ABSTRACT

The current rate of depletion of fresh water resources are poses a threat to our future life support system. In order to maintain the status of our natural aquatic resources, sustainability is the main focus of an Integrated Water Resources Management (IWRM). Sustainable development will secure the availability of resources for further generations. On the downstream side of the Okhla barrage, Yamuna river has almost dried up, due to the abstraction of all the fresh water. The river on the downstream of Okhla Barrage has turned completely dark and dirty, and not fit to support any aquatic life. The present study was conducted to determine the amount of water pollution load caused by various human activities, which makes the Yamuna River dirtier day by day.

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. During non-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 Faridabad, Vrindavan, Mathura and Agra is the major contributor of pollution in the Yamuna River. About 85% of the total pollution in the river is contributed by domestic sources. The condition of river deteriorates 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 280 km long river stretch between Okhla barrage and Taj Mahal in Agra confluence is critically polluted. This stretch is characterized by high organic contents, high nutrients, significant depletion or increase in dissolved oxygen, severe odours etc. In the stretch from Okhla to Agra water quality monitoring was carried out to evaluate the pollution load of the river. Water quality monitoring facilitates evaluation of nature and

extent of pollution and effectiveness of pollution control measures, water quality trends and prioritization of pollution control efforts.

Water samples were collected from the different river and drain location and pH, COD, DO, BOD, TSS and heavy metals were measured as per the APHA-AWWA standards. As the water quality standards are not remain same all over the stretch of the river. Therefore, it necessary to determine or have knowledge of the water quality of river before it enters the study area. Water quality of the Yamuna also studied thoroughly in the stretch starting from downstream of Hathnikund barrage to upstream of Okhla barrage to determine the fluctuation in the various parameters of river Yamuna. Variation in the water quality up to Okhla barrage is covered in chapter 4.

From the Okhla barrage 101 cusec of water enters downstream of barrage, this is lesser than the minimum flow required for maintaining the sufficient flow in the river. Water samples collected from the downstream of the barrage even doesn't meet the water quality criteria of class "C" of river water. Water samples also collected from the all the STPs, drains and river locations in the study area. Water quality status of the study area covered in chapter 5 and results obtained from the analysis of various physio-chemical parameters and heavy metals are detailed in chapter 6. Heavy metals were studied in the stretch between Okhla to Agra. Cadmium, Nickel and Lead were rarely present in the river, whereas zinc and iron were generally present. BOD was found exceeding the standards at almost every sample and DO were found nil in the stretch up to Agra.

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. 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.

Chapter 1

INTRODUCTION

1.1 INTRODUCTION

Water pollution control is usually specifically addressed in connection with the establishment of environmental legislation and action plans, but also within the framework of water resources management planning. During recent years there has been increasing awareness of, and concern about, water pollution all over the world, and new approaches towards achieving sustainable exploitation of water resources have been developed internationally.

The Water (Prevention and Control of Pollution) Act, 1974 is the primary federal legislation that protects surface waters such as lakes and rivers. This Act establishes standards for water quality and effluent. This act has been and continues to be subject to change as new information and a more complete understanding of the natural system and our impacts (both positive and negative) are identified.

The main purpose of the Water (Prevention and Control of Pollution) Act is to improve and protect water quality through restoration and maintenance of the physical, chemical, and biological integrity of the nation's waterways. The Act provides a mechanism to evaluate the status of the nation's waters, designate beneficial uses for specific water bodies, and establish criteria for water quality to protect those uses.

Under the provisions of this Act, the Central Government constituted the Central Pollution Control Board (CPCB) while each State Government was to constitute similar State Pollution Control Boards to implement the provisions of the Act. In so far as Union Territories are concerned, the CPCB delegated its functions to the Governments of the

Union Territory. In pursuance of the above provisions, Government of Delhi constituted the Delhi Pollution Control Committee (DPCC) to monitor and control pollution in Delhi in terms of the provisions and objectives of the Act.

In addition, Section 24(1) of the Water Act issues prohibition on use of stream for disposal of polluting matter, Section 25(1) requires that no person shall establish any industry or process which is likely to discharge an sewage into stream or well and Section 43 & 44 subjects to the provision of these section have right to penalty for contravention of section 24 & 25 respectively. Once the state has identified the pollutant load discharged from both point and nonpoint sources in to river or lake are more than the estimated standards limits, controls can be implemented to reduce the daily load of pollutants until the water body is brought back into compliance with water quality standards.

