CHAPTER -1

INTRODUCTION

1.1 GENERAL

River Yamuna is a major River of north India having length of 1370km (appx). It is also called as ‘Jumna’, and it originates from Yamunotri glacier near Banderpoonch peaks, in the Mussorie range of the lower Himalayas at an elevation of about 6387 meters above mean sea level in district Uttarakashi, the Uttarakhand Himalaya. This river, flows in a southerly direction through the Himalayan foothills, on to the northern Indian plain, and a series of valleys for about 200 Kms, along the Uttar Pradesh, Haryana state border. At this point, the Eastern and Western Yamuna canals are fed from the river.

It is also the largest tributary of the Ganga and flows through the states of Haryana, Delhi and Uttar Pradesh, before merging with the Ganges at Allahabad. The major tributaries of this river are the Tons, Chambal, Betwa, Sindh and Ken. Among these the Tons is the largest. The Yamuna, after receiving water through other important tributaries, joins the river Ganga and the underground Saraswati at Prayag (Allahabad) after traversing about 950 Km.

In the upper stretch of 200 Km, it draws water from several major strams. The combined stream flows through the Shivalik range of hills of Himachal Pradesh and Uttaranchal states of India and enters into plains at Dak Pathar in Uttaranchal where the river water is regulated through weir and diverted into canal for power generation. From Dak Pathar it flows through the famous Sikh religions place of Poanta Sahib. On the right side of the Yamuna basin is the Mussourie spur-along, which lies sprawled, the hill station of Mussourie. Flowing through Poanta Sahib it reaches

Hathnikund/Tajewala in Yumna Nagar district of Haryana state, where the river water is again diverted into Western Yamuna canal and Eastern Yamuna canal for irrigation. During dry season, no water is allowed to flow in the river downstream to Tajewala barrage and the river remains dry in some stretches between Tajewala & Delhi. The river regains water because of ground water accrual and contributions of feeding canal through Som nadi (seasonal stream) upstream of Kalanaur. It enters Delhi near Palla village after traversing a route of about 224 Km.

TABLE –1.1 DISTINGUISHED INDEPENDENT SEGMENTS OF RIVER YAMUNA

Himalayan Segment	From origin to Tajewala Barrage	(172 kms)
Upper Segment	Tajewala Barrage to Wazirabad Barrage	(224 Kms)
Delhi Segment	Wazirabad Barrageto Okhla Barrage	(22 kms)
Eutriphicated Segment	Okhla Barrage to Chambal Confulence	(490 kms)
Diluted Segment	Chambal Confluence to Ganga Confluence	(468 kms)

Source: - CPCB,2002

1.1.1 ORIGIN OF RIVER YAMUNA

The Origin of River Yamuna is at Yamunotri, in the Uttarakhand Himalaya, which lies north of Haridwar in the Himalayan Mountains. The river flows through the states of Delhi, Haryana and Uttar Pradesh, before confluencing with the Ganges at Allahabad. The cities of Baghpat, Delhi, Mathura, Noida, Etawah, Agra, Hamirpur, Allahabad and Kalpi lie on its banks. The major tributaries of the river are the Tons, Chambal, Betwa and

Ken; with the Tons being the largest. Yamunotri is the source of the Yamuna River and the seat of the Goddess Yamuna. This spot is considered as one of the four sites in India's Char Dham pilgrimage.

1.1.2 HISTORY OF RIVER YAMUNA

The History of River Yamuna is significant because of the importance of this river in Indian mythology. Some ancient evidence indicated that River Yamuna was a tributary of the Ghaggar River in the past; with time it changed its course to east with a tectonic event in north India and became a tributary of the Ganges instead. The goddess of the Yamuna River, also known as Yami is the sister of Yama, god of death, and the daughter of Surya, the Sun god, and his wife Samin. Consequently, popular belief is that those who take a dip in its holy waters are not tormented by fears of death. It is also connected with Lord Krishna's past times. The Lord Krishna sanctified the River Yamuna, while his father Vasudeva was crossing the Yamuna with baby Lord Krishna. When baby fell down in the river, the dust of his lotus feet sanctified the river at once.

1.1.3 GEOGRAPHY OF RIVER YAMUNA

The Geography of River Yamuna is closely related to the topography and the geographical formation of Northern India. Yamuna or Jumna River is a river of northern India. River Yamuna is the longest tributary of the Ganges River, having length of approximately 860 miles or 1,380 km. The source of the Yamuna happens to be in the western Himalayas. The river initially flows south and then southeast, thus running parallel to and just west of the Ganges.

Most of the course of River Yamuna is covered up in the state of Himachal Pradesh. After originating in Yamunotri, River Yamuna enters Himachal Pradesh at Khadar Majri in Sirmaur district. Yamuna River is the largest tributary of the Ganga. The Yamuna River has a mythical association to the Sun. The river rises from Yamunotri in Gharwal hills and thus forms the Eastern boundary with Uttar Pradesh.

River Yamuna enters Delhi near Palla at an altitude of 210.3 meter and transverse of about 40 km. It leaves Delhi at and altitude of 198.2 meter near Jaitpur in the South.

1.1.4 GEOLOGY OF YAMUNA RIVER

The Geology of Yamuna River is known from the silt deposits it have all through the riverbed. The sediments that are collected from Delhi and Agra urban centres were examined for concentration and distribution of nice heavy metals by means of atomic adsorption spectrometry. The religious importance of Yamuna River is related to the companionship of Lord Shri Krishna. This River originates from the Champasar Glacier at an altitude of 4421 m in the state of Uttarakhand; the respected Yamuna is specially mentioned in the Hindu mythology as a mythological river. Some say the source of the river is the Saptarishi Kund, a glacial lake, where a sacred shrine of Yamnotri or Yamnotri is constructed. There is also a temple dedicated to the Goddess Yamuna, which remains closed from November to May. At Hanumanchatti, the Hanuman Ganga converges with Yamuna River. According to a legend, this remote hilly spot was the home of an ancient sage, the Asit Muni.

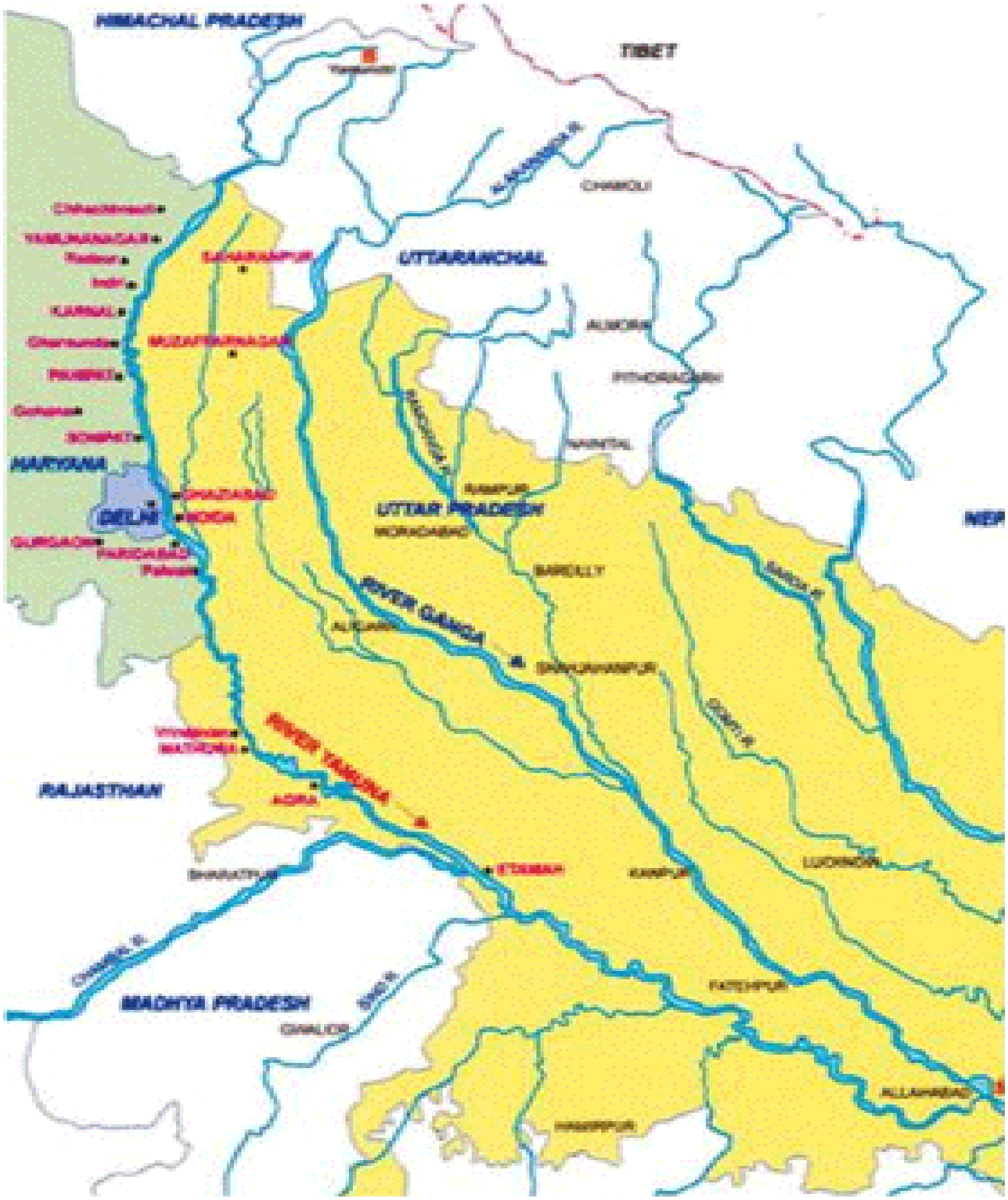
The wildlife and surroundings of River Yamuna is a serene frontier to fabulous greenery. The surroundings of River Yamuna are abundance in wildlife and ecological species. The boundary line of River Yamuna has the rare collection of Asian Elephant. There are no elephants to be found over 900 km of the western Himalayas and their foothills and also not in the west of the Yamuna. Pollution and protection of River Yamuna have become on the burning issues of the nation now. Yamuna is unfortunately one the most polluted rivers in the world, especially in the banks near New Delhi, the capital of India. Almost 57% of the city's waste is dumped into the river. Numerous attempts have been made to clean it, however the efforts have brought few changes.

Triveni Sangam is the convergence of three major Indian rivers, namely the Ganga, the Yamuna and the legendary Saraswati River near Allahabad, India. This spot have become a well-known pilgrimage spot in India. Confluence of three rivers, the Ganga, Yamuna and Saraswati.

Delhi is the largest contributor of pollution to Yamuna River. The sewage zones of Delhi, i.e. Okhla, Keshopur, Rithala, Shahdra etc. generate heavy BOD load.

Delhi is divided into five sewerage zones with five major sewage treatment plants and two oxidation ponds located at Vasant Kunj and Timarpur. Oxidation ponds are shallow.

Ponds that are well lined with high embankments. The raw sewage is allowed to stand in this pond for a period of time. During this time the organic matte is oxidized through the combined action of algae and other microorganisms. By the time it is released into the river of lake the BOD content in the water is much less than it was when the sewage was first released into pond.


HIMACHAL PRADESH
TIBET
UTTARANCHAL
CHAMOLI
ALMORA
PITHORAGARH
NAINITAL
HARYANA
DELHI
SAHARANPUR
MUZAFFARNAGAR
GHAZIABAD
NOIDA
KARNAL
PANIPAT
SONIPAT
GURGAON
FARIDABAD
RAMPUR
UTTAR PRADESH
MORADABAD
RIVER GANGA
ALIGARH
SHAHJAHANPUR
RIVER YAMUNA
MATHURA
RAJASTHAN
AGRA
ETAWAH
KANPUR
LUCKNOW
BHARATPUR
MADHYA PRADESH
GWALIOR
FATEHPUR
ALLAHABAD
HAMIRPUR

The river is again tapped at Wazirabad through a barrage for drinking water supply to Delhi. Generally, no water is allowed to flow beyond Wazirabad barrage in dry season, as the available water is not adequate to fulfill the demand of water supply of Delhi.

Whatever water flows in the downstream of Wazirabad barrage is the untreated or partially treated domestic and industrial wastewater contributed through several drains along with the water transported by Haryana Irrigation Department from Western Yamuna Canal (WYC) to Agra Canal via Najafgarh Drain and the Yamuna. After 22 Km downstream of Wazirabad barrage there is another barrage, Okhla barrage, through which Yamuna water is diverted into Agra Canal for irrigation. No water is allowed to flow through barrage during dry season. Whatever water flows in the river beyond Okhla barrage is contributed through domestic and industrial wastewater generated from East Delhi, Noida and Sahibabad and joins the river through Shahdara drain. The Yamuna after receiving water through other important tributaries joins the river Ganga and the underground Saraswati at Prayag (Allahabad) after traversing about 950 Km. Thus, Yamuna river can not be designated as continuous river particularly in dry seasons (almost 9 months), but can be segmented in five distinguished independent segments due to characteristic hydrological and ecological conditions. The Yamuna River may be disintegrated into 5 segments due to their hydrological & ecological condition. These segment are Himalayan segment, upper segment, Delhi segment, Eutrophicated segment. The first two segments are comparatively clean having oligotrophic condition. Delhi segment is the most polluted segment in the entire Yamuna River. This segment has oligotrophic head and saprobic tail. Eutrophicated segments except few patches of saprobic condition have diurnal variation of oxygen levels, an indication of eutrophication. The stretch of Yamuna River after its confluence with Chambal River is termed as diluted segment, as it receives significant dilution water. This segment after confluence with Chambal River regain its water quality up to some extent.

1.2 RELEVANCE AND NEED OF PRESENT STUDY

The best way is to categorize on the basis of identification of processes & agencies involved in polluting, responsible for controlling and measures adopted or being adopted. As regards polluting processes and agencies these can be further categories as internal, external and ritual/religious. In Delhi reach the river water is polluted by agriculture and industrial waste discharged & culminating into the river in upper reaches mainly from Haryana. These discharges contain organic load, heavy metals and pesticides and fertilizers.

However, if discharge from Tajewala remains sufficient this is not of more concern as on date. Excessive drawing of water at Tajewala and Wazirabad barrage indirectly contributes to the pollution by reducing the self-purifying capacity of the river.

Externally heavy polluting load in form of treated/untreated domestic/industrial sewage is being poured into the river in Delhi reach. Religious activity like Purnima Snan, Chhath Pooja, Murty viserjan, disposal of domestic of Residual mortal remains of dead bodies and disposal of domestic pooja / yagyan remains are having large impact on the pollution of river due to heavy population density in Delhi. Besides this jhuggi dwellers residing in the bed & on bank discharge their all kinds of waste for daily uses they also become the carrier of infectious diseases.

