to meet the prescribed standards before it can be discharged into the river. The experience of using various technologies under GAP has been utilised in selection of appropriate treatment technologies in river pollution abatement programmes subsequently taken up under the NRCP.

The system design for the schemes of interception, diversion & treatment of sewage catered to the hydraulic and organic load at the time of designing, with provision for increased load in future. However, treatment facilities at many places were soon found to be inadequate due to phenomenal growth of population and new residential colonies coming up without adequate wastewater treatment infrastructure. Large volume of wastewater in excess of treatment capacity of the STPs, had to be discharged into the river without treatment.

5.6 CONCLUSION

GAP has been a mixed success. Though the programme yielded good results in many stretches, the problem of pollution in river Ganga has not been fully addressed. The river water quality has improved at many locations despite significantly increased demographic and other pressures. However, the critical parameters of water quality, which adversely impact human health, exceed the prescribed standard limits at major locations.

06 Future Course of Action

6.1 REVAMPING OF THE RIVER CONSERVATION PROGRAMME

The need for revamping the river conservation programme was widely recognised in view of the shortcomings in the approach followed in the Ganga Action Plan. The implementation was piecemeal and focussed more on municipal sewage. Though this approach yielded good results in many stretches, the problem was not fully addressed. In the meanwhile, the challenges have grown. Over the years, the demand for river water is growing for irrigation, drinking water, industrial use and power. The increasing pollution load from expanding cities, diminishing flows due to melting glaciers, adverse health impacts, ineffective enforcement of environmental norms and lack of social mobilization compound the challenge.

6.2 CONSTITUTION OF NATIONAL GANGA RIVER BASIN AUTHORITY

It was felt necessary that a new holistic approach based on river basin as the unit of planning and institutional redesign may be adopted. Accordingly, the Government of India has given Ganga the status of a 'National River' and has constituted the 'National Ganga River Basin Authority' (NGRBA) on 20.02.2009. The NGRBA is an empowered planning, financing, monitoring and coordinating authority for the Ganga River set up under Section 3(3) of the Environment (Protection) Act, 1986. The Ministry of Environment and Forests would provide the necessary administrative and technical support to the Authority.

6.3 FUNCTIONS AND POWERS OF THE NGRBA

- The Authority has both regulatory and developmental functions. The Authority will take measures for effective abatement of pollution and conservation of the river Ganga in keeping with sustainable development needs. These include:-
- development of a river basin management plan and regulation of activities aimed at prevention, control and abatement of pollution in the river Ganga to maintain its water quality, and to take measures relevant to river ecology and management in the Ganga Basin States;
- maintenance of minimum ecological flows in the river Ganga with the aim of ensuring water quality and environmentally sustainable development;
- measures necessary for planning, financing and execution of programmes for abatement of pollution in the river Ganga including augmentation of sewerage infrastructure, catchment area treatment,

protection of flood plains, creating public awareness and such other measures for promoting environmentally sustainable river conservation;

- collection, analysis and dissemination of information relating to environmental pollution in the river Ganga;
- investigations and research regarding problems of environmental pollution and conservation of the river Ganga;
- creation of special purpose vehicles, as appropriate, for implementation of works vested with the Authority;
- promotion of water conservation practices including recycling and reuse, rain water harvesting, and decentralised sewage treatment systems;
- monitoring and review of the implementation of various programmes or activities taken up for prevention, control and abatement of pollution in the river Ganga; and
- issuance of directions under section 5 of the Environment (Protection) Act, 1986 for the purpose of exercising and performing all or any of the above functions and for achievement of its objectives.

The NGRBA would thus be responsible for addressing the problem of pollution in Ganga in a holistic and comprehensive manner. The responsibilities of the Authority would include integrating activities related to sustainable use of water, pollution abatement, maintenance of ecological flows, and river conservation. The NGRBA would identify the pollution sources, build a database using scientific methods, analyse the data and ensure its sharing. The NGRBA will draw up a work plan with clear timelines and sources of funding.

The Authority would coordinate with other regulatory agencies like the Central Pollution Control Board (CPCB) and the State Pollution Control Boards (SPCBs) for access to data, and expertise and for promoting new technological options. Since water quality is directly impacted by abstraction, it may issue directions for taking appropriate measures with a view to ensuring minimum flows in the river in the interest of pollution control and environmental management. The Authority will also encourage States, ULBs, industry and farmers to increase water use efficiency and reuse wastewater after proper treatment.

The State Governments would set up the State River Conservation Authorities (SRCAs) for coordinating and implementing the river conservation activities at the State level. These would function under the chairmanship of the Chief Ministers. Based on the integrated basin management plan drawn by the NGRBA, the State Governments will take steps for comprehensive management of the river in the States through their respective Authorities.