1.2 MAXIMUM DAILY LOAD ASSESSMENT PROCESS

A Maximum Daily Load Assessment (MDLA) study describes the amount of an identified pollutant that a specific stream, lake, river, or other water body can contain while preserving its beneficial uses and maintaining state water quality standards. Those MDLA completed by the State of India include watershed-based plans for restoring beneficial uses of impaired water bodies. These plans identify the causes of impairment and determine the reduction in pollutant loads necessary to meet standards and restore beneficial uses. Water quality criteria are specific to each use. Of particular importance to the beneficial uses in Yamuna River are dissolved oxygen (DO), bacteria, temperature, pH, total dissolved solids (TDS), phosphorus, and nitrogen.

The MDLA process involves an evaluation of available data from different locations of river along its length and drains joining the river to determine the maximum allowable load from point and nonpoint sources of pollution. Pollutant load refers to the quantity of pollution contributed to a water body from a single point (e.g., a permitted industrial facility or a wastewater treatment plant (WWTP) or from a group of diffuse sources (e.g., an urban development, agricultural fields, and upland erosion).

A MDLA study outlines a watershed-wide or basin-wide pollution budget for a water body. The budget is determined by the amount of pollutants that can be added without causing exceeding of water quality standards; this amount is referred to as the water body's loading capacity. Calculations for pollutant loading capacity take into account seasonal variations, natural and background sources of loading, and a margin of safety (MOS) to allow for uncertainty in the analysis. Once the loading capacity is determined, sources of the pollutants are considered.

1.2.1 Point Sources

Point sources of pollution such as WWTPs typically involve pipes that convey discharges directly into a water body. A point source is simply described as a discrete discharge of pollutants, as through a pipe or similar conveyance. Point sources are grouped into a waste load allocation (WLA), which will become part of the MDLA equation.

1.2.2 Non-point Sources

Nonpoint sources such as roads, farmland, residential landscapes, and construction sites contribute pollution diffusely through runoff. Pollution may result from sources and activities such as livestock grazing, timber harvesting, leaking underground storage tanks, septic systems, fertilizers and pesticides applied to residential yards, construction sites, stream channel alteration, and other diffuse sources. Nonpoint sources are groups into a load allocation (LA) which will become part of the MDLA equation.

1.2.3 Load Allocations (LA)

Once all point and nonpoint sources are accounted for, pollutants are then allocated among the sources in a manner that will describe the maximum amount of each pollutant (the total maximum load) that can be discharged into a water body over a specified amount of time while maintaining water quality standards. The LAs, distributed among the sources, indicate the maximum amount of a pollutant that can be discharged. Ultimately the responsibility for improving water quality belongs to everyone who lives, works, or recreates in the watershed. The MDLA study does not mandate how load reductions must be attained, but it provides recommendations, particularly for nonpoint sources. Nonpoint sources, grouped as LAs, and point sources, grouped as WLAs, are combined with a MOS when designating the total pollutant load capacity or budget. The MOS accounts for uncertainty in the loading calculations. Combined, the loading capacity equation is:

Loading capacity: **MDLA = WLAs + LAs + MOS**

1.3 MDLA SCOPE

Once all point and nonpoint sources are accounted for, including the MOS, MDLAs are drafted to allocate the total pollutant loading among the various sources in a manner that meets water quality standards. The objective of MDLAs is to reduce loading from all point and nonpoint sources to restore the designated beneficial uses of a water body. The primary purpose of MDLAs is to accurately estimate the contribution of point and nonpoint sources to total pollutant loads in a water body.

1.4 ELEMENTS OF A MDLA

Generally, TMDLs generally consist of three major sections:

1) Water body and watershed assessment
2) Loading analysis
3) Implementation plan(s)

1.4.1 Water body and Watershed Assessment

Assessment of the water body and watershed describe the affected area, the water quality concerns and status of designated beneficial uses of individual water bodies, nature and location of pollution sources, and a summary of past and ongoing management activities.

1.4.2 Loading Analysis

A loading analysis provides an estimate of a water body's pollutant load capacity and outlines MDLA allocations. The sum of LAs and WLAs must meet the load capacity, with a portion of the load reserved for the MOS. Minor nonpoint sources may receive a lumped allocation. Generally, a loading analysis is required for each pollutant of concern. However it is recognized that some listed pollutants are actually water quality problems that result from other pollutants. A complete loading analysis lays out a general pollution control strategy and an expected time frame in which water quality standards will be met.

1.4.3 Implementation Plan

Point source WLAs are implemented through an existing regulatory program. The LA covers nonpoint sources and therefore is not covered by any specific regulatory program. Rather, the LA is usually implemented through incentive-based programs, volunteer efforts, or government funded projects. Provided that a viable trading framework is in place, pollutant trading is allowed between or within the LA and the WLA categories, but the MOS cannot be traded. A similar level of data density is seldom available for nonpoint sources. Therefore, the MDLA process must develop load calculations for nonpoint sources of pollution and for natural sources of pollution.