In Delhi the responsible agencies for control of pollution are CPCB, DPCC, MCD, DJB & DSIDC in government sector. Some N.G.O's, Judiciary has shown interest in control of Pollution. On account of different excuses all these government agencies are showing in-abilities to control the same and can be termed indirectly polluting agencies. Certain measures have been adopted or being adopted to control the pollution and revive the river like setting of S.T.P's/E.T.P's/C.T.P's, regular monitoring, increase in fresh water discharge, removal of floating materials, provision of nets in the vicinity of bridges, removal of jhuggies from the Yamuna bank and bed etc. There are about 29 S.T.P's and 15 C.T.P. in the Delhi.

With all these approaches active in India, and with worldwide-acknowledged scientific personnel, the question remains as to the reason for the poor translation of this awareness into ground realities. The present study makes and attempt to discover some of the reasons after verifying the trend in water quality status in one of the urban river reaches.

1.3 OBJECTIVES OF STUDY:

The following are the objectives of the present study: -

a) To study the status of River Yamuna.
b) To study the quality of River Yamuna.
c) To identify the sources of Pollution of River Yamuna.
d) To suggest preventive measures for preventions of pollutions in River Yamuna.
e) To study the various legislations with regard to water quality of River.

CHAPTER-2

LITERATURE REVIEW

2.1 INTRODUCTION

The length of the River Yamuna from its origin Yamunotri to its confluence with Ganga River at Allahbad is 1376 Kilometer. The total basin area of the river is 366223 km^2 which covers part of geographical area in the states of Uttaranchal, Uttar Pradesh, Himachal Pradesh, Haryana, Rajasthan, Madhya Pradesh & NCT- Delhi.

The flow of the Yamuna River varies significantly during monsoon and non-monsoon seasons. The river constitutes maximum flow i.e. around 80% of the total annual flow during monsoon period the Yamuna cannot be designated as a continuous river but segregated into four independent segments due to the presence of three barrages from where almost the entire water is being diverted for various human activities.

The sources contributing pollution are both point & non-point type. Urban agglomeration at NCT-Delhi is the major contributor of pollution in the Yamuna River followed by Agra and Mathura. About 85% of the total pollution in the river is contributed by domestic sources. The condition of river deteriorate further due to abstraction of significant amount of river water, leaving almost no fresh water in the river, which is essential to maintain the assimilation capacity of the river.

About 580 km long river stretch in between Wazirabad barrage and Chambal river confluence is critically polluted. This stretch is characterized by high organic contents, high nutrients, significant depletion or increase in dissolved oxygen, severe odors etc. The 22 km long Delhi stretch is polluted severely.

In this stretch, there was practically no perennial flow during dry weather while a quantity of treated and untreated sewage (about 3300 MLD) was being discharged into the river. The self-purification capacity of the River Yamuna is due to lack of minimum flow in the river and heavy discharge of 22 drains (treated and untreated) waste in River Yamuna. Even though Delhi constitutes only 2% of the catchments of the Yamuna basin, yet it contributes 80% of the pollution load.

In the last three four decades, the city become a major center of commerce, industry and education. The growth of govt. offices and complexes has also contributed to spread of the city. Civic amenities have not kept place. Unlimited migration has compounded the problem. Land use regulations have been flouted. The green cover has dwindled.

Water pollution makes water unsuitable for drinking, recreation, agriculture and industry, it eventually also diminishes the aesthetic quality of rivers. Even more seriously, when contaminated water destroys aquatic life and reduces its reproductive abilities, it eventually menaces human health. Nobody escapes the effects of water pollution. When organic matter is discharged into a stream, the decomposable organic matter becomes the food supply of the organisms in the aquatic environment. The organic matter is decomposed and converted into the stabilized form at the final state of the decomposition. These are two types of decomposition process, namely aerobic and anaerobic, which are distinct from each other. In the aerobic decompositions process, the dissolved oxygen is consumed for the satisfactions of biochemical oxygen demand where the oxygen required for the decomposition of any particular quantity of waste is expressed as its biochemical oxygen demand. On the other hand, in the anaerobic decomposition, an undesirable and prolonged septic condition in the stream takes place by production of methane, sulphides, carbon dioxide, ammonia and water as end products.

The present concern for surface water quality has made it necessary for engineers and planners to predict the distribution of pollutants discharged into the river. There is a need to study, analyse and predict the important water quality and quantity vector so that it does not fall below acceptable level. The natural direction and current human actions unfortunately have not been conductive to enhance the environmental state of river basin.

2.2 POLLUTION POTENTIAL IN THE YAMUNA BASIN

The entire Yamuna River right from its origin to confluence with the Ganga and its tributaries are subject to human activities, which directly or indirectly affect the water quality.

Yamuna enters Delhi at Palla village 15 km upstream of Wazirabad barrage, which acts as a reservoir for Delhi. Delhi generates 3300 million litre per day (mld) of sewage, against an installed wastewater treatment capacity of 2190 MLD. Thus, 1110 MLD of untreated and a significant amount of partially treated sewage enter the river everyday. The Wazirabad barrage lets out very little water into the river. In summer months especially, the only flow downstream of Wazirabad is of industrial and sewage effluents. Lesser discharge means lesser river flow and thus, greater levels of pollution. From the Okhla barrage, which is the exit point for the river in Delhi, the Agra canal branches out from Yamuna. During the dry months, almost no water is released from this barrage to downstream Yamuna. Instead, discharge from the Shahdara drains joins the river downstream of the barrage, bringing effluents from east Delhi and Noida into the river. This is the second largest polluter of the river after the Najafgarh drain

The main problem lies in undetected and untreated pesticide residues. Waterworks officials in Delhi and Agra point out that pesticide traces cannot be removed with conventional treatment. “Organic substances can be assimilated in freshwater, provided there is enough freshwater in the river”, states R Dalwani, scientist, ministry of environment and forests (MEF). But for micro pollutants such as pesticides, only more freshwater can reduce the percentage of trace in water. These cannot be dissolved or assimilated, but certainly can be diluted to an extent. The river has a dilution requirement of 75 per cent, which implies that for every 100 liters of wastewater, 75 liters of freshwater is required. Scientists state that with the flow of water, pollutants (especially organic pollutants) degrade to a large extent. But a every step, this purified water is abstracted, and ever larger loads of pollution make their way into the river.

The pollution potential in the catchment area depends on various human activities and categorized into groups:

2.2.1 POINT SOURCES OF POLLUTION

The point sources of pollution are contributed at a single point in significant amount such as wastewater drain joining a water body. The point source pollution covers two major categories: Domestic Pollution & Industrial pollution.

DOMESTIC POLLUTION

Sewage is discharged in to the river without any treatment from the cities located along the banks of river and its tributaries. This affects aquatic life and depletes oxygen level resulting in to bad odors and turbidity. The river water does not remain suitable due to pollution, for uses like drinking, outdoor bathing, propagation of aquatic life, irrigation and industrial purposes

INDUSTRIAL POLLUTION

Industrial pollution dissolved oxygen, temperature & pH etc. Some industrial effluents cause toxicity. Large and medium industrial unit-22 in Haryana, 42 in Delhi and 17 in Uttar Pradesh have been identified as directly discharging and polluting the river Yamuna under the Action Plan area. These industries include paper, sugar, chemical, leather, distillery and pharmaceuticals etc. These industries are contemplated to adopt adequate pollution control measures under the existing environment laws to ensure that treated effluent confirming the prescribed standards should only be discharged in to river ensure that treated effluent confirming the prescribed standards should only be discharged in to river effects water quality.

The entire Yamuna River right from its origin to confluence with the Ganga & its tributaries are subject to human activities, which directly or indirectly affect the water quality.

2.2.2 DIFFUSED SOURCES OF POLLUTIONS

The diffused pollutions originate mainly from the catchments area through movement of water. Pollutants originated from the top soil losses, includes soil organic matter, plants residue, nutrient elements, organic chemicals, toxic elements and bacteria.

2.3 LEGISLATION POINTS ABOUT WATER QUALITY

It is generally recognized that water quality objectives, the setting of emission limits on the basis of best available technology, and the use of best environmental practice should all form part of an integrated approach to the prevention, control and reduction of pollution in inland surface water. In most cases, water quality objectives serve as a means of assessing pollution reduction measures. For example, if emission limits are set for given water body on the basis of best available technology, aquatic communities under certain conditions may nevertheless, experience toxic effects. In addition, other sensitive water uses, such as drinking-water supplies, may be adversely affected. The water quality objectives help to evaluate, therefore, whether additional efforts are needed when water resources protection is based on using emission limits for point sources according to the best available technology or on best environmental practice for non-point sources.

Experience gained in some countries suggests that catchments planning play an essential role in setting water quality objectives. It provides the context in which the demands of all water users can be balanced against water quality requirements. Catchments planning also provide the mechanism for assessing and controlling the overall loading of pollutants within whole river catchments and, ultimately, into the sea, irrespective of the uses to which those waters are put. The need for “catchments accountability” is becoming increasingly important in order to ensure that both national and international requirements to reduce pollutant loadings are properly planned and achieved.

2.4 WATER QUALITY CLASSIFICATION

Water quality classification in different countries has been made on different bases. Some of the classifications are as under:

In India, five water quality classes have been designated (A-E) on the basis of the water quality requirements for a particular use:

Class A	waters for use as drinking water source without conventional treatment but after disinfection.
Class B	waters for use for organized outdoor bathing.
Class C	waters for use as drinking water source with conventional treatment followed by disinfection.
Class D	waters to maintain aquatic life (i.e. propagation of wildlife and fisheries).
Class E	waters for use for irrigation, industrial cooling and controlled waste disposal.

The five classes have been used to set quality objectives for stretches of the Yamuna and Ganga rivers, and surveys have been carried out to compare the actual river-quality classification with that required to sustain the designated best use. Where a river has multiple uses, the quality objectives are set for the most stringent (best) use requirements. After comparing ambient water quality with the designated water quality objective, any deficiencies will require appropriate pollution control measures on the discharges, including discharges in upstream stretches. This system is also helpful for the planning and sitting of industry. No industries are permitted to discharge any effluent in stretches of rivers classified in class A.

A pollution control action plan was drawn up for the Ganga in 1984 project directorate was established under the central Ganga Authority in

1985. This directorate oversees pollution control and abatement (ESCAP, 1990). The classification and zoning of 12 other major rivers has also been recently accomplished.

2.5 INDIAN STANDARDS

In 1957, Indian standards institution had set up its waters sectional committee (CDC 26) to prepare, among others, standards for industrial and sewage effluents before discharge into inlands surface waters, marina coastal areas, on land and into sewers. The sectional committee has, initially brought out two Indian standards. The first one (IS 2488) covers in five parts method of sampling and test for industrial effluents. The second Indian standards (IS 2490) prescribe in nine parts tolerance limits for industrial effluents discharged into inland surface waters, marine coastal areas, public sewage and land for irrigation purposes. While part 1 of OS 2490 is applicable to all industries as regard tolerance limits for industrial effluents, the second part cover specific industries, such as distilleries etc. Indian standard (IS 6582-1971) lays down the bioassay methods for evaluating the toxicity of industrial effluents and wastewaters to fish and other aquatic organisms in the receiving waters which can help decide whether an effluent can be discharged at a given rate without causing direct injury to aquatic fauna and flaura. IS 2296-1974 deals with the tolerance limits for inland source water subject to pollution and IS 1967-1976 deals with criteria for controlling pollution of marine coastal areas. Indian standard institution has also prepared codes of practice for the treatment and disposal of effluents emanating from individual industries including distillery, cane sugar, cotton etc.

2.6 ENVIRONMENTAL LAWS IN INDIA

India laws pertaining to almost all aspects of environment like Air, Water, Forest etc. are available separately. A separate protection act covering the entire aspects of environment is also in existence. Though air, water, forest and land are giving considerable effect on each other, having more relevance to the study water Act & EP Act are being discussed here.

2.6.1 WATER ACT (PREVENTION & CONTROL OF POLLUTION, 1974

An Act to provide for the prevention and control of water pollution and the maintaining or restoring of wholesomeness of water for the establishment, with a view to carrying out the purposes aforesaid, of boards for the prevention & control of water pollution, for conferring on and assigning to such boards powers & functions relating there to and for matters connected therewith;

Where as it is expedient to provide for the prevention and control of water pollution and the maintaining or restoring of wholesomeness of water for the establishment, with a view to carrying out the purposes aforesaid, of boards for the prevention & control of water pollution & for conferring on and assigning to such boards powers & functions relating there to;

And Where As Parliament has no power to make laws for the states with respect to any of the matters aforesaid except as provided in articles 249 and 250 of the constitution;

And Where As in pursuance of clause (1) of article 252 of the constitution resolutions have been passed by all houses of the Legislatures of the states of Assam, Bihar, Gujrat, Haryana, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Madhey Pradesh, Rajasthan, Tripura and West

Bengal to the effect that the matters aforesaid should be regulated in these states by parliament by law;

Environmental law appears to be recent invention and not a sudden creation.

Many provisions dealing with the environment are scattered in pieces and are found in the different enactments of this country.

Under water (prevention and control of pollution) act, 1974 pollution control boards have been set up at the centre and in the states for the prevention, abatement and control of pollution of rivers and streams by regulating the quantity of existing and industrial waters.

This Act was enacted in accordance with the provisions of article 252 of the constitution of India after resolutions in pursuance of clause (1) of article 252 of the constitution has been passed by the houses of the legislatures of the various states to the effect that the mater aforesaid should be regulated in those states by parliament by law.

By central Act no 4 of 1978; certain amendments were introduced in the act. Among the amendments were to omit the time limit for the constitution of state boards.

A summary of Water Act, its provision along with its drawbacks is as under:

WATER (PREVENTION AND CONTROL OF POLLUTION) ACT OF 1974

The Act was passed by the parliament pursuant to enabling resolution by twelve states, under Art. 252 (1) of the constitution, for prevention and control of water pollution and maintaining of restoring of wholesomeness of water.

MAIN FEATURES

- The main features of the act can be summarized as under:-
- Amended in 1978 and revised 1988.
- Comes under state list of the Constitution.
- Establishes state and central pollution control boards.
- Applies to river, watercourse, inland waters, subterranean waters and sea or tidal waters.
- Specifies functional of state boards.
- The central board also performs the functions of state boards for the union territories.
- Since 1982, the central board has been attached to the Department of Environment, Forest and Wildlife, Govt. of India.

2.6.2 E P ACT

The strength and Weaknesses of Environment Protection Act 1986 in a summarized form is as under:

An Act to provide for the protection and improvement of environment and for matter connected therewith.