It is expected that this new initiative would rejuvenate the collective efforts of the Centre and States for cleaning the national river Ganga.

6.4 ACTION PLAN

A detailed plan of activities with milestones to be achieved will be formulated for approval of the Authority. This would include timelines and budgetary resources. Essential preliminary activities in this regard have been initiated. These are:

- Preparation of a River Basin Management Plan for the Ganga Basin
- Preparation of a Status paper on Ganga
- Preparation of Action Plans for the hotspots like Haridwar, Kanpur, Allahabad, Varanasi, Patna, etc. in consultation with the State Governments.
- Discussion on modalities of setting up of Special Purpose Vehicles (SPVs) at appropriate locations as a means of mobilizing private sector resources and achieving efficiencies.
- Mapping of the Ganga Basin
- Preparation of a Compendium of sewage treatment technologies
- Preparation of a memorandum of agreement to be signed between the Central Government, State Governments and ULBs linking flow of funds to achievement of agreed milestones.

6.5 RESOURCES

The allocations for pollution abatement and other river conservation works in the Ganga Basin under the existing Central and State schemes are inadequate, and not commensurate with the objective of cleaning the river to the desired standards in a time bound manner. Significant upscaling of budgetary support for the river cleaning activities would, therefore, be essential. For carrying out the mandate of the Authority, and to achieve the objective of cleaning the river Ganga in a time-bound manner, substantial resources will be required. These resources could be mobilized by using a combination of options. These include

- Dovetailing the existing schemes like Jawaharlal Nehru National Urban Renewal Mission (JNNURM), Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT), etc.
- Encouraging the State Governments and the Urban Local Bodies to generate resources through taxes, levies, cess, user charges etc.
- Creating a corpus for the Authority to be provided by the Central Government.
- Approaching the 13th Finance Commission for a special provision, considering the impact on a very large population.
- Creating SPVs for implementing specific river conservation activities. This would help mobilize resources from the private sector and the financial institutions.
- Seeking external assistance from multi-lateral financial institutions.

Annexure-I

Catchment Area, Annual Water Yield and Mean Flow Rate of Streams in Ganga Basin.

(Source: CWC/GBWRD publication - A Perspective Plan - 1986)

S. No.	Sub-Basin	Mean Annual Flow (BCM)	Percentage contribution
1.	Ramganga	17789	3.39
2.	Yamuna (excluding Chambal)	57.241	19.90
3.	Chambal	32.554	6.20
4.	Tons-Kararmnasa	10.609	2.02
5.	Gomti-Ghaghra	113.511	21.62
6.	Sone-East of Sone	44.144	8.41
7.	Gandak-Burhi Gandak	58.967	11.23
8.	Kodi-Mahananda	81.848	15.59
	Total (Tributaries)	416.663	79.36
9.	Ganga Main Stem	84.980	16.19
10.	Evaporation * (attributable to Ground Water)	23.380	4.45
	Total Ganga (Upto Indian Border)	525.023	100.00

* CWC Publication “Water Resources of India 30/88”

Annexure -II

Major Water Resources Projects in Ganga Basin

a. Diversion/Storage Projects for consumptive use

Year of Completion/ Commissioning	Name and Location	Diversion/ Storage	Discharge(m^3/s)/ storage in (MCM)	Purpose
1854	Upper Ganga Canal, Haridwar	Diversion	297 m^3/s	Irrigation (0.924 million Ha)
1874	Agra Canal, Okhla Barrage, Delhi	Diversion	30.8 m^3/s during Non-monsoon and 56 m^3/s during monsoon	Irrigation
1880	Lower Ganga Canal, Narora	Diversion	157 m^3/s	Irrigation (0.5 million ha)
1960	Gandhisagar Dam/ M.P.	Storage	6797 MCM Live Storage	Irrigation over 0.757 million ha. 115 MW
1990-91	East Ganga Canal Bhimgoda Haridwar	Diversion	237 m^3/s	Irrigation during Kharif 0.233 million ha
In between 1719-1748 AD during Mughal Dynasty	Eastern Yamuna Canal	Diversion	85 m /s	irrigation
1355 AD During Ferozshah Tuglaq rule	Western Yamuna Canal	Diversion	190 m^3/s	irrigation
2000	Sharda Sahayak Canal, Lakhimpur Kheri	Diversion	650 m^3/s	Irrigation (1.674 million ha)
1985	Gandak Canal	Diversion	147 m^3/s	irrigation (0.96 million ha)
1963	Kosi Canal	Diversion	425 m^3/s	irrigation (0.44 million ha)
1960	Kota Barrage	Diversion	230 m^3/s	irrigation (0.5 million ha)
1994	Madhya Ganga Canal, Bijnor	Diversion	234 m^3/s	Irrigations (0.306 million ha)