1.5 OBJECTIVE OF THE STUDY

1) To monitor the water quality of Yamuna river on its various locations with the purpose of determining the causes of deterioration of water quality

2) To assess the functioning of the existing pollution control systems with regard to their effectiveness, suitability, and being adequate and to assess nature and extent of requirement of additional pollution control measures.
3) To assess the improvement in water quality as a result of the implementation of the Yamuna Action Plan
4) To assess the pollution loads in terms of significant water quality parameters, joining the river in 280 km stretch of Yamuna River
5) To assess the impact of pollution on intake of Agra Water works
6) To study ongoing schemes / rehabilitation works in trapping sewage joining the Yamuna river
7) To assess the impact of tributaries or other out falls e.g. drains etc.
8) To determine the expected changes in the Yamuna river basin in the adjoining area by the water quality prediction.

Chapter 2

LITERATURE REVIEW

2.1 BACKGROUND OF YAMUNA RIVER

The River Yamuna is the largest tributary of River Ganga. This river is as prominent and sacred as the great River Ganga itself. It has been acclaimed as a holy river in Indian mythology and various pilgrimage centers e.g. Yamunotri (Uttaranchal), Paonta Sahib (Himachal Pradesh), Mathura, Vrindavan, Bateshwar & Allahabad (all in Uttar Pradesh) are located at the banks of this river. Large urban centers e.g. Yamuna Nagar, Sonepat, Delhi, the political nucleus of India, Gautam Budh Nagar, Faridabad, Mathura, Agra and Etawah are also established on its banks. Large industrial centers have also been developed either on banks or in its basin. In agriculture front also the Yamuna basin is one of the highly fertile and high food grain yielding basin, especially areas in Haryana and Western district in Uttar Pradesh as shown in Fig 2.1. All this reflects that the River Yamuna not only flows in the hearts of India but also plays a significant role in the economy of the country. The river Yamuna is facing problems caused by industrialization, urbanization and rapid agricultural developments along its stretch similar to that of other river systems in the country.

The total length of Yamuna River from origin at Saptrishi Kund to its confluence with Ganga at Allahabad is 1376 km traversing through five states. The main stream of river originates from the Yamunotri glacier (Saptrishi Kund) near Bander punch peaks (380 59' N 78027'E) in the Mussoorie range of the lower Himalayas at an elevation of about 6320 meter above mean sea level in Uttarkashi district of Uttaranchal. The head waters of Yamuna river are formed by several melt streams, the chief of then gushing out of the morainic smooth at an altitude of 3250 m, 8 km North West of Yamunotri, hot springs at the latitude 310 2'12" N and longitude 780 26' 10". Arising from the source, the river flows through series of curves and rapids for about 120 km to emerge into Indo-Gangetic plains at Dak Patthar in Uttaranchal. At Dak Patthar the river water discharge is regulated through a weir & diverted into a canal for irrigation and power generation.

From Dak Patthar it flows down through famous Sikh religious center Paonta Sahib (Himachal Pradesh) and reaches Hathnikund in Haryana district where the major part of river water is diverted again into Eastern & Western Yamuna canals for irrigation. In dry season, no water is allowed to flow in the river, downstream to Hathnikund barrage. The river is almost dry in some stretches between Hathnikund and Delhi. Downstream of Hathnikund the river regains water from ground water accrual and contributions of feeding canals and small tributaries etc. From Hathnikund the river sluggishly meanders and reaches Delhi at Palla after travelling a distance of about 224 km.

At Wazirabad the river is trapped again through a barrage for drinking water supply to urban agglomeration at Delhi. From Wazirabad barrage no water is allowed to flow down particularly during summer, as the available water in the river is not adequate to fulfill the water supply demand of Delhi. The water flows in the Yamuna River downstream of Wazirabad is the treated, partially treated or untreated domestic & industrial wastewater contributed by various drains joining river Yamuna and canal water. Once the lifeline which spawned the many civilisations and Cities that grew in the area of the present NCT of Delhi, the River Yamuna today suffers from inadequate flow and quantum of water and an extremely high degree of pollution. The length of the river in the NCT of Delhi is 48 kms from Palla in the North to Okhla in the South. After 22 km downstream from Wazirabad barrage the Yamuna water is again blocked and diverted into Agra Canal for irrigation through another barrage at Okhla. Similar to downstream of Wazirabad, at downstream Okhla barrage, the water flows in the river is the drain water of domestic & industrial origin contributed mainly by Shahdara drain. After travelling a distance of around 166 km, the river reaches at Mathura from where again a major part of water is diverted for drinking water supply through Gokul barrage. The Yamuna from Gokul barrage after receiving water through other important tributaries and city drains joins river Ganga at Allahabad after traversing about 790 km via cities of Agra, Bateshwar, Etawah, Hamirpur and Pratapgarh.