Environment Protection act 1986

An Act to provide for the protection and improvement of environment and for matters connected therewith:

Where As the decision were taken at the United Nations conference on the Human Environment held at Stockholm in June 1972, in which India participated, to take appropriate steps for the protection and improvement of human environment;

And Where As it is considered necessary further to implement the decisions aforesaid in so far as they relate to the protection and improvement of environment and the prevention of hazards to human beings, other living creatures, plants and property.

- After the Tragedy of Bhopal gas case Government of India enacted EPA 1986 under article 253 of constitution.
- The purpose of the Act is to protect and improve the human environment and prevention of hazards to human beings other living creatures, plants and property.
- The EPA 1986 is an umbrella legislation to control Govt. to coordination the activities of various control and state authorities established under previous laws such as water and Air Act.
- It is an enabling low-means it enable bureaucrats to frame necessary rules & regulation.

SHORTCOMING OF EPA 1986

- Shoddy drafting in the 191 Coastal Regulations.
- Numerous Key expressions used in EPA.
- E.g. (Land for irrigations standards, inland surface water standards) not defined.
- Printing errors.
- Pollution control Boards norms vary from the EPA standards which standards apply those issued under EPA or standards published by state Boards Assuming EPA prevails should not the parliament repeal section 17 (g) of water and air Act to reduce confusion.

- A Prepublication requirement to write objections from public was existing however on 16 March 1994 new sub rule Section 5 (4) was introduced permitting the center to dispense with pre publication requirement in the public interests. This has provided Govt. a convenient clause to dispense with Prepublication Procedure.
- In EIA mandatory public hearing requirement was done away with

SHORTCOMING OF EPA

Section 2 provides that if any act or omission constitutes an offence punishable under the EPA as well as other law, the offender shall be liable to be punished under the other law and not under EPA.

This is very curious and controversial provision. Generally recent legislation supercedes the previous legislation.

PENALTIES UNDER THE ACT

Under EPA central Govt. has the authority to issue direct written orders including orders to close prohibits, regulate any industry, operation, and process or regulate the supply of electricity water or any other service.

Other Power includes:

- Power of entry
- Testing of Equipment
- Power to take samples of air, water soil etc.

  The Act provides for severe penalties
- Prison term up to five years of Rs. 10,000/- fine or both
- Corporate officials directly in charge of a companies business are liable for offences under the act. Similar liability extends to the head of the department of Govt. and other offices.

The relevant standards stipulated by the Act have been given in the following tables Nos. 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7.

TABLE -2.1

PRIMARY WATER QUALITY CRITERIA FOR CLASS SW-I WATERS

(For salts pans, shell fishing, Mari culture and Ecologically Sensitive Zone)

SI. NO.	Parameter	Standards	Rationale/Remarks
(1)	(2)	(3)	(4)
1	PH range	6.5	General broad range, conductive for propagation of aquatic lives, is given. Value largely dependent upon soil water interaction.
2	Dissolved oxygen	5.0 mg/1 or 60 percent saturation value, whichever is higher	No less than 3.5 mg/1 at any time of the year for protection of aquatic lives.
3	Colour and odour	No noticeable colour off offensive odour	Specially caused by chemical compounds like creosols, phenols, naptha, pyridine, benzene, toluence etc., causing visible coloration of salt crystal and tainting of fish flesh.
4	Floating matters	Nothing obnoxious or detrimental for use purpose.	Surfactant should not exceed an upper limit of 1.0 mg/1 and concentration not to cause any visible foam.
5	Suspended solid	None from sewage or industrial waste origin	Settle able inert matters not such concentration that would impair any usages specially assigned to this class.
6	Oil and Grease (including petroleum products)	0.1 mg/1	Concentration should not exceed 0.1 mg/1 as because it has effect on fish eggs and larvae.

7	Heavy metals mercury (as Hg) Cadmium (as Cd) Lead (as Pb)	0.001 mg/1 0.01 mg/1 0.1 mg/1	Values depends on : I. Concentration in salts, fish and shellfish, II. Average per capita consumption per day III. Minimum ingestion rate that induces symptoms of resulting diseases.

Source: EP Rules, 1986

Note:- SW-1 is desirable to be safe and relatively free from hazardous chemical likes pesticides, heavy metals and radionuclide concentration. Their combined (synergetic or antagonistic) effects on health and aquatic lives are not yet clearly known. These chemicals undergo Bioaccumulation, magnification and transfer to human and other animals through food chain. In areas where fisheries, salt pans are governing consideration, and presence of such chemicals apprehended/ reported, bioassay test should be performed following appropriate method for the purpose of setting case- specific limits.

TABLE -2.2

PRIMARY WATER QUALITY CRITERIA FOR CLASS SW-II WATERS.

(for bathing, Contract water sports and commercial building)

SI. NO.	Parameter	Standards	Rationale/Remarks
(1)	(2)	(3)	(4)
1	pH range	6.5-8.5	Range does not cause skin or eye irritation and is also conductive for propagating aquatic lives.
2	Dissolved oxygen	4.0 mg/1 or 50 percent saturation value, whichever is higher	Not less than 3.5 mg/1 at any time of the year for protection of aquatic lives
3	Colors and odor	No noticeable color of offensive odour	Specially caused by chemical compounds like creosols, phenols, naphtha, pyridine, benzene, toluene etc., causing visible coloration of salt crystal and tainting of fish flesh.
4	Floating matters	Nothing obnoxious or detrimental for use purpose.	None in concentration that would impair usages specially assigned to this class
5	Turbidity	30 NUT (Nephelo Turbidity unit)	Measured at 0.9 depths.
6	Fecal coliform	100/100 ml (MPN)	The average value not exceeding 200/100 ml. in 20 percent of samples in monsoon months
7	Biochemical oxygen demand (BOD) (3 days at 27^0 C)	3 mg/1	Restricted for lathing (aesthetic quality of water). Also prescribed by IS: 2296-1974.

Source: EP Rules, 1986

TABLE -2.3

PRIMARY WATER QUALITY CRITERIA FOR CLASS SW-III WATERS

(For Industrial Cooling, Recreation (Non Contract) and Aesthetic)

SI. NO.	Parameter	Standards	Rationale/Remarks
(1)	**(2)**	**(3)**	**(4)**
1	pH range	6.5-8.5	The range is conductive for propagation of aquatic species and restoring natural system.
2	Dissolved oxygen	4.0 mg/1 or 50 percent saturation value, whichever is higher	To protect aquatic lives.
3	Colour and odour	No noticeable colour of offensive odour assigned to this class	None in such concentration that would impair usages specifically assigned to this class.
4	Floating matters	No visible obnoxious	As in (3) above.
5	Fecal coliform	500/100 ml. (MPN)	Not exceeding 1000/100 ml in 20 per cent of samples in the year and in 3 consecutive samples in monsoon months.
6	Turbidity	30 NTU (Nephelo Turbidity unit)	Reasonable clear water for recreation, aesthetic appreciation and industrial cooling purposes.
7	Dissolved iron (as Fe.)	0.5 mg/1 or less	It is desirable to have the collective concentration of dissolved Fe and Mn less or equal to 0.5 mg/1 to avoid scaling effects.
8	Dissolved manganese (as Mn.)	0.5 mg/1 or less	

Source: EP Rules, 1986

TABLE – 2.4

PRIMARY WATER QUALITY CRITERIA FOR CLASS SW – IV WATER

(For Harbor Water)

SI. NO.	Parameter	Standards	Rationale/Remarks
(1)	**(2)**	**(3)**	**(4)**
1	pH range	6.5-9.0	To minimize corrosive and scaling effect.
2	Dissolved oxygen	3.0 mg/ or 40 percent saturation value whichever is higher	To protect aquatic lives.
3	Colour and odour	No noticeable colour of offensive odour.	None from reactive chemicals, which may corrode paints/metallic surfaces.
4	Floating materials, oil grease and scum (including petroleum product)	10 mg/1	Floating matter should be free from excessive living organisms, which may clog or coat operative parts of marine vessels/equipments.
5	Fecal coliform	500/100 ml (MPN)	Not exceeding 1000/100 ml in 20 percent of samples in the year and in 3 consecutive samples in monsoon months
6	Biochemical oxygen demand (BOD) (3 days at 27^0 C)	5 mg/1(MPN)	To maintain water relatively from pollution caused by sewage and other decomposable waste.

Source: EP Rules, 1986

TABLE – 2.5

PRIMARY WATER QUALITY CRITERIA FOR CLASS SW – V WATER

(For Harbor Water)

SI. NO.	Parameter	Standards	Rationale/Remarks
(1)	**(2)**	**(3)**	**(4)**
1	PH range	6.5-9.0	As specified by the new England Interstate Water Pollution Control Commission.
2	Dissolved oxygen	3.0 mg/ or 40 percent saturation value whichever is higher	To protect aquatic lives.
3	Colour and odour	None-in such concentration that would impair any usages specifically assigned to this class.	As in (1) above.
4	Sludge deposit	None accept for solid refuse floating such small amount that may solids. Oil, grease, result from discharged and the scum of appropriately treated sewage and/or industrial waste effluents.	As in (1) above
5	Fecal coliform	500/100 ml (MPN)	Not exceeding 1000/100 ml in 20 per cent of samples in the year and in 3 consecutive samples in monsoon months.

Source: EP Rules, 1986

TABLE – 2.6

PRIMARY WATER QUALITY CRITERIA FOR CLASS SW-V WATER

(Water is used for organized outdoor bathing)

CRITERIA			RAFTIONALE
1	Fecal coliform MPN/100 ml Permissible	500 (desirable) 2500 (maximum)	To ensure low sewage contamination. Fecal coliform and fecal streptococci are considered as they reflected the bacterial pathogenicity.
2	Fecal Streptococci MPN/100 ml	100 (desirable) 500 (maximum Permissible)	The desirable and permissible limits are suggested to allow for fluctuation in environmental condition such as seasonal change, changes in flow conditions etc.
3	PH:	Between 6.5-8.5	The range provides protection to the skin and delicate organs like eyes, nose, ears, etc. which are directly exposed during outdoor bathing.
4	Dissolved Oxygen	5 mg/1 or more	The minimum dissolved oxygen concentration of 5 mg/1 ensures reasonable freedom from oxygen consuming organic pollution immediately upstream which is necessary for preventing production of anaerobic gases (obnoxious gases) from sediment. The biochemical oxygen demand of 3 mg/1 or less of the water ensures reasonable freedom from oxygen demanding pollutants and prevents production of obnoxious gases.
5	Biochemical oxygen 3mg/1 or less 3 days at 27' C:		The biochemical oxygen demand of 3 mg/1 or less of the water ensures reasonable freedom from oxygen demanding pollutants and prevents production of obnoxious gases.

Source: EP Rules, 1986

TABLE – 2.7

[SCHEDULE – VI]

[See Rule 3 (3A)]

GENERAL STANDARDS FOR DISCHARGE OF ENVIRONMENTAL POLLUTANTS

PART –A EFFLUENTS

SI. NO.	Parameter	Standards			
		Inland Surface	Public Sewage	Land for Irrigation	Marine Coastal areas
1		3 (a)	3 (b)	3 (c)	(d)
1	Colour and odour	See 6 of Annexure-1	…… ……	See 6 of Annexure-1	See 6 of Annexure-1
2	Suspended solids mg/1, Max	100	600	200	a) For process waste water- 100 b) For cooling water effluent 10% above total suspended matter of influent.
3	Particle size of suspended solids.	Shall pass 850 micron IS Sieve	… …....		c) Floatable solids max 3 mm. d) settleable solids, max 850 microns.
4	Ph Value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
5	Temperature	Shall not exceed 5^0 C above the receiving water temperature	…… …….	……………	Shall not exceed 5^0 C above the receiving water temperature

6	Oil and grease mg/1 Max.	10	20	10	20
7	Total residual chlorine mg/1 Max	1.0	…………	………..	1.0
8	Ammonical nitrogen (as N) mg/1 Max	50	50	………..	50
9	Total Kjedahi nitrogen[3] [N]; mg/1 Max	100	……….	…………	100
10	Free Ammonia [3] [NH_3] mg/1 Max.	5.0	……….	…………	5.0
11	Biochemical oxygen demand (5 days at 2^0 C) [3][mg/1 Max.]	30	350	100	100
12	Chemical Oxygen demand. Mg/1 Max.	250	…………	………….	250
13	Arsenic (as As) [1][mg/1 Max]	0.2	0.2	0.2	0.2
14	Mercury (as Hg), mg/1 Max.	0.01	0.01	…………..	0.01
15	Lead (as Pb), mg/1 Max.	0.1	0.1	…………	2.0
16	Cadmium (as Cd), mg/1 Max.	2.0	1.0	…………	2.0
17	Hexavalent chromium (as Cr+6), mg/1 Max.	0.1	2.0	………….	1.0

18	Total Chromium (as Cr), mg/1 Max.	2.0	2.0	……….	2.0
19	Copper (As Cu), mg/1 Max.	3.0	3.0	……….	3.0
20	Zinc (as Zn), mg/1 Max.	5.0	1.5	………	1.5
21	Selenium (as Se), mg/1 Max.	0.05	0.05	………	0.05
22	Nickel (as Ni), mg/1 Max.	3.0	3.0	………	3.0
23	Cyanide (as CN), mg/1 Max.	0.2	2.0	0.2	0.2
24	[1][Fluoride] (as Hg), mg/1 Max.	0.1	0.1	………	0.1
25	Mercury (as F), mg/1 Max	2.0	15	………	15
26	Dissolved phosphates (as P), Mg/l Max	5.0	-------	-------	------
27	Sulphide (as S), mg/L Max	2.0	-----	---	5.0
28	Phenolic compounds (as C6H5OH mg/l Max	1.0	5.0	----	5.0

29	Radioactive materials: (A) Alpha emitters [Micro curie/ml] Max. [B] Beta emitters [Micro curie/ml] Max.	0.0000001 0.00000	0.0000001 0.000001	0.0000001 0.0000001	0.0000001 0.0000001
30	Bio-assay test	90%survival of fish after 96 hrs in 100% effluent	90% survival of fish after 96 hrs in 100% effluent	90%survival of fish after 96 hrs in 100% effluent	90%survival of fish after 96 hrs in 100% effluent
31	Manganese (as Mn)	2 mg/l	2 mg/l	-------	2 mg/l
32	Iron (as Fe)	3 mg/l	3 mg/l	-------	3 mg/l
33	Vanadium (as V)	0.2 mg/l	0.2 mg/l	-------	0.2 mg/l
34	Nitrate Nitrogen	10 mg/l	-------	-------	10 mg/l

Note: 1.) All affects should be made to remove color and unpleasant odour as far as possible.