b. Storage Projects for Hydroelectricity Generation

Year of Completion/ Commissioning	Name and Location	Storage	Storage (MCM)	Purpose
1962	Rihand Dam/ Sonbhadra, UP	Storage	8900 MCM Live Storage	Hydro Electricity 300 MW + Water Supply to Thermal Plants
1970-71	Obra Dam Sonbhadra, UP	Storage	211 MCM Gross Storage	Hydro Electricity 99 MW
1973	Chambal Valley Project (Excluding Kota Barrage)	Stogare	10500 MCM Live Storage	370 MW Hydro Electricity
1974	Ramganga Multipurpose Project at Kalagarh in Bijnor	Storage	2190 MCM-Gross Storage	Hydroelectric (198 MW) and Irrigation (.575 million Ha Flood Control
1991	Tons I at Bansagar	Diversion	Barrage	Hydro Electricity
2001-02	Tons II & III at Bansagar	Storage	5410 MCM Live Storage	Hydro Electricity 90MW
2006	Tehri Dam on Bhagirathi	Storage	2615 MCM Live	2400 MW of Hydropower and Irrigation to 0.27 million ha Land. Drinking water supply to Delhi @ 10 m^3/s
2006	Dhauliganga Pithoragarh	Storage	-	Hydro Electricity 280 MW
Under construction	Tapovan Vishnugarh Project, Joshimath (Chamoli)	Run of the River	Dhauliganga	Hydro Electricity 520 MW
Under construction	Lakhwar Phase I and Phase II on River Yamuna	Storage	333 MCM Live Storage	Installed Capacity 420 MW
Under construction	Jamrani Multipurpose Dam near Kathgodam	Storage	144 MCM Live Stogage	Irrigation (0.15 Million Ha) + 30 MW Hydro + drinking

Annexure -III

Parametric values of Ganga River during Pre GAP at Selected Stations

Stations	Distance in km	pH*	Dissolved Oxygen PM	W	S	BOD PM	W	S	Total Coliform PM	W	S
Rishikesh	0	7.0	-	-	-	-	-	-	-	-	-
Haridwar D/S	30	8.0-7.0	5.25	6.8	4.87	13.2	3.17	2.5	43	2400	2400
Garhmukteshwar	175	8.0-7.0	8.05	7.87	6.67	2.5	2.0	5.0	2400	1880	1416
Kannauj	430	7.0-8.0	6.7	6.7	10.1	12.9	8.2	16.3	-	$40×10^3$	-
Kanpur U/S	530	8.0	7.1	6.85	6.38	12.4	13.9	13.9	-	-	-
Kanpur D/S	548	8.0	6.5	8.02	4.35	15.5	14.15	16.39	-	-	-
Allahabad U/S	733	8.0	6.6	6.8	7.5	8.04	8.92	6.76	21.780	17310	21230
Allahabad D/S	743	8.0	7.9	10.7	7.08	7.10	5.4	6.95	38100	15440	17520
Varanasi U/S	908	9-8	8.2	11.14	7.03	6.0	5.9	6.49	31885	25930	14010
Varanasi D/S	919	9-8	7.45	8.75	6.88	5.4	5.85	6.38	33612	20892	5910
Patna U/S	1188	8-8	7.6	8.9	7.71	2.7	1.64	1.71	$24×10^3$	$40×10^3$	$46×10^3$
Patna D/S	1198	8.0	7.2	8.85	7.39	1.55	1.85	3.5	24×10	66635	55403
Rajmahal	1508	-	7.57	4.67	7.45	0.9	1.28	1.47	4940	58633	19563
Palta	2050	-	4.67	8.3	6.86	0.57	1.07	1.12	19667	748667	469767
Uluberia	2500	8.0	4.58	7.67	6.69	0.6	1.57	1.02	48333	916667	835333
Diamond Harbour			6.73	7.47	6.20	1.3	1.47	15.58	31333	8833	22600

* pH variation (May– July 1982); PM (Post Monsoon); W (Winter); S (Summer)