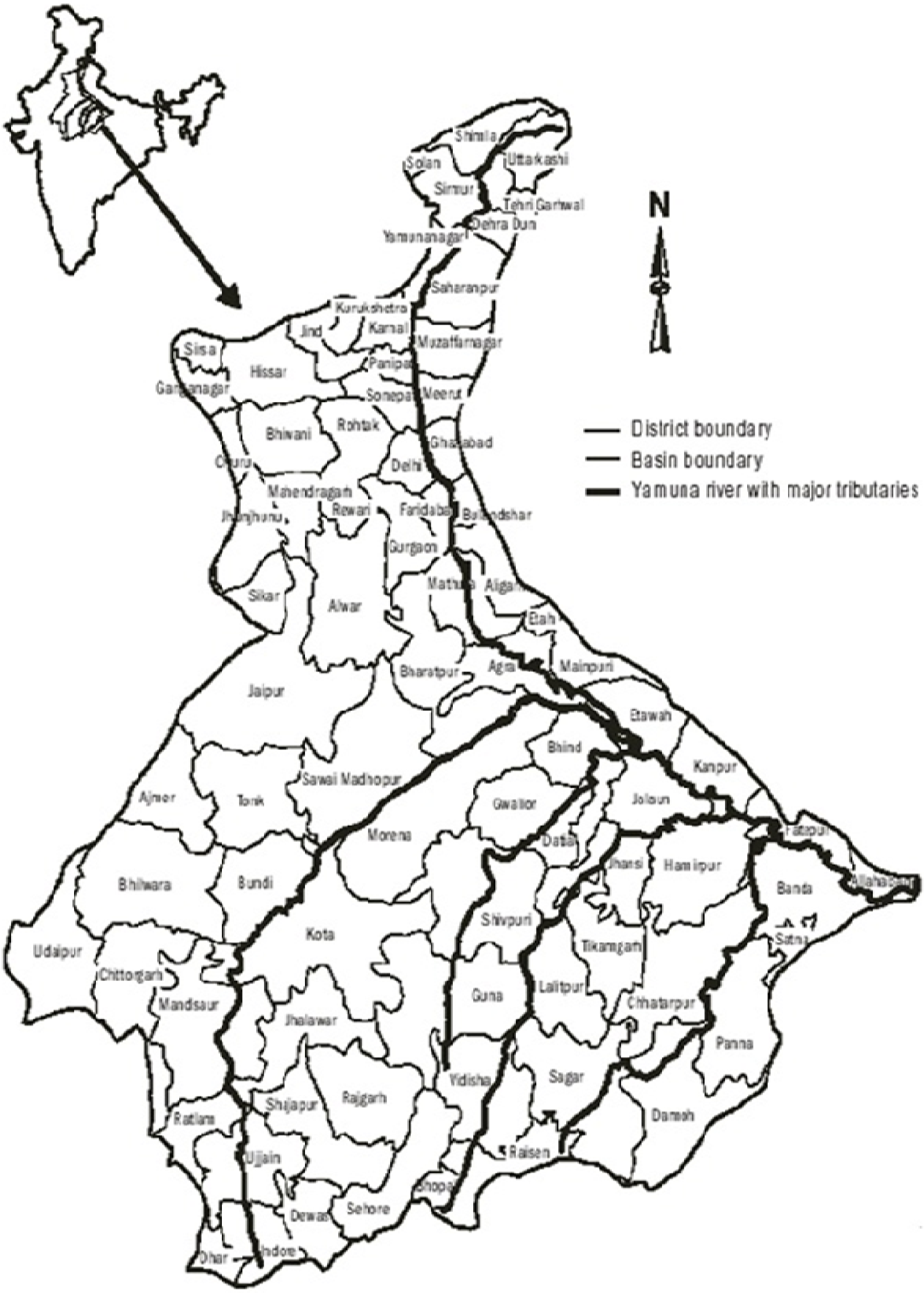

Fig2.1: Yamuna River basin

In the upper reaches of River Yamuna, there are several hill streams join together to form the main stream. There are four main rivers that joins Yamuna in the higher Himalayan ranges, these are Rishi Ganga, which joins on the right bank of Yamuna, where as Unta and Hanuman Ganga joins on left bank. In the lower Himalayan ranges the Yamuna River receives Kamal, Tons, Giri & Bata on its right bank and on left banks receives Aglag & Asan. The Chambal, Betwa, Sindh & Ken are the important tributaries joining Yamuna on right bank in plain & on left bank Hindon river joins River Yamuna. Among all these tributaries, Tons at hills and Chambal at plains are the most important tributaries in terms of their discharges. The Tons is the principal source of water in mountainous range and generally carries more water than mainstream. In plains, during non-monsoon period, River Chambal contributes about 5-10 times more water to the Yamuna than its own flow. However, since the year 2003, there is a significant reduction in the water quantity that River Chambal discharges into the Yamuna River. The main tributaries of Yamuna along with location of major cities are depicted in Fig.1.2.

The untreated wastewater from Vrindavan-Mathura & Agra is added to the flow of the river Yamuna in this segment. The famous city of Agra and Mathura refinery are drawing their drinking and industrial water from the Yamuna river in this segment. The major input to flow in this segment is through Chambal river near Etawah in U.P. and subsequently Sindh Ken and Betwa rivers. Two more barrages are under construction in this segment, one at Gokul Ghat near Mathura and another near Sikandara at Agra. These barrages will further sub-divide the river into more segments.

2.2 SEGMENTS OF YAMUNA RIVER

The water flow characteristics of Yamuna River changes significantly from monsoon to non-monsoon period. This change in water flow along with the construction of various barrages hampers the continuous flow of the river. During the non-monsoon period (October to June) the river flow reduced significantly and some rivers stretches become dry.