2.) The standards mentioned in this notification shall apply to all the effluent discharged such as industrial, mining and mineral Processing activities Municipal sewage etc.

Source: http://www.dpcc.delhigovt.in

CHAPTER 3

METHODOLOGY

Data from various sources have been collected such as CPCB, DJB, MCD, website of DPCC and samples were collected from the different locations of River Yamuna and some selected drains.

The following tests were conducted in laboratory of Delhi College Of Engineering:

1. PH
2. TDS
3. COD
4. DO
5. BOD

Tests were conducted as per standard methods with different instruments.

The different instruments are:

a) PH Meter
b) DO Meter
c) Multiparameter for TDS
d) COD incubator and spectrometer

PH Study: - Direct values were taken with the help of PH meter by dipping electrode in the sample. The pH value of water indicates the logarithm of reciprocal of hydrogen ion concentration present in water. It is thus an indicator of the acidity or the alkalinity of water. Since the pH is the log of reciprocal of H + the higher value of pH means lower hydrogen ion concentrations, and thus representing acidic solutions. If the pH of water is less than 7, it will be alkaline.

D O: - DO was find out with the help of DO meter. DO meter gives direct values by dipping DO electrode in the sample. In the raw water, the level of dissolved oxygen gives in idea about the purity of water, because it is the principal parameter responsible for the self-purification of water and for support to aquatic life. Water acutely lacking in dissolved oxygen content invariably contains gaseous impurities and substances in their reduced forms, such type of water becomes quite troublesome for the removal of impurities at the time of treatment of water, unless pretreatment of water is done ahead of the conventional water treatment. Deficiency of oxygen in the purified water gives rise to taste & odour problems; as such it is important to ascertain that no deficiency of dissolved oxygen is occurring in the water during its storage, transit & distribution.

C O D: - COD was find out by taking sample (1ml) and distilled water (1ml) in two different vials and acid reagent (1ml) and potassium dichromate (1.5ml) and then properly mixed. Then the vials were put in the incubation unit for 2 hours at 150 Degree Celsius. Then after cooling COD was find out with the help of spectrometer. This test is used for finding out the amount of oxygen required for the chemical oxidation of organic matter existing in the water, and it involves the use of strong oxidant like Potassium. Dichromate under the acidified condition of solution, this test gives an idea about the magnitude of pollution existing in the domestic and industrial waste waters. Therefore the purpose of this test is more or less same as the of BOD test. But this test fails to specifically differentiate between the biologically degradable organic matter and biologically inert organic matter and therefore BOD & COD test cannot be correlated directly. However the principal merit associated with COD test in that it takes much short time as compared to BOD test.

B O D: - BOD was find out by taking values of D O by measuring difference before and after incubation of other set of sample for 5 days at 20 Degree Celsius. Biochemical Oxygen Demand (BOD) refers to the amount of oxygen consumed by bacteria in stabilizing decomposable organic matter biologically under aerobic conditions. This test is carried out for knowing the consumption oxygen by bacteria in 5 days at 20 degrees Celsius, for the biological oxidation of organic matter. Since about 70 to 80 percent of the biological oxidation of organic matter takes place in 5 days, when sufficient oxygen exists in the water and the water environment remains aerobic.

The period of this test is restricted to 5 days, in order to avoid oxidation of Ammonia. The purpose of this test is to know about the organic matter existing in the water, which is biologically degradable. Thus it gives an idea about the degree of pollution existing in the raw water of the stage of self-purification process in the raw water. However the principal use of this test is limited to the wastewater treatment for assessing the efficiency of wastewater treatment process and to evaluate pollution load of wastewater and its effects on the natural water.

T D S: - TDS was find out with the help of electronic balance, oven, etc. Total Dissolved solids, as the name suggests, given the quantity of dissolved solids and in the lab. It’s measured quickly & automatically using the apparatus for determination of conductivity, DO etc. in which we first standardize the instrument for a fixed value of cell constant & then connect it for determination of T.D.S.

The value of Total Dissolved solids should not be more than 1000 mg/lit for irrigation, industrial cooling and controlled waste disposal.

CHAPTER-4

RESULTS & DISCUSSION

4.1 INTORDUCTION

A healthy river should contain at least 4mg/I of Dissolved Oxygen (DO) and a maximum of 3mg/I of Biochemical Oxygen Demand (BOD) in its water. Pathogens or the disease causing bacteria's indicated by faucal coli forms counts should not exceed 5000 per 100 ml of water. When sewage or industrial effluents containing pollutants (organic matters) are discharged into river, these draw oxygen from the river water for oxidation organic matter. Continuous discharge of pollutants results in depletion of DO in river water adversely affecting the flora and fauna of eco-system. Untreated sewage which also contains pathogenic or faecal matters gives rise to disease causing bacteria in the river water. When people take bath in the river pathogenic bacteria get transmitted to the human body impacting on their health.

Organic pollutants can be removed or minimized by proper treatment of swage. Treated sewage is required to be disinfected to kill the pathogenic bacteria before it is finally discharged in to water body.

4.2 CHARACTERISTICS OF DRAINS OF WATER AT DIFFERENT LOCATIONS

22 drains joins River Yamuna, causing heavy pollution in terms of BOD, COD and suspended soiled and also involve micro pollutants, which include generally pesticide, heavy metals, DDT, BHC. Characteristics of important drains are as under :-

TABLE-4.1:- Characteristics of various pollution loads and withdrawals

S. No.	Discharge/ Withdrawal	Flow (m^3/S)	D O (mg/I)	BOD (mg/I)	Load (tones/ day)
1.	Head water	15.0	8.10	6.00	-
2.	Wazirabad waterworks	-11.1	-	-	-
3.	Najafgarh drain	26.5	0.0	75.00	171.720
4.	Magazine Road Drain	0.04	0.0	308.18	1.1982
5.	Sweeper Colony drain	0.04	0.0	139.25	0.4813
6.	Khyber pass drain	0.04	0.0	42.60	0.1546
7.	Metcalf house drain	0.08	0.0	112.83	0.7506
8.	Qudusia + Mori Gate drain	0.20	0.0	156.30	2.7144
9.	Tonga Stand drain	0.05	0.0	184.30	0.7962
10	Civil Military drain	0.5	0.0	114.00	4.8923
11.	Power House drain	0.41	0.0	163.00	5.7276
12.	Sen Nusring Home drain	0.31	0.0	168.33	4.46606
13.	Drain No14	0.83	0.0	133.35	9.5282
14.	Barapulla drain	1.23	0.0	63.00	6.6951
15.	Hindon Cut	14.48	0.1	45.00	56.2944

16.	Maharani Bagh Drain	0.39	0.0	258.85	8.8117
17.	Agra Canal	-45.83	1.2	20.00	-
18.	Okhla Barrage	3.62	0.0	70.00	21.8938
Total					**296.119**

SOURCE: CPCB 2000, (-) SIGNS SIGNIFIES WITHDRAW

Samples were collected from 10 different drains i.e. Najafgarh drain, Magazine road drain, ISBT drain, Civil Military drain, Power House drain, Sen Nursing Home drain, Maharani Bagh drain, Sarita Vihar drain, Tuglakabad drain and Shahdara drain. The test results of the samples are as under:

TABLE 4.2 Water qualities of drains

Date of sampling: 09/04/09

S.No.	Locations	PH	TSS (mg /l)	COD (mg /l)	BOD (mg /l)
1.	Najafgarh drain	7.1	80	210	32
2.	Magazine road drain	6.9	170	350	150
3.	ISBT drain	7.2	42	266	80

4.	Civil Military drain	7.0	186	290	92
5.	Power House drain	7.0	390	450	170
6.	Sen Nursing Home drain	7.3	436	490	176
7.	Maharani Bagh drain	6.8	402	485	158
8.	Sarita Vihar drain	6.9	192	305	135
9.	Tuglakabad drain	7.1	290	405	125
10.	Shahdara drain	7.2	299	295	98

TABLE 4.3 Water qualities of drains

Date of sampling: 12/06/09

S. No.	Locations	PH	TSS	COD	BOD
1.	Najafgarh drain	7.2	90	220	35
2.	Magazine road drain	7.0	195	380	145
3.	ISBT drain	7.3	49	270	86
4.	Civil Military drain	7.2	180	289	98
5.	Power House drain	7.0	410	585	185

6.	Sen Nursing Home drain	7.6	425	540	172
7.	Maharani Bagh drain	7.1	390	450	162
8.	Sarita Vihar drain	7.2	205	310	140
9.	Tuglakabad drain	7.4	300	432	152
10.	Shahdara drain	7.3	310	302	120

TABLE 4.4 Water quality of drains

Date of sampling: 11/08/09

S. No.	Locations	PH	TSS	COD	BOD
1.	Najafgarh drain	7.0	75	185	34
2.	Magazine road drain	7.2	490	392	148
3.	ISBT drain	7.0	130	150	49
4.	Civil Military drain	7.1	210	380	136
5.	Power House drain	7.0	368	340	145
6.	Sen Nursing Home drain	7.5	230	258	78
7.	Maharani Bagh drain	6.9	239	368	125

8.	Sarita Vihar drain	7.0	298	456	150
9.	Tuglakabad drain	7.2	250	330	115
10.	Shahdara drain	7.4	190	220	38

TABLE 4.5 Water Quality Status of Drains

Date of Sampling: 02/06/2009

S.No	Name of Sample	PH	TSS (mg/l)	COD (mg/l)	BOD (mg/l)
	General Standard	5.5- 9.0	100	250	30
1	Najafgarh Drain	7.5	124	140	38
2	Metcalf House Drain	7.4	64	128	40
3	Khyber Pass Drain	7.5	26	44	11
4	Sweeper Colony Drain	7.1	184	288	120
5	Magazine Road Drain	7.1	240	444	180

6	ISBT Drain	7.4 56 244 70
7	Tonga Stand Drain	7.3 164 348 150
8	Moat Drain	No Flow No Flow No Flow No Flow
9	Civil Mill Drain	7.1 192 292 110
10	Power House Drain	7.2 460 660 220
11	Sen Nursing Home Drain	7.7 544 484 180
12	Drain No. 12A	- - - -
13	Drain No. 14	7.4 16 64 15

14	Barapulla Drain	7.6 276 168 60
15	Maharani Bagh Drain	7.3 420 448 180
16	Kalkaji Drain	7.6 44 48 14
17	Sarita Vihar Drain (Mathura Road)	7.6 234 344 140
18	Tehkhand Drain	7.3 328 456 170
19	Tuglakabad Drain	7.6 336 476 160
20	Drain Near LPG Bottling Plant	7.5 212 324 130
21	Drain Near Sarita Vihar Bridge	7.5 172 236 90

22	Shahdara Drain	7.5 384 248 96
23	Sahibabad Drain	7.4 670 612 210
24	Indrapuri Drain	7.5 380 424 170

Source: http://dpcc.delhigovt.nic.in

Test results and DPCC data shows that BOD varies from 34 mg/l to 220 mg/l. BOD in the samples collected in the month of June is slightly more. TSS found is more in the samples collected in the month August. All the drains discharging wastewater into River Yamuna either partially treated or not treated at all.

4.3 CHARACTERISTICS OF RIVER YAMUNA AT DIFFERENT LOCATIONS IN DELHI

River Yamuna is regularly being monitored by Central Pollution Control Board for assessment of water quality from its origin at Yamunotri to its confluence with Ganga River at Allahabad. It has been found that 22 km Delhi stretch of River Yamuna from downstream Wazirabad barrage to Okhla barrage is most polluted stretch of River Yamuna followed by Agra stretch. There is drastic change in Yamuna River water quality from Palla (upstream) to Niazamuddin old bridge and upstream Okhla barrage at Agra Canal as revealed by the water quality data. At Agra, the BOD ranged between 4 to 43 mg/I with annual average of 20 mg/I whereas Total coliform ranged between 2.1×10^6 to 17.1×10^7 Nos./100ml. This indicate that the river water quality is not confirming the Total Coliform standard i.e 5000 Nos/100 ml at most of the locations. The main reason of pollution in the river is the significant discharge of domestic and industrial waste from urban centers and over-extraction of river water for drinking and irrigation purposes.

During the past few decades the water quality of the river yamuna has been degraded. The major reasons of water quality degradation are:-

1. Rapid industrialization in river catchment area, discharge of treated & untreated industrial effluents.
2. Increase the population of towns located on its banks resulted increased domestic pollution loads.
3. Decrease in flow of river due to intensive use of surface & ground water in catchment area.

Generally 85%of pollution in River Yamuna is form the domestic resources & the unabated discharge of treated & untreated for deterioration of water quality in River Yamuna.

TABLE 4.6 Water quality in River Yamuna in Delhi during 1990-1998 and 2002

Parameter	Location	YEARS									
		1990	1991	1992	1993	1994	1995	1996	1997	1998	2002
PH	PALLA	8.1	8.21	8.00	8.1	8.4	8.0	8.31	8.2	8.22	8.38
	NZB	-	-	-	-	-	7.8	7.6	7.5	8.07	7.54
	OKHLA	7.6	7.7	7.7	7.6	7.6	7.8	7.5	7.4	8.15	7.64
Do	PALLA	8.46	8.1	7.1	7.3	6.9	9.0	9.3	7.5	10.50	9.9
	NZB	-	-	-	-	-	3.0	1.1	1.2	6.00	2.1
	OKHLA	.3	2.3	0.0	2.1	1.9	2.1	1.2	1.3	5.80	4.7
BOD	PALLA	3.00	3.10	3.30	3.60	2.30	2.70	3.10	2.30	2.00	4.00
	NZB	-	-	-	-	-	9.7	8.6	18.4	11.00	36.0
	OKHLA	22.6	25.6	19.0	37.5	49.7	15.0	18.2	16.0	12.0	21.0
COD	PALLA	11.50	12.60	10.20	10.90	8.30	18.20	49.20	9.50	20.00	
	NZB	-	-	-	-	-	31.0	56.1	63.6	67.80	
	OKHLA	69.5	58.2	57.0	108.5	87.0	49.2	72.1	61.5	70.00	
TC	PALLA	-	-	-	5483	36.45	8506	-	-	61000	102000

	NZB	-	-	-	-	-	386091	170318	402312	544000	26100000
	OKHLA	-	-	-	33437	91955	329312	-	-	474000	10000000
FC	PALLA	1505	3435	1580	795	193	3944	2901	743	750	6400
	NZB	-	-	-	-	-	141456	142682	376599	262000	1570000
	OKHLA	165710	188900	190210	40450	204250	184967	76136	273875	174000	260000
TKN	PALLA	0.63	0.60	3.10	1.30	1.10	-	-	-	-	
	NZB	-	*	-	-	-	9.19	-	-	-	
	OKHLA	9.2	8.9	9.5	9.2	10.9	13.4	-	-	-	
WT	PALLA	24.3	23.6	24.2	23.6	23.0	23.6	26.2	25.8	26.8	
	NZB	-	-	-	-	-	25.3	27.3	26.5	7.3	
	OKHLA	24.8	24.2	24.0	23.2	23.6	24.6	26.5	26.3	26.5	
AMM	PALLA	0.21	0.2	1.0	0.7	0.3	0.2	0.7	0.4	0.20	
	NZB	-	-	-	-	-	4.6	8.8	10.5	10.37	
	OKHLA	6.8	7.2	3.8	7.4	8.1	7.7	13.3	8.3	8.2	

Source: CPCB, 2000

NOTE :

NZB :Nizamuddin Bridge

DO :dissolved oxygen, mg/1

FC :Fecal Coliform, No./100 ml

BOD :Biochemical Oxygen Demand, mg/1,

TKN :Total Kjeldahal Nitrogen, mg/1

COD :Chemical Oxygen Demand mg/1,

WT :Water Temperature, Degree Celsius.