Annexure-IV

Water Quality Data of Ganga River During 1986-2008

Sl No	Station/ Location	Distance in km	1986		1993		2002		2005		2008		Standard values	
			DO (mg/l)	BOD (mg/l)	DO (mg/l)	BOD (mg/l)	DO (mg/l)	BOD (mg/l)	DO (mg/l)	BOD (mg/l)	DO (mg/l)	BOD (mg/l)	DO (mg/l)	BOD (mg/l
1	Rishikesh (0 km)	0	8.1	1.7	9.0	1.3	8.2	1.2	8.5	1.0	8.1	1.2	5.0	3.0
2	Haridwar D/s (30 km)	30	8.1	1.8	7.2	1.4	7.8	1.7	8.1	1.4	7.9	1.4	5.0	3.0
3	Garhmukteshwar (175 km)	175	7.8	2.2	8.5	1.6	7.5	2.1	7.8	2.0	7.8	1.9	5.0	3.0
4	Kannauj U/S (430 km)	430	7.2	5.5	7.2	2.3	7.7	1.2	8.5	1.7	6.5	2.9	5.0	3.0
5	Kannauj D/S (433 km)	433	6.5	5.1	8.4	2.5	6.5	4.2	7.6	4.5	6.2	3.1	5.0	3.0
6	Kanpur U/S (530 km)	530	7.2	7.2	7.5	1.9	6.3	3.8	6.2	4.3	4.9	3.4	5.0	3.0
7	Kanpur D/S (548 km)	548	6.7	8.6	5.2	24.5	6.7	4.9	4.7	5.4	6.0	4.1	5.0	3.0
8	Allahabad U/S (733 km)	733	6.4	11.4	6.9	1.8	13.0	8.0	8.5	5.5	8.4	4.8	5.0	3.0
9	Allahabad D/S (743 km)	743	6.6	15.5	7.2	1.9	8.2	3.8	8.4	3.1	7.7	3.2	5.0	3.0
10	Varanasi U/S (908 km)	908	5.6	10.1	8.2	0.8	10.8	3.0	8.6	2.0	7.5	2.2	5.0	3.0
11	Varanasi D/S (916 km)	916	5.9	10.6	7.6	1.0	7.5	2.5	8.3	2.3	7.3	3.0	5.0	3.0
12	Patna U/S (1188 km)	1188	8.4	2.0	8.2	1.2	7.1	1.9	7.4	2.0	6.0	1.7	5.0	3.0
13	Patna D/S (1198 km)	1198	8.1	2.2	8.0	1.5	7.1	2.0	8.0	2.2	5.9	2.4	5.0	3.0
14	Rajmahal (1508 km)	1508	7.8	1.8	8.5	0.7	7.9	1.5	7.4	1.8	6.2	2.0	5.0	3.0
15	Patna (2050 km)	2050	7.3	1.0	7.1	0.9	7.3	2.7	7.0	3.0	6.9	2.2	5.0	3.0
16	Ulberia (2500 km)	2500	5.8	1.1	6.1	0.9	5.4	1.9	5.4	2.6	5.3	3.6	5.0	3.0

Annexure -V

Classification of Ganga Water at Various Locations According to Designated Best Use

Locations	Desired Class	Observed Class and Critical Parameter					
		1997	1998	1999	2000	2001	2008*
Ganga at Rishikesh	A	D CF	B CF	C CF	NA	C CF	B
Haridwar	B	C CF	C CF	C CF	NA	C CF	B
Garhmuktesar (UP)	B	B BOD	-	D BOD	NA	D BOD, CF	NA
Kannauj u/s U.P.	B	D BOD, CF	D BOD	D CF	D BOD, CF	D BOD, CF	C CF
Kannuaj d/s U.P.	B	D BOD, CF	D BOD	D CF	D BOD, CF	D BOD, CF	C BOD, CF
Kanpur u/s U.P.	B	D BOD, CF	NA	D CF	D CF	D CF	D CF
Kanpur d/s U.P.	B	D BOD, CF	D BOD	D CF	D BOD,CF	D BOD,CF	D BOD, CF
Raibareilly U.P.	B	D CF	D CF	C CF	NA	NA	NA
Allahabad u/s U.P.	B	D BOD, CF	E CF	D CF	NA	NA	C CF, BOD
Allahabad d/s U.P.	B	D BOD, CF	E CF	D CF	NA	NA	D BOD, CF
Varanasi u/s U.P.	B	D BOD, CF	D BOD	D CF	-	D CF	D BOD, CF
Varanasi d/s U.P.	B	E DO, BOD, CF	E BOD, DO	D BOD	NA	NA	D BOD, CF
Gazipur U.P.	B	D BOD, CF	D BOD	D BOD	D CF	NA	NA
Buxar	B	D BOD	D CF	D CF	D CF	D CF	C CF
Patna u/s	B	D CF	D CF	D CF	D CF	D CF	NA
Patna d/s	B	D CF	D CF	D CF	D CF	D CF	NA
Rajmahal	B	D CF	D CF	D CF	D CF	D CF	D CF
Palta (WB)	B	D BOD	B	NA	D BOD, CF	D BOD, CF	D CF
Uluberia (WB)	B	D	B	NA	D	D BOD, CF	D BOD, CF

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