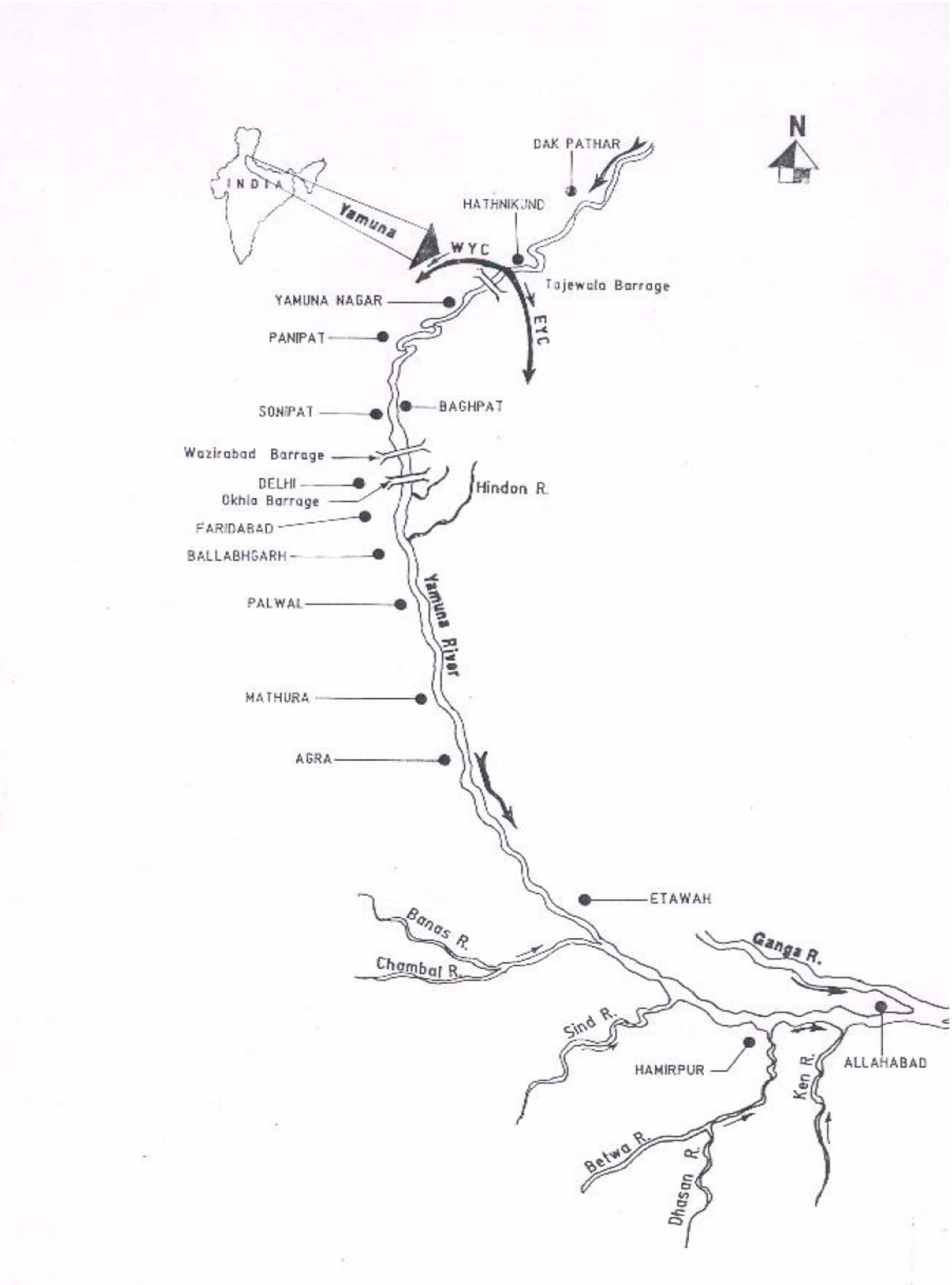

Fig. 2.2: Location of Major Cities along Yamuna River

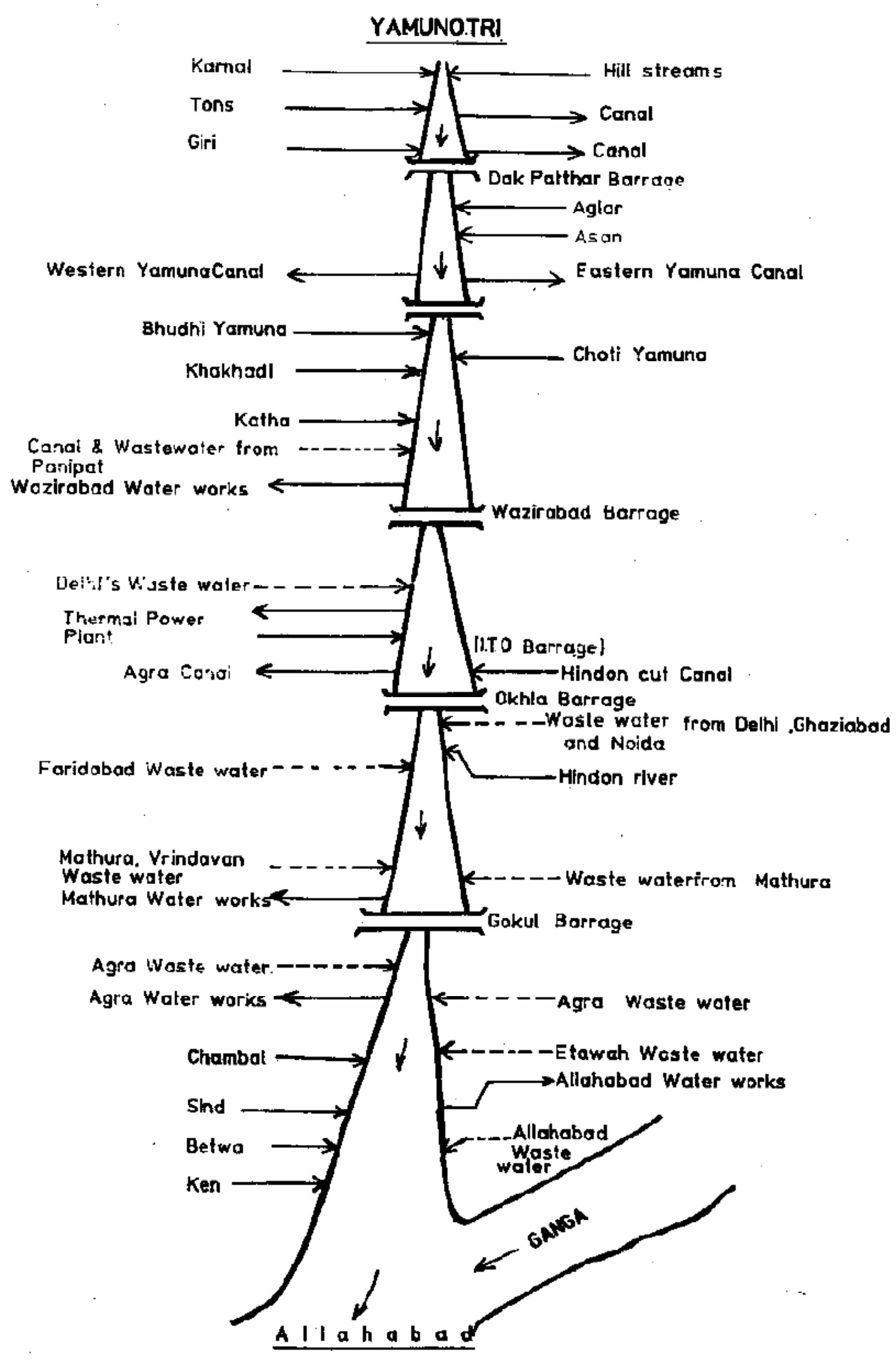

Fig. 2.3: Points of Water Abstraction & Additions in Yamuna River

Just opposite of this, during monsoon period the rivers receives significant amount of water, which is beyond their capacity and resulting in flood. The River Yamuna also experiences such periods of drought and floods. Yamuna River carries almost 80% of total annual flow during monsoon period. The water flow reduces significantly during non-monsoon period and that too diverted from river and extensively used for irrigation and drinking purpose, leaving very little or no water flow in the river. The points of abstraction and addition in water of Yamuna River are presented in Fig. 2.3.

As evident, the Yamuna river is trapped through 5 barrages during its total course of flow i.e. At Dak Patthar (about 160 km from origin in Uttaranchal) at Hathnikund (172 km distance from origin, just at foothills in Haryana) at Wazirabad (in National Capital Territory of Delhi, 396 km distance from origin) at Okhla (in NCT – Delhi, 418 km distance from origin & at Mathura (Near Gokul village in Uttar Pradesh about 570 km distance from origin). These barrages are the major water abstraction locations on the river. The water is contributed into the Yamuna River, not only through its tributaries but also by the canals & drains originating from various urban centers. Thus, in dry season (almost nine months) the river becomes segmented in four distinguished independent segments.