TC :Total Coliform, No. /100ml

AMM :Ammonia, mg/1

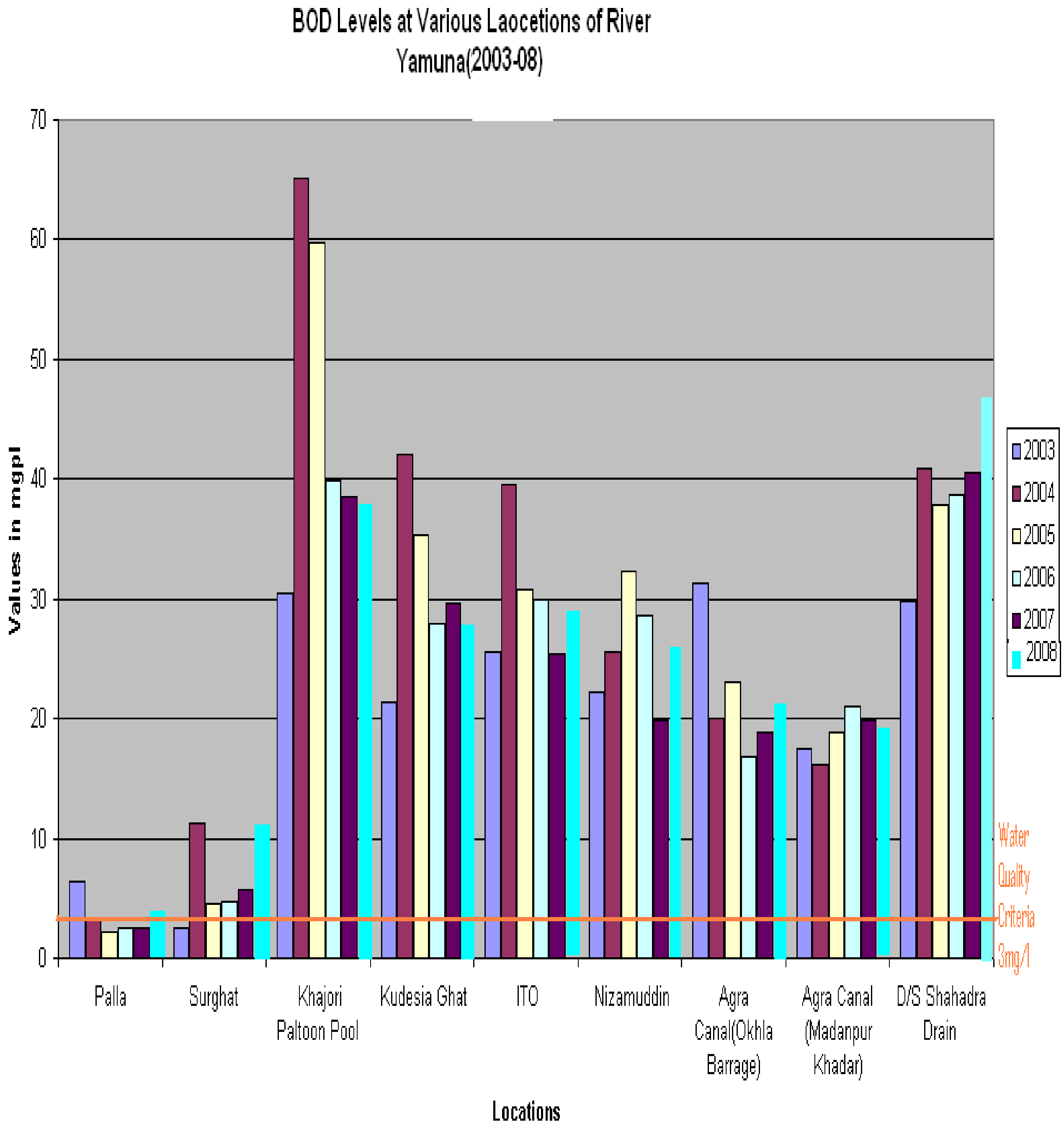
TABLE 4.7 Quality of water at different location (January – December 2003)

S.No	Parameters	Water Quality Standard for 'C' class		Monitored location		
				Palla	Nizamuddin Bridge	Agra Canal (Okhla Barrage u/s)
1.	Ph	6.5-8.5	Min	7.39	6.83	6.82
			Max	8.64	7.96	7.82
			Av	8.04	7.41	7.37
2.	Dissolved Oxygen, Mg/I	4.0	Min	5.6	0.0	0.0
			Max	12.3	4.6	3.9
			Av	8.1	0.9	0.9
3.	Bio-chemical Oxygen Demand Mg/I	3.0	Min	1	4	5
			Max	2	36	23
			Av	1	22	13
4.	Total Coliform Nos. /100 ml	5000	Min	400	500000	101000
			Max	4350000	890000000	262000000
			Av	427425	102508333	37522583
5.	Faecal Coliforms Nos./100 ml.	-	Min	120	40000	20000
			Max	7000	199000000	97000000
			Av	1943	18036333	15295083

Min=Minimum, Max=Maximum, Av=Average

Sources: CPCB 2003

FIGURE 4.1 Variation of BOD level at different locations at Delhi.



Source: http://dpcc.delhigovt.nic.in

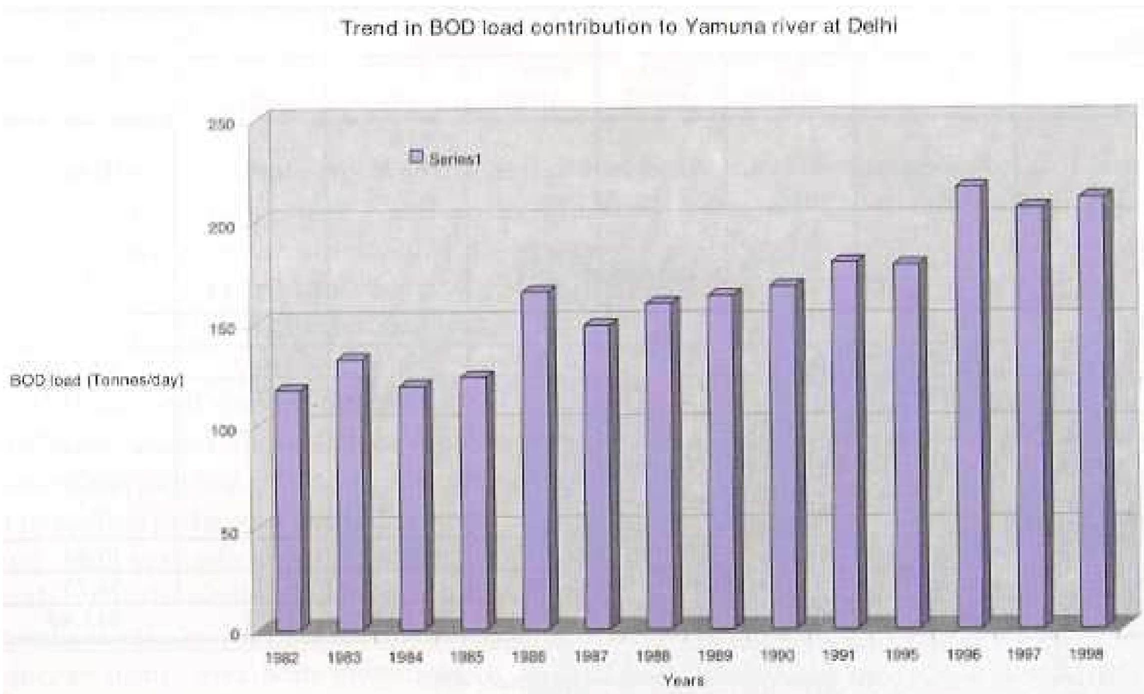


FIGURE 4.2 (SOURCE: CPCB)

Delhi generated 3300 million litres per day (MLD) of wastewater against the city treatment capacity for only 2190 MLD, contributing to the 79 percent pollution of the river Yamuna. The Government of NCT of Delhi has officially stated that over 200kms of its trunk sewer system is in a state of collapse. Most of the trans-Yamuna areas do not have a sewer system at all. Of the city's 44 resettlement colonies only 19 have sewer while only 523 of the 567 unauthorized but regularized colonies have sewers. Almost all i.e.1500 unauthorized colonies have no sewers, so this is the reasons behind environmental degradation of river Yamuna.

The Delhi segment of river Yamuna has characterized by high bacterial load (except at Palla) having high BOD with strong disagreeable order. The anaerobic condition in rivers is frequently reflected by masses of gaseous sludge rising from the bottom and floating at the surface at water. The CPCB is regularly monitoring the Yamuna river on monthly basis in Delhi segment at three locations i.e. Palla, Nizamuddin barrage and Okhla barrage. In addition, monitoring of 22 drains, which are the major source of pollution in the river are also being undertaken regularly. The major reason of pollution in river Yamuna is not only discharges from domestic and industrial sources but also over exploitation of fresh water available in the river, which is essentially required to maintain the self purification in the river. The total pollution load in terms of Biochemical Oxygen Demand carried by these 22 drains during the year 2002 is about 259.61 tonnes per day (TPD), out of which 248.67 TPD joins the river and the rest joins the canals.

Samples were also collected at different locations of River Yamuna i.e. Palla, D/S of Wazirabad, D/S of Najafgarh drain (Pontoon Pool), Kudesia Ghat, ITO Bridge, Nizamudin Bridge, Okhla Bridge (D/S of Shahdara drain) and at Jaitpur (Agra canal). Tests results are as under:

TABLE 4.8 Water quality status

Date of sampling: 5/12/08

S. N.	Locations	PH	TSS Mg/l	COD Mg/l	BOD Mg/l	DO Mg/l
1.	Palla	7.6	28	14	2	8.0
2.	D/S of Wazirabad barrage	7.0	35	30	9	5.5
3.	D/S of Najafgarh drain (Pontoon Pool)	7.2	120	125	40	NIL
4.	At Kudesia Ghat	7.3	64	89	30	NIL
5.	At ITO Bridge	7.8	50	70	32	NIL
6.	At Nizamudin Bridge	7.6	99	65	20	NIL
7.	D/S of Shadara drain (Okhla Barrage)	7.7	125	130	35	NIL
8.	Jaitpur (Agra canal)	7.8	110	92	26	NIL

TABLE 4.9

Date of sampling: 09/04/09

S. N.	Locations	PH	TSS Mg/l	COD Mg/l	BOD Mg/l	DO Mg/l

1.	Palla	8.2	18	20	2.9	8.0
2.	D/S of Wazirabad barrage	8.0	60	31	12	4.0
3.	D/S of Najafgarh drain (Pontoon Pool)	8.0	130	64	30	NIL
4.	At Kudesia Ghat	7.9	35	58	18	NIL
5.	At ITO Bridge	7.8	46	59	25	NIL
6.	At Nizamudin Bridge	7.8	34	87	32	NIL
7.	D/S of Shadara drain (Okhla Barrage)	7.6	55	150	54	NIL
8.	Jaitpur (Agra canal)	7.6	26	85	25	NIL

TABLE 4.10

Date of sampling: 12/06/09

S. N.	Locations	PH	TSS Mg/l	COD Mg/l	BOD Mg/l	DO Mg/l
1.	Palla	8.0	18	21	2.5	7.5
2.	D/S of Wazirabad barrage	7.2	48	34	16	3.0
3.	D/S of Najafgarh drain (Pontoon Pool)	8.0	63	102	30	NIL
4.	At Kudesia Ghat	7.8	32	92	28	NIL
5.	At ITO Bridge	7.8	52	154	34	NIL
6.	At Nizamudin Bridge	7.6	100	86	28	NIL
7.	D/S of Shadara drain (Okhla Barrage)	7.8	182	162	46	NIL
8.	Jaitpur (Agra canal)	7.9	58	151	26	NIL

TABLE 4.11

Date of sampling: 11/08/09

S. N.	Locations	PH	TSS Mg/l	COD Mg/l	BOD Mg/l	DO Mg/l
1.	Palla	7.5	35	15	2.5	5.9
2.	D/S of Wazirabad barrage	7.2	52	35	10	3.5
3.	D/S of Najafgarh drain (Pontoon Pool)	7.3	169	150	39	NIL
4.	At Kudesia Ghat	7.1	175	145	35	NIL
5.	At ITO Bridge	7.0	60	89	24	NIL
6.	At Nizamudin Bridge	7.2	80	95	26	NIL
7.	D/S of Shadara drain (Okhla Barrage)	7.4	250	190	39	NIL
8.	Jaitpur (Agra canal)	7.5	85	60	20	NIL

STANDARDS: -

PH : - 6-9

BOD : - 3 mg/l Max.

DO : - 4 mg/l Min.

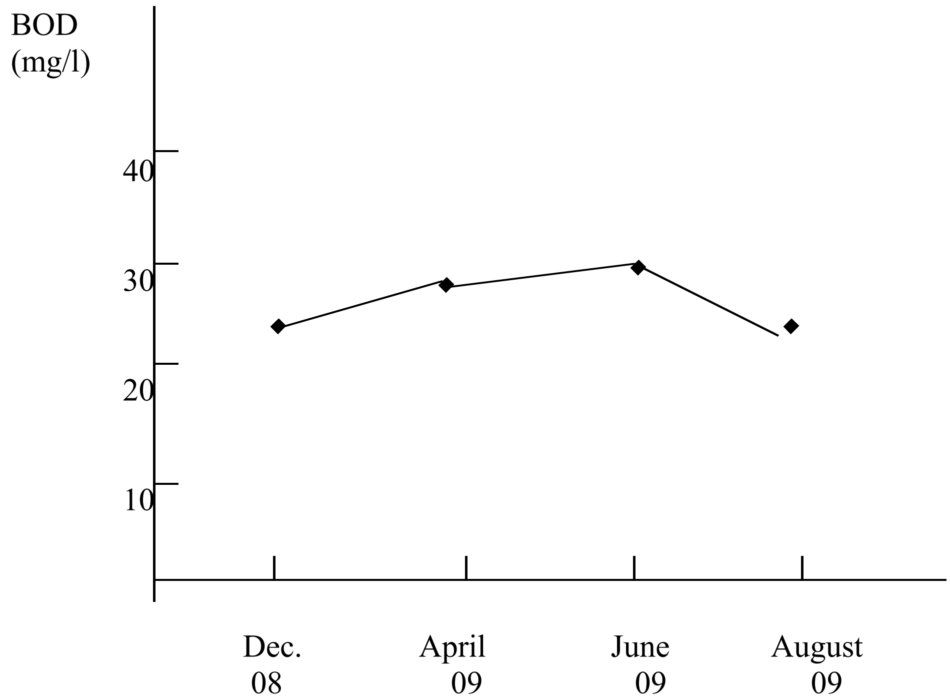


FIGURE 4.3 V**ariation of BOD at different seasons**

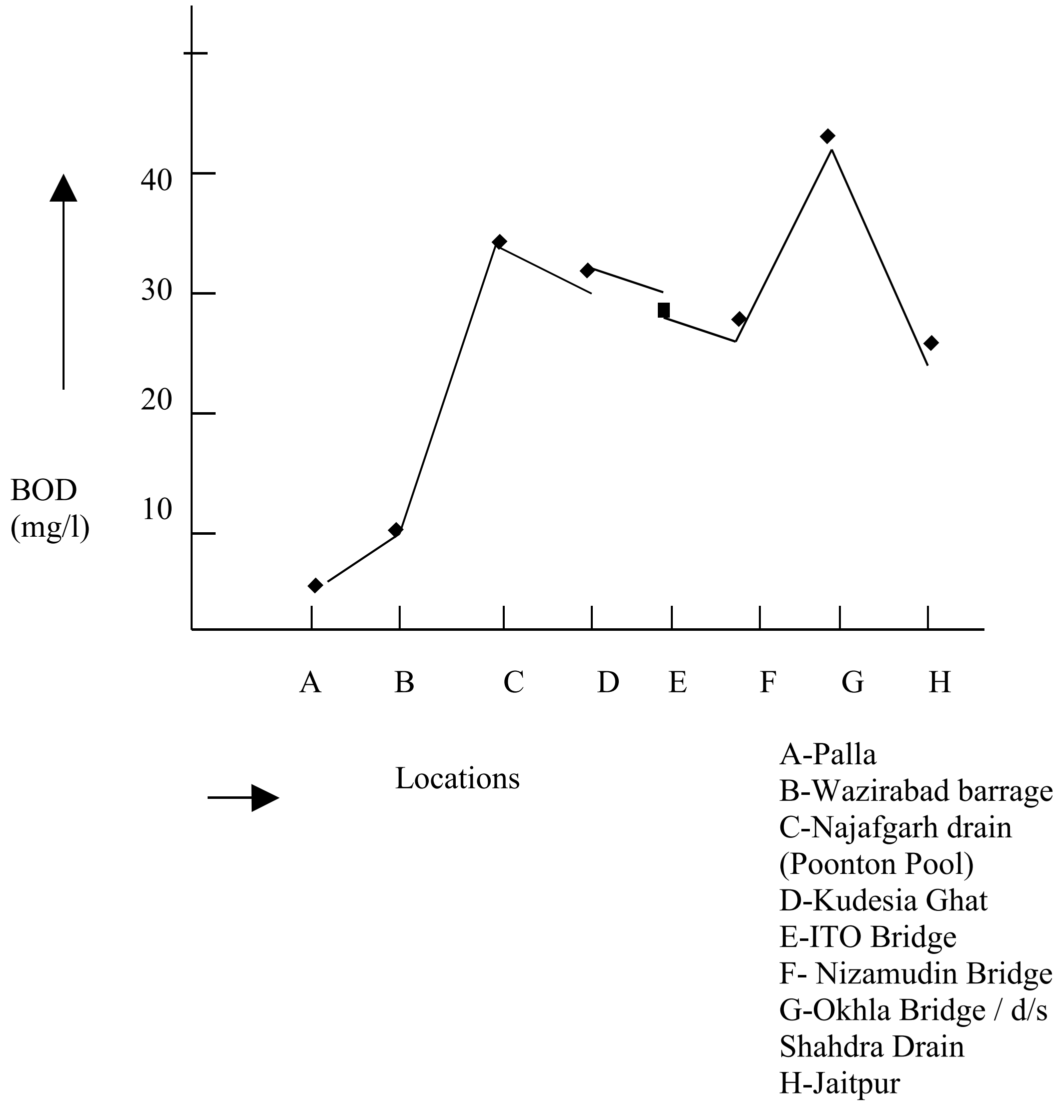


FIGURE 4.4 V**ariation of BOD at different locations**

TABLE –4.12 Water quality status of River Yamuna

Date of Sampling: 04.11.2008

S. No.	Locations	PH	TSS (Mg/I)	COD (Mg/I)	BOD (Mg/I)	DO (Mg/I)	Total Coliform (MPN/100ml)
Water Quality Criteria ('C' Class)		6.0-9.0	-	-	3(max)	4(min)	5000
1.	River Yamuna at Palla	7.8	32	12	2	9	16000
2.	Surghad (Down stream of Wazirabad Barrage)	7.8	38	28	10	6.5	230000
3.	River Yamuna at Khajori Paltoon Pool (Down stream Najafgarh Drain)	7.7	138	128	42	NIL	950000
4.	River Yamuna at Kudesia Ghat	7.6	76	80	28	NIL	640000
5.	River Yamuna at ITO Bridge	8.0	52	82	26	NIL	750000
6.	River Yamuna at Nizamudin Bridge	7.6	96	64	22	NIL	260000
7.	Agra Canal (Okhla)	7.9	60	48	15	NIL	430000
8.	River Yamuna after meeting Shahdara Drain (Downstream Okhla Baragge)	7.4	118	132	38	NIL	1200000
9.	Agra Canal (Jaitpur)	7.7	114	96	28	NIL	530000

Source: http://dpcc.delhigovt.nic.in

TABLE –4.13 Water quality status of River Yamuna

Date of Sampling 01.04.2009

S.No.	Locations	pH	TSS (mg/I)	COD (mg/I)	BOD (mg/I)	DO (mg/I)	Total Coliform (MPN/100ml)	Ammonicla Nitrogen (As NH_3)
Water Quality Criteria ('C' Class)		6.0-9.0	-	-	3(max)	4(min)	5000	-
1.	River Yamuna at Palla	8.3	16	16	2.7	8.0	-	ND
2.	Surghad (Down stream of Wazirabad Barrage)	8.2	68	32	8	6.0	-	ND
3.	River Yamuna at Khajori Paltoon Pool (Down stream Najafgarh Drain)	8.2	136	68	23	NIL	-	0.9
4.	River Yamuna at Kudesia Ghat	7.7	38	60	19	NIL	-	0.76
5.	River Yamuna at ITO Bridge	7.5	48	52	18	NIL	-	0.94
6.	River Yamuna at Nizamudin Bridge	7.8	36	96	26	NIL	-	0.8
7.	Agra Canal (Okhla)	7.9	24	58	16	NIL	-	0.7
8.	River Yamuna after meeting Shahdara Drain (Downstream Okhla Barage)	7.5	58	164	44	NIL	-	2.1
9.	Agra Canal (Jaitpur)	7.7	32	80	21	NIL	-	1.8

Source: http://dpcc.delhigovt.nic.in

TABLE-4.14 Water quality status of River Yamuna

Date of Sampling 02.06.2009

S. No.	Locations	pH	TSS (mg/I)	COD (mg/I)	BOD (mg/I)	DO (mg/I)	Total Coliform (MPN/100 ml)	Ammonicla Nitrogen (As NH_3)
Water Quality Criteria (‘C’ Class)		6.0-9.0	-	-	3(max)	4(min)	5000	-
1.	River Yamuna at Palla	7.8	22	16	1.5	5.8	-	Nil
2.	Surghad (Down stream of Wazirabad Barrage)	7.1	30	36	8	2.4	-	0.02
3.	River Yamuna at Khajori Paltoon Pool(Down stream Najafgarh Drain)	7.4	48	124	32	NIL	-	0.2
4.	River Yamuna at Kudesia Ghat	7.4	40	112	28	NIL	-	0.5
5.	River Yamuna at ITO Bridge	7.5	54	164	46	NIL	-	0.6
6.	River Yamuna at Nizamudin Bridge	7.6	108	80	24	NIL	-	0.32
7.	Agra Canal (Okhla)	7.9	52	88	27	NIL	-	0.26
8.	River Yamuna after meeting Shahdara Drain (Downstream Okhla Barage)	7.5	256	184	48	NIL	-	0.77
9.	Agra Canal (Jaitpur)	7.7	50	176	28	NIL	-	0.26

Source: http://dpcc.delhigovt.nic.in

Tests results and data from DPCC website shows that dissolved oxygen is nil at all locations except Palla and at Wazirabad Barrage. Even during monsoon it does not meet the standards. It is due to addition of wastewater from 22 major drains. BOD Values at Palla only is with the specified limit i.e. 3 mg/l max. At all other locations it varies from 10mg/l to 54 mg/l averaging 26 mg/l. In summers values of BOD increases slightly.

4.4 WATER QUALITY STATUS OF RIVER YAMUNA AROUND DELHI

Yamuna is the largest tributary of river Ganga and the main source of fresh water in Northern India. Originating from Himalayas, its total length is 1.376km covering a catchments area of 366.220 km^2 besides irrigation, The river provides a source of drinking water and bathing. Three major barrages are located on river Yamuna, namely Tajewala, Wazirabad, and Okhla, diverting water for irrigation and other uses.

The river water in upper segment is relatively unpolluted. Downstream of Tajewala, domestic and industrial wastewaters from urban and rural areas are discharged into the river.

The Delhi Reach, located between two barrages, has practically no perennial flow of its own and receives partly treated and untreated wastewater effluents from Delhi. Therefore, this stretch is the most polluted segment. The BOD load is observed to be 27 mg/l (almost similar to treated wastewater) at Nizamuddin Bridge in Delhi.

Yamuna water downstream of Okhla barrage up to the confluence with the Chambal River is eutrophicated and BOD loads at Mazawali and Agra downstream is above 30mg/l.

TABLE – 4.15 Characteristics of river quality at various segments

Parameters Average Value	Himalayan Segment	Upper Segment	Delhi Segment	Eutrophicated Segment	Diluted
Temps ^{O}C	19.6	22.4	25	25.7	24.5
D .O. (mg/1)	8.05	9.7	3.2	6.8	7.9
B .O.D (Mg/1)	0.6	1.1	17	8.0	1.9
T. D.S. (mg/1)	200	270	563	793	470
R esp. Rate gm./$_{O\ 2/m^2\ /d}$	0.90	1.4	4.6	2.02	1.00
Photosynthesis rate gm/$O_{2/m^2\ /d}$	1.02	1.54	0.85	4.49	1.06
Chlorophyltx	500	11.76	36.61	169.5	54
P/r ratio	1.15	1.10	0.18	2.18	1.o6
Total coliform	7129	9557	10822	45297	11505
Faecal coliform	172	352	135089	49614	2466
Tropic state	Oligotroplic	Oligotroplic	Polytropic	Antrophic	Oligotroplic

Source: CPCB, 2000

TABLE –4.19 Primary water quality criteria for designated best use classes

Designated –Best-Use	Class of Water	Criteria
Drinking water source without conventional treatment but after disinfections	A	1. Faecal Coliforms organism MPN/ 100ml shall be 50 less. 2. pH between 6.5 and 8.5. 3. Dissolved oxygen 6mg/I or more 4. Biochemical oxygen demand 5 days 20°c 2mg/I or less.

Outdoor Bathing (Organized)	B	1. Faecal Coliforms Organism MPN/ 100ml shall be 500 or less. 2. PH between 6.5 and 8.5. 3. Dissolved oxygen 5mg/I or more 4. Biochemical oxygen demand 5 days 20^{o}c 3mg/I or less
Drinking water source after conventional treatment and disinfections	C	1. Faecal Coliforms organism MPN/ 100ml shall be 5000 less. 2. PH between 6 and 9 3. Dissolved oxygen 4mg/I or more Biochemical oxygen demand 5 days 20^{o}c 3mg/I or less.
Propagation of wild life and fisheries	D	1. PH between 6.5 and 8.5. 2. Dissolved oxygen 4mg/I or more 3. Free Ammonia (as N) 1.2mg/I or less.
Irrigation, Industrial cooling, controlled waste disposal	E	2. PH between 6.0 to 8.5 3. Electrical conductivity at 25^{o} C micro mhos/ max.2250 4. Sodium absorption ratio max. 26 5. Boron max.2mg/I.

(SOURCE: CPCB)

TABLE –4.16 BOD status in and around Delhi

S.N.	LOCATION	BOD (mg/l)

1.	Tejawala Hathni Kund	1.0
2.	Kalanaur	1.o
3.	Sonipat	1.0
4.	Palla	2.0
5.	Nizamudin Bridge	27.0
6.	Agra canal	10.0
7.	Mezawali	32.0
8.	Mathura u/s	6.0
9.	Mathura d/s	6.0
10.	Agra u/s	6.0
11.	Agra d/s	39.0
12.	Etawah	6.0

SOURCE: - CPCB, 2003

TABLE –4.17 Water quality segment of River Yamuna

S.NO.	**Segments**	**Length of Segments (km.)**	**Reason for critically of pollution**
1.	Wazirabad to Okhla	22	Domestic & Industrial waste water of Delhi
2.	Okhla to Virindavan	140	Domestic & industrial waste from Mathura & Virindavan
3.	Virindavan to Mathura	14	Domestic & Industrial waste from Mathura & Virindavan

4.	Mathura to Etawah	165	Domestic wastes water from agra Etava

Source: CPCB, 2009

4.5 REASONS FOR DECLINING WATER QUALITY AT DELHI

With the population rising at an alarming rate, the amount of wastewater generated by domestic and industrial activities has increased during 1961-99. There is a growing lag between increased wastewater discharges and treatment capacities and this will worsen the quality of existing raw water sources and increase the costs for treatment. Domestic sources contribute maximum to wastewater discharges. Industrial discharges are, however, maximum in Rithala and Keshopur zones. The present sewage treatment capacity of Delhi Jal Board (DJB) is of the order of 512 MGD and utilization is only 390 MGD The DJB on an average, produces about 775 MGD of drinking water. About 80 percent of it returns as wastewater. All most all the unauthorized colonies have no sewers. There is, therefore, a small gap between the sewage treatment capacity presently available and the capacity required treating the wastewater.