Segment I: This segments (length 157 km) is identified from Yamunotri and terminate at Hathnikund / Tajewala barrage. The major source of water in this segment is the melting of glaciers. The water flow in this segment terminates into Western Yamuna canal (WJC) and Eastern Yamuna Canal (EJC) for irrigation and drinking water purposes in command areas.

Segment II: This segment (about 224 km) lies between Hathnikund / Tajewala barrage and Wazirabad barrage. The main source of water in this segment is ground water accrual. Few small tributaries also contribute water in this segment. The water is diverted in this segment from WJC through drain No. 2 to fulfill the raw water demand for drinking water supply in Delhi.

The water segment is terminated into Wazirabad reservoir formed due to stagnation of water at Wazirabad barrage. The reservoir water is pumped to the various water works as raw water for treatment to met drinking water demand of the capital city. No or very little water is allowed to flow downstream Wazirabad barrage during lean seasons.

Segment III: This 22 km segment of Yamuna River is located in between Wazirabad barrage and Okhla barrage. This segment receives water from seventeen sewage drains of Delhi and also from WJC and Upper Ganga Canal via Najafgarh drain and Hindon cut canal respectively. Little contribution of water is also made in this segment by Surghat, where Ganga and Yamuna water is provided for bathing purposes. This river segment terminates into Agra Canal, which is used to augment its flow for irrigation in the states of Haryana and Uttar Pradesh.

Segment IV: This Segment of Yamuna River is about 973 km long initiate immediately downstream to Okhla barrage and extends upto confluence to Ganga River at Allahabad. The source of water in this segment are ground water accrual, its tributaries like Hindon, Chambal, Sindh, Ken, Betwa etc. and waste water carrying