Pictures related to river Yamuna pollution

FIGURE 4.5 Drain joining Yamuna River

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FIGURE 4.6 Washing of clothes in River Yamuna at dhobi ghats.

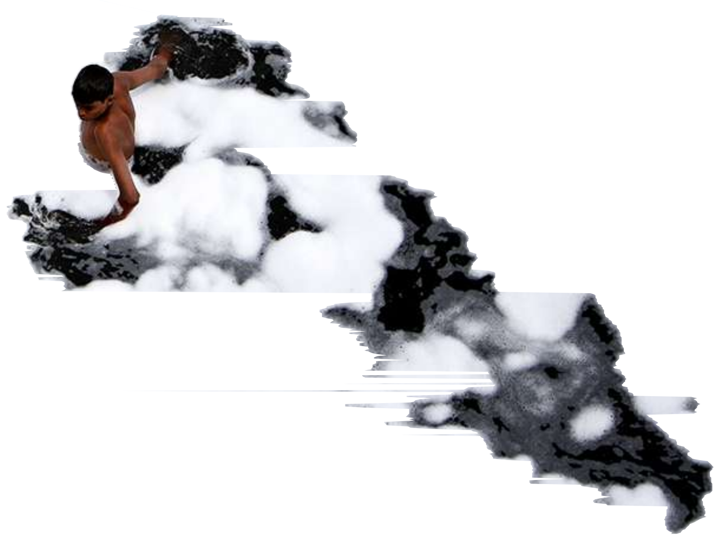

FIGURE 4.7 Formation of foam due to oily substances and chemicals

FIGURE 4.8 Najafgarh drain

FIGURE 4.9 Solid waste disposals

FIGURE 4.10 Washing of clothes

FIGURE 4.11 Immersion of idols in River Yamuna

FIGURE 4.12 Collection of samples at D/S of Wazirabad Barrage.

CHAPTER-5

INITIATIVE TAKEN BY GOVERNMENT TO CONTROL POLLUTION IN RIVER YAMUNA

5.1 INTRODUCTION

Though numerous attempts have been made to clean it, the efforts have proven to be futile. The main reasons for this is due to high density of population living in Delhi, the dumping of untreated water and solid waste in to it (mostly illegally), the lax attitude of the government and mismanagement of projects focused at cleaning it. Also the water in this river remains stagnant for almost 9 months in year aggravating the situation.

WATER QUALITY

Water of the Yamuna River in the Capital is not fit for drinking even after treatment and disinfection, a classification report of the Central Pollution Control Board (CPCB) said. As per the CPCB's best use classification, the quality of water in the river in the stretch between Wazirabad and Okhla was class E, which meant the water was only suitable for irrigation, industrial cooling and controlled waste disposal, the report said. However, the quality of water as it entered the city at Palla till Wazirabad, from where industrial activity and dense settlements began, was classified C, indicating it was suitable for drinking after conventional treatment and disinfection.

I. ALTERNATIVE MEASURES.
II. YAP (YAMUNA ACTION PLAN)

5.2 ALTERNATIVE MEASURES.

(A). SEWERAGE COMPONENT

Intercepting and trunk sewers are provided to capture the untreated sewage from the drains/pumping stations out falling into the river. The intercepted sewage is taken to a sewage treatment plant for removing the organic as well as pathogenic pollution. Appropriate technologies such as well as pathogenic pollution. Appropriate technologies such as activated sludge process, up flow Anaerobic Sludge Blanket (UASB) digester, oxidation ponds, agro-forestry etc. are used for treatment of sewage. Low cost technologies like oxidation ponds are well suited to address the pathogenic pollution. However, availability of land for pond becomes a limitation to use this system in large towns. The older methods of controlling pathogenic pollution are chlorination of treated sewage, Ultra Violet (UV) disinfection etc. Higher running cost of these methods is a limiting factor in Indian conditions.

(B) NON SEWERAGE COMPONENT

LOW COST SANITATION

The Low Cost Sanitation scheme under YAP mainly consists of community toilet complexes provided at strategic locations in a town like bus depots, market places etc. as well as in slums and other areas inhabited by economically weaker sections (EWS) of people who do not have good sanitation facilities. This will reduce pollution of the town as well as of the river as people will not have to go for open-air defecation and urination.

(C) ELECTRIC AND IMPROVED CREMATORIA

From religious point of view, people prefer to cremate human bodies on the banks of river, and sometimes partly burnt bodies are thrown into it. The firewood requirement is high per dead body. Therefore, provisions of crematoria have been made under YAP schemes. These will ensure complete burning of the bodies, saving the river pollution due to dead bodies and consume less wood thereby saving trees.

(D) PLANTATION AND LAND SCAPING

Plantation has been done along Yamuna and it carries considerable amount of flow around the facilities created under YAP, wherever land was available for such purposes.

5.3 YAMUNA ACTION PLAN (Phase- I & II)

In India, big cities have been experiencing rapid growth of urban population and industrialization. The river water quality across the country has experienced deterioration. Therefore, it was inevitable for the Government of India to prepare plan for sustainable pollution abatement in rivers across the country. River Ganga, being one the most sacred and largest in the country, was identified for priority intervention in 1985. The Central Pollution Control Board (CPCB), India, carried out a study and the results were presented in the report titled "Basis, Sub-basin Inventory of Water Pollution-Ganga Basin" in 1984. This report emphasized on the pollution level of River Ganga and its tributaries and the attention was drawn towards pollution abatement. This also resulted into launching of a program called "Ganga Action Plan (GAP)" by the Government of India in 1985, as a five year program with the aim of improving water water quality in Ganga River. A government body called the "Central Ganga Authority" was formed under the chairmanship of the Prime Minister to develop policy decision and to monitor the plan. An organization called "Ganga Project Directorate" was established in the Ministry of environment and Forests (MoEF) by the Central Ganga Authority to deal with the program under the GAP. Later on, the activities of GAP were also extended to other rivers including Yamuna, Gomati, Damodar. The National River Conservation Plan (NRCP) was formulated and the Ganga Project Directorate was transformed into the present body, the "National River Conservation Directorate (NRCD)".

5.3.1 YAMUNA ACTION PLAN PHASE-1 (YAP-I)

In order to reduce the pollution in river Yamuna, YAP-I was launched by the Ministry of Environment and Forests (and implemented by NRCD) in 1993 with Japan's ODA loan amounting to 17.77 billion yen (700 cr) with an interest rate of 2.6% and repayment period of 30 years including a 10-year grace period. Under YAP-I, 15 Class-I towns including six in Haryana, eight in Uttar Pradesh State and Delhi were covered. Pollution arising from the domestic sector was considered to be major concern and given the highest priority. At the time of project formulation it was estimated that by 1997 (the design year) the total population in 15 towns would be 34.75 million and corresponding sewage generation was estimated to be 2.953 million m^3/day. Excluding Delhi, none of these towns had any sewage treatment arrangement. Thus, there was a need to prioritize and develop wastewater collection and treatment facilities in these towns. The project was originally planned to be completed by April 2000,but was later extended until February 2003.

Broadly two types of schemes were taken up in YAP-I including sewerage and non–sewerage components. Sewerage schemes comprised construction of drain interceptors, diversion sewer lines, sewage pumping stations, and rehabilitation and construction of sewage treatment plant (STP). The sewer networks and house connections were not included in the YAP-I because of the difficulty of gathering the relevant basic data and records.

Altogether 29 STPs were constructed with a total treatment capacity of about 726,000m^3 /day. Non-sewerage component included works on low-cost sanitation, river front development, improved crematoria, plantation, and public participation and awareness. Under low-cost sanitation works, total 1,216 sets of public toilets were constructed. Improved wood based crematoria were established at 98 locations and river front improvement works were carried out at nine locations. Public participation workshop were also organized 7023 times during the entire project period to raise the level of public participation and awareness related to pollution abatement activities.

5.3.2 YAP-II: POLLUTION CONTROL ENHANCEMENT IN YAP AREA

Based on the success and lessons learned from YAP-I, JBIC signed a new Loan Agreement in March 2003 for the ongoing YAP Project as a continuation and expansion of the earlier program. The Loan Agreement provided financial assistance of 13.33 billion yen (624 cr). Besides construction and rehabilitation works of STPs and trunk sewers, the following components are included in YAP-II.

- Public Participation and Awareness (PP&A) Programs on public involvement in the decision making process by utilizing numerous NGOs.
- Public Relations/Information Program in Delhi.
- Institutional Strengthening and Capacity Building of the Urban Local Bodies (ULBs).
- Capacity Building for NRCD (which is executing agency for this Project).
- Water Quality Monitoring Program.
- O&M Study on YAP-I Assets
- Engineering Technology Transfer to ULBs in Haryana

The YAP-II project commenced in December 2004 and is expected to be completed by November 2009. Delhi being major polluter receives a proportionally higher share of fund allocation in this program. Under YAP-II, sewerage components include construction and rehabilitation of trunk sewers Ring Road, Bela Road, Wazirabad. Okhla STP extension, Keshopur STP rehabilitation in Delhi; construction of STPs and SPSs in UP.

5.4 INITIATIVE TAKEN BY MCD UNDER YAP-II

The Yamuna River is one of the major sources of fresh water in Northern India. Due to the extremely high rate of growth of the urban population and the significant agricultural and animal husbandry activities in the watershed, the water quality of the river has continued to experience severe deterioration from organic pollutions. This deterioration has a significant impact on the health and welfare of millions of Indian citizen living in the town situated adjacent to the Yamuna River.

The Yamuna Action Plan (YAP) Phase-I project was launched by the Ministry of Environment and Forests (MoEF) and implemented by the National River Conservation Directorate (NRCD) in 1993 with the objective of restoring the water quality of the Yamuna River to an acceptable standard.

Building on the success and lessions learned from YAP-I, JBIC signed a new Load Agreement for Rs. 624 Crores with MoEF GOI with Delhi share as Rs.387 crores on March 31, 2003 for the current YAP-II Project as a continuation and expansion of the Phase-I Program. The share of Govt. of India in the project will be Rs.329.09 crores and that of Govt. of Delhi will be Rs.58.08 crores, on 85:15 basis.

Out of above 387.17 crores of Delhi shares MCD's components for implementation of works amount to Rs. 49.08 crores as detailed below:

TABLE -5.3

S.No.	Name of Components	Cost (Rs. in crores)	Status as o 30.04.2009
1.	Institutional Capacity Building.	5.00	
	a) High Resolution Satellite Imagery.		Completed
	b) Reform action Plan		Study completed
2.	Public Participation & Awareness	12.00	
	a) Clean Yamuna Manch		In progress
	b) School Health & Hygiene Programme		In progress
	c) Region Specific Innovative Programme		In progress
3.	Dairy Farm Waste Management Project including demonstration plant, MCD, Delhi.	12.10	In progress
4.	Dhobi Ghat Improvement Project including demonstration plant MCD, Delhi (Dhobi Ghat Sudhar Yojna).	2.50	In progress
5.	Study & DPR on improvement of electric Crematoria & Demonstration Plant (Antim Niwas Sudhar Youjna).	3.00	In progress
	Dropped/ Transferred Components		
6.	Integrated Wastewater Management (IWM) through Decentralized Wastewater Treatment (DWT) and wastewater reuse including Demonstration Plant.	10.40.	Transferred to DC (Revenue)
7.	Slum Rehabilitation	3.30	Transferred to Depts. Of UD, GNCTD
8.	Delhi Slaughter House Modernization and Waste Management Project.	1.50.	Dropped
	Total	**49.8**	

Out of the 49.8 crores allotted for Municipal Corporation of Delhi, 85%, i.e. Rs. 42.33 crores will be given by NRCD (MoEF), Govt. of India and the balance Rs.7.47 crores will be released by GNCTD towards its 15% Share.

5.5 LATEST INITIATIVE TAKEN BY DELHI JAL BOARD.

At present, treated effluent from the STPs is discharged into open drains that finally discharge into River Yamuna. These drains, on their way, collect the untreated waste from large parts of the city, where sewerage network is not yet laid. The sewage finds its way into the open drains and finally flows to River Yamuna through larger drains. This mixing of untreated sewage with treated effluents negates the pollution- control efforts.

For reduction of pollution in River Yamuna, DJB evolved a new concept of "Interceptor Sewer" along the three major drains to check untreated sewage from flowing in to the Yamuna.

<u>SALIENT FEATURES OF THE PROJECT: -</u>

(i) Laying of interceptor sewers in length of around 50 kms along three major drains of Irrigation & Flood Control Department {i.e. Najafgarh (25 km), Supplementary (15 km) and Shahadra (10 km)} to intercept sewage flowing in their subsidiary small drains and conveying to the nearest Sewage Treatment Plants for treatment to ensure that only treated sewage is discharged into drains. Cost of this project is Rs.1800 cr.

(ii) Augmentation of the existing capacity of Sewage Treatment Plants at the mouth of Delhi Gate drain and Dr. Sen Nursing Home Drain constructed as Pilot plants under YAP-I, from existing 2.2 MGD to 15 MGD at each plants.

(iii) Intercepting 13 small drains into Bela Road and Ring Road Trunk sewer after rehabilitation. The work of rehabilitation is being carried out under YAP-II.

(iv) Construction of additional Sewerage Treatment Plants after utilization of full capacity of existing plants. i.e. up-gradation of existing STP at Okhla and Keshopur.

ADVANTAGES OF THE PROJECT: -

a) Both the river as well as the major drains would be protected and would not carry any untreated effluent.
b) There would be no duplication of effort regarding treatment of effluent, as would be the case if STPs were set up at the mouth of the drain.
c) The sewage from more than 1500 unauthorized colonies and other unsewered areas, including rural village and JJ Clusters would be trapped before it is per mitted to reach all the major drains. This would be important in the context of statistical factor that otherwise it would take several years to sewer these unauthorized colonies. The interceptor sewers would be completely independent and neutral to the time frame within which unauthorized colonies will be sewered.
d) Since new STPs would only be put up after the capacity of the existing underutilized STPs is fully utilized, it would have a positive impact on the cost factor also.
e) As against an STP creation capacity of 507 MGD required for the STPs at the mouth of the drain concept, the interceptor sewer concept would need only two or three additional STPs in the course of the next 2-3 years for around only 140 MGD capacity.

This would ensure that the three major drains, which account for 70% of the pollution problem, receive only treated effluent and, therefore, the quality of water entering the river will improve.

.

OTHER STAKEHOLDERS:

There following other stakeholder who are directly or indirectly involved in cleaning of River Yamuna:

Action to be taken by various stakeholders:

IRRIGATION & FLOOD CONTROL DEPARTMENT: -

i) The wall along these drains is to be constructed in the phased manner especially in inhabitant areas to prevent dumping of garbage into the drains.

ii) Desiliting is to be carried out to maintain the flow in these drains.

iii) The steel mesh is to be provided at various bridges/ flyover to prevent the dumping of garbage.

M.C.D.:

Similar action is to be taken by MCD in addition to penalizing the defaulters dumping the garbage into the drains and awareness among the public.

DSIDC:

i) To accommodate 28 industrial areas, 14 CETPs were to construct.

ii) 10 CETPs have been constructed and commissioned which have been handed over to the industrial associations for further maintenance.

iii) 1 CETP is being constructed and likely to be commissioned shortly.

iv) Further study is being conducted to accommodate the discharge of all the industrial estates into these 11 CETPs.

D.D.A.:

DDA has removed almost all the JJ cluster/ unauthorized encroachments within the bed of river Yamuna except for some places, which are under dispute.

It is important to mention that without the combined efforts of all the stakeholders, the expected result may not be achieved.

BASIC FACTS ABOUT SEWAGE TREATMENT: -

- Water produced : 775 MGD.
- Swage Generated @ 80% : 620 MGD.
- Installed Capacity of STO : 512.4 MGD
- Utilization : 390 MGD.

UNSEWERED AREAS

Colonies/ village	Total	Sewered	unsewered
Unauthorized /Regularized	567	523	44
Urban village	135	108	27
Rural village	189	0	189
Unauthorized colonies	1500	0	1500
JJ Cluster	1080	Nil	1080

CHAPTER- 6

CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSIONS

1) As it was expected the analysis shows the pollution load in river Yamuna, in an around Delhi. Except for pH & TDS, all the parameters are crossing the standard limits and its unfortunate that in spite of such a high level of pollution people are still using for various purposes like swimming, fishing and other such purposes at various sites where from samples were collected. Therefore it is very dangerous for the health of those, specially, who are dwelling in the nearby are and using this water frequently.
2) Though large sum of money is being spent by the government under Yamuna Action plan to save this river from pollution but that is very difficult to achieve without sufficient level of general awareness towards this issue.
3) Results indicate 3 major points of concern from pollution point of you i.e. B.O.D., DO & Total Coilforms. The major cause of the problem as identified in this project is mainly the absence of minimum fresh water flow required in the river, which is due to the fact that large amount of water is being taken away from the river at Tajewala through two canals. After that the water is regenerated by groundwater till it reaches Delhi wherein the effluent from the industries into from Haryana are also mixed in the river. As it reaches Delhi again water in stopped at

Wazirabad and after that what constitutes the flow is mainly a huge load of sewage, which is disposed off into the river. This problem is further accentuated due to the political activities and intervention. Due to which its not been possible to maintain the minimum fresh water flow of 10 cusec per second even after Supreme Court's decision. Along with this the malfunctioning of the STP's lack of power and poor infrastructural facilities are prominent features worsening the situation.

4) Bacteriological contamination is significantly high in the entire Yamuna River stretch. Total Coliforms are generally well above the prescribed water quality standard even sometimes at Yamunotri also. The microbiological analysis confirms that human beings predominantly contributed the bacteriological contamination.
5) Micro-pollutants were studied in the stretch between Delhi and Agra. Cadmium, Nickel and Lead were rarely present in the river, whereas zinc and iron were generally present. Among pesticides, BHC was generally present in studied stretch, whereas other monitored pesticides e.g. Aldrin, Dieldrin, endoslfan, & DDT were present rarely. The micro-pollutants were generally observed during dry seasons. Study of micro-pollutants reflects gradual decrease in the level of micro-pollutants.
6) Seasonal variation in BOD reflects that upto Palla generally BOD meets the limits during both monsoon and non-monsoon period. After Delhi, BOD exceeds the limit till Chambal confluence during non-monsoon period; however, during monsoon after Agra the BOD generally meets the standard. At Delhi except at Palla, the DO generally violate the standard even during monsoon period. The total and faecal coliform reduced significantly during monsoon but was much higher than water quality standard.

7) Based on the water quality, the entire Yamuna river stretches may be segregated into five distinguished stretches i.e. Himalayan stretch, upper stretch, Delhi stretch, mixed stretch and diluted stretch.

8) The aggregate discharge from 22 major drains joining river Yamuna and canals at NCT-Delhi was 49.57m^3/sec during the year 2000, which has been reduced to 42.65 m^3/sec during the year 2005. Correspondingly there was reduction of about 25% in BOD load.

9) As per estimation, the Total BOD load generation at NCT- Delhi during the year 2003 was 443 tonnes/day (TPD). The sewage treatment facility was available for 355 TPD of BOD load, however, treatment facility of 265 TPD of BOD load was utilized. Because of which, there was reduction of about 43% in the total BOD load generated during the year 2003 by NCT-Delhi.

10)Najafgarh drain of NCT- Delhi is the biggest polluter of River Yamuna, which contributes about 26% (year 2001) to 33% 22 (year 2000) of total BOD load and 48% (year 2003) to 52% (year 2001) of total discharge that joins Yamuna river and canal at Delhi by various drains. There are 70 sub drains that join main Najafgarh Drain. The study indicated that the total BOD load at the terminal end of the Najafgarh Drain through sub-drains was 136 TPD, whereas the BOD load at the terminal end of the Najafgarh Drain was 83 TPD only. This reduction may be contributed by biodegradation, deposition of settable material at the bottom and diversion of drain water for irrigation etc.

6.2 RECOMMENDATIONS: -

Based on the study following recommendations are made :-

(i) For abatement of domestic source of pollution in Yamuna river various steps are required to be undertaken, which includes reduction of gap between wastewater generation and its treatment; maximum utilization of sewage treatment facilities; decentralization of sewage treatment plants; segregation of industrial and domestic waste; the treated sewage must be used for irrigation; aqua culture etc.

(ii) To control industrial pollution, careful planning for the development of industrial areas based on environmental impact assessment is necessary. All the small-scale industries should be connected with Combined Effluent Treatment Plant (CETP's). All the rules as specified under various acts should be followed strictly.

(iii) To significant measure to be undertaken for abatement of pollution in river Yamuna areas below:

- Industries should treat their effluents so as to confirm the specified requirements.
- To reduce over exploitation of river water for various human activities, adoption of water harvesting system on large scale becoming necessary.
- Construction of small barrages in the entire Yamuna river stretch will also solve the water scarcity problem.
- Disposal of garbage, solid, semi-solid, waste into river, its tributaries and drains should be restricted.
- Community participation in various Yamuna water quality restoration programme should be encouraged.

(iv) The activities proposed to control water pollution in the river Yamuna in Delhi are as under: -

A very peculiar aspect of specifications prepared under legislation has emerged during the study that these specification might not have been formulated without assuming characteristic of a typical natural streams but there is no provision of minimum required characteristic of a natural stream with regard to quality and quantity so that the resultant characteristics after discharge of permitted effluent does not go down a particular limit.

(v) Keeping in view the very high coliform microorganism count tertiary treatment should be made mandatory before discharge into river.

(vi) Keeping in view the DO level, which is zero all along the reach under study, no drain having DO<2 mg/l should be allowed to be discharged into river.

(vii) Effects are required to be made to aerate the river water. Two suggested processes are: -

- Mechanical aeration try developing vigorous navigation.
- Aeration by installing fountains on the banks drawing water from and discharging back into river.

(viii) In any case effluents carrying carcinogenic pollutants should not be allowed to be discharged.

(ix) In present conditions even after treatment to the level specified by CPCB Yamuna is not going to withstand to the pollution load due to lack of sufficient fresh water discharge during lean period. Therefore, after treatment water of all drains should be chenalized and if, found fit taking into consideration the entry into food chain and bio-magnification aspect also, should be utilized for irrigation purposes.

WHAT NEEDS MORE TO BE DONE?

- Desilting/ refurbishing sewers.
- Trapping sewage before it enters the drain.
- STPs to function at optimal capacity.
- New STPs at appropriate locations.
- Providing sewerage facilities in unauthorized colonies and other unsewered areas.
- Channelization/ Desilting of major drains.
- Prevention of dumping of solid waste in Drains/ River.
- River front development.

References

1. APHA, AWWA, WPCE (2000). Standard methods for the examination of water wastewater. American public health Association, New york .
2. CPCB, Control of Urban pollution series Cups/2/1978-79,8.
3. CPCB, Water quality Status of Yamuna River, April 2000,26.
4. CPCB, Parivesh-Highlights 2003, 2002, 1999.
5. D.J.B., Report May 2009 about yamuna River Pollution.
6. EPA, 1986; Schedules, universal law publishing company (p) Ltd., 2002.
7. Escap, 1990; Venugupal, 1994
8. Dhar, M.L., Kalsotra, B. l., Durami, smeer and fortedar, B.K.1989. Trace elements in water of river tawi, jammu. Indian j. Environmental protection.9 (6), 473-480.
9. Holas, j. and Hrncir, M. 2002. Integated watershed approach in controlling point and non-point source pollution within Zelivka Drinking water reservoir. Water science technology.45 (9), 293-300.

10. Inoue, t., Ebise, s. Numabe, A., Nagafuchi, o., Mastui, 2002. Runoff characteristics of particulate pesticides in a river from paddy fields. Water science Technology.45 (9), 121-126.

11. Ruparelia, S.G., Verma, Yogendra, and Hargen, M.c. (1996). A short-term study on the pollution Statistics of river Bhadar with special reference to BOD and COD. Indian jr.of Environmental protection.

12. Krikelis, v., Markoulatos, p., And Spyrou, N. 1986, Viral pollution of coastal water resulting from the disposal of untreated sewage effluents. Water science technology. 18,43-48.

13. Olivotti,R. Faganeli, J. and Male,1986 Impact if organics Pollutants on coastal water gulf of Trieste. Water Science Technology. 18, 57-68.

14. Sinha, A.K., Srivastava, Seema., and Srivastava, K.N. 1989, Physico-Chemical studies of river Ganga waterat Kalakankar (pratapgarh).Indian j. Environmental protection, 9 (3), 194-197.

15. Sholz, g., Vanlarhoven, j., et.al, 2002, Managing for river health integrating water and community participation. Jr. water science technology, 45(11), 209-213.

16. Singh, J.P. Singh, S.K. Singh, Shakun, Yadav, P.K. 1993, Assessment of BOD Load in river Yamuna in respect to Potable water at Agra. Indian jr. of environmental Protection, 13 (2), 119-123.
17. Salas, H.J. (1986). History and application of microbiological water quality standard in the marine environment. Water Science Technology. 18 (11), 47 –53.
18. Sharan, Nidhi, Kumar, Bipul and Sen, P.K. 1997, An attempt to correlate BOD and COD of a Municipal Swage treatment plant-A case study. Indian j. Environmental Protection, 17 (80), 610- 612.
19. Municipal Corporation of Delhi report about Yamuna Action Plan-II, 2009.
20. Delhi Jal Board report about interceptor sewer, 2009.
21. Trivedy R.K., Handbook Of Environment (Laws, Acts, Guidelines, Compliances & Standards) Vol. 1&2, 2004.

Annexure -I
Water Quality Criteria for the Various Designated Best Uses

SOURCE : CPCB, 1978-79

Water quality classification	Designated best use	Parameters affecting the state the	Quality criteria proposed
A	Drinking water sources without conventional treatment but after disinfection.	Coliform MPN Turbidity Colour BOD DO Toxicants (Including Pesticides etc) Plate Count Floating matter Taste and odour	Less than 50/100 ml Less than 10 units Less than 10 units Less than 2 mg/1 More than 6 mg/1 No acute toxicity To be present Less than 50/100 ml Absent No perceptible
B	Bathing, swimming and Recreation	1. Coliform MPN 2. Turbidity 3. Colour 4. BOD 5. DO 6. Toxicants (Including Pesticides etc) 7. Floating matter 8. Taste and odour	Less than 50/100 ml Less than 25 units Less than 10 units Less than 3 mg/1 More than 5 mg/1 No acute toxicity To be present Not noticeable No perceptible
C	Drinking water resource after conventional treatment	1. Coliform MPN 2. Colour 3. BOD 4. DO 5. Toxicants (Including pesticides etc.)	Less than 5000/100 ml Less than 25 mg/l Less than 10 units Less than 3 mg/1 More than 4 mg/1 No acute toxicity To be present
D	Propagation of wild life, fisheries	1. Coliform MPN 2. BOD 3. DO 4.Toxicants (Including pesticides etc.)	Less than 5000/100 ml Less than 25 mg/l Less than 10 units Less than 3 mg/1 More than 4 mg/1 No acute toxicity To be present
E	Irrigation, industrial cooling and controlled wastes disposal	1. TDS 2. Ca+Mg) 3. Sodium Ratio 4. Chlorides 5. Boron	Less than 1000 ml Less than 100 mg/l Less than 0.5 Less than 250 mg/1 More than 2 mg/l

Annexure -II

Use based classification of surface waters in India

Designated Best Use	Quality Class	Primary Quality Criteria
Drinking water source without conventional treatment, but with chlorination.	A	6.5 to 8.5(1); 6 or more (2); 2 or less (3); 50, not> 5% 200 and not >20% - 50 (4); NIL (5-8)
Outdoor bathing (Organized)	B	6.5 to 8.5(1); 5 or more (2); 3 or less (3); 500, not> 5%- 2000, and not >20% - 500 (4); NA (5-8)
Drinking water source with conventional treatment	C	6.5 to 8.5(1); 4 or more (2); 3 or less (3); 5000, not> 5% -20000, and not >20% -5000 (4); NA (5-8)
Propagation of wildlife and fisheries.	D	6.5 to 8.5(1); 4 or more (2); NA (3-4); 1.2 (5); NA (6-8)
Irrigation, industrial cooling and controlled waste disposal.	E	6.0 to 8.5(1); NA (2-5); 2250 (6); 26(7); 2(8)

Source: EP Rules, 1986

(1) PH, (2) dissolved oxygen, mg/1 (3) BOD (20C) mg/l, (4) total coliform (MPN/100 ml) (5) free ammonia mg/1, (6) electrical conductivity in (MhO/cm), (7) sodium adsorption ratio, and (8) boron mg/l, NA= Not applicable.