drains of Delhi, Mathura-Vrindavan, Agra and Etawah. The water of this segment is used for drinking and industrial uses at Mathura & Agra. At Mathura, recently Gokul barrage has been constructed to trap the Yamuna river water for drinking purposes. Due to low drinking water demand only part of water is pumped out and rest flows downstream. As the water demand will increase in future. It is likely that no water will be allowed to flow downstream like Wazirabad and Okhla barrage. This may create further segmentation of segment IV into two segments of 154 & 804 km. With the construction of another barrage near Sikandara at Agra the river would be further segmented.

2.3 USES OF YAMUNA RIVER WATER

Water is one of the essential requirements of life. In the modern age it also plays a significant role in various economic activities. The higher growth rate is reflected during good monsoon period and availability of good amount of water in the river. The various uses of river water can be kept into two major groups. In one group the water is abstracted and transported away from the natural water bodies for beneficial uses and are called abstractive uses or uses involving collection and transportation. The other is just opposite of the first, in which withdrawal and transportation of water is not required but the water is utilized. It is known as non-abstractive or in-situ water uses.

The river water is abstracted at different locations for varied uses. At two places i.e. Hathanikund / Tajewala & Okhla, the water abstraction is significant. Amount of the water flow in river Yamuna after abstraction at various locations are again used for various activities and percent use of abstracted water for various purposes are as below.

2.3.1 Domestic Water Supplies

The large urban centres located on river banks and where suitable ground water is not available, water is abstracted for drinking water supplies after suitable treatment. The urban agglomerations in Delhi use the Yamuna water significantly for domestic water supplies. At Wazirabad, Delhi the entire river water is diverted for this purpose along with the increase in demand of water for drinking purposes. Along with the population increase, there are plans at various locations to withdraw more and more water from the river.

2.3.2 Irrigation

Irrigation is an important use of Yamuna river water. It is estimated that about 92% of Yamuna river water is used for irrigation. In the entire Yamuna basin the irrigated land is about 12.3 million hectares and approximately half of it (about 49%) is irrigated exclusively from surface water. At present there are four irrigation canals transporting the Yamuna river water to the command areas.

2.3.3 Cattle bathing and Washing

The cattles at most of the towns & villages along the rivers are regularly taken toward the river for drinking and bathing. It is estimated that about 70% of the total cattle population in the Yamuna basin uses flowing water of river and canals for bathing and watering purposes directly. These cattle activities impart substantial impact on water quality. This occurs not only through direct discharge of urine, dung and washed off organic inorganic materials but the bottom sediments are also churn up because of cattle wading. Besides these uses, the river Channel of Yamuna River, particularly in Delhi stretch is also used for the transportation of water for irrigation from one water body to another or from one place to another.

2.3.4 River Bathing & Washing

River bathing and washing is one of the most important use of river water in the country. The Hindu culture and the other cultures of Indian origin are generally considered as river oriented. Bathing is an essential part of various Hindu rituals. Bathing in flowing water and that too on rivers like Ganga, Yamuna, Narmada, Godawari etc. is considered more superior than bathing in house with well or tap water. On religious and cultural occasions millions of people take bath especially near religious towns in a congested stretch of the river within the span of a few hours. The river water is also used for washing clothes and utensils by nearby communities, particularly by the poor inhabitants.

2.3.5 Recreational uses

The Yamuna River is used very rarely for recreational purpose due to unsuitable conditions like Rocky River bed, low water depth etc. However, at urban centers and at various barrages it has the potential for water sports like boating.

2.4 POLLUTION SOURCES OF RIVER YAMUNA

The entire stretch of Yamuna River from origin to confluence with Ganga is used for various human activities. The results of these activities are the generation of wastewater. The various sources of pollution are categorized in two groups.

2.4.1 Point Source of Pollution

When the source of pollution is single, well specified and generate significant amount of pollutants such source is known as point source. Urban centers located along or near the bank of Yamuna River are the major pollution sources of River Yamuna. The point source of pollution covers two major categories.

2.4.1.1 Domestic Pollution

The domestic pollution is the major source of pollution in Yamuna River. About 85% of the total pollution in the river is caused by the domestic sources. The domestic pollution is mainly caused by the urban centers. The major urban centre dumping domestic waste into Yamuna River is Delhi, Mathura, Agra etc. The intensity of impact of domestic pollution on river depends on the efficiency of the wastewater collection system, type and length of the waste transportation system. If wastewater gets more retention time within urban premises before reaching to receiving water bodies, in such case the pollution load will reduce due to biodegradation and settling. The organic matters and micro-organisms are the main constituents of the domestic waste. Besides these, total salts, chlorides, nutrients, detergents, oil & grease etc. are also contributed by the domestic sources.

There are numerous unauthorized colonies exist in various urban centres. Due to non-availability of sewerage system in these colonies, the night soil is collected, transported and dumped either in drains, tributaries or directly into river without any treatment. During last few years because of proliferation of Jhuggi Jhonpri settlement this activity increased significantly and now become a major non-point source of river water pollution.

2.4.1.2 Industrial Pollution

After independence, rapid industrialization occurred in the Yamuna river basin. There are large clusters of industries established in and around Kota, Gwalior, Indore, Nagda, Khetri, Yamuna Nagar, Panipat, Sonepat, Delhi, Baghpat, Ghaziabad, Gautam Budha Nagar, Faridabad, Mathura & other places. There are large categories of industries discharging wastewater into Yamuna River from the more than 30 industrial areas only from Delhi and many more from other urban centres. The categories of industries discharging wastewater into Yamuna river includes Pulp & paper, Sugar, Distilleries, Textiles, Leather, Chemical, Pharmaceuticals, Oil Refineries, Thermal Power Plants, food etc. For the 30 industrial areas of Delhi there are only 11 CETPs which are operating in Delhi to treat the waste water from the industries. This is the major reason of increase in pollution level of Yamuna River. In order to compliance to the environment laws, it is compulsory for these industries to treat the effluent to achieve prescribed standards before discharging effluent into the environment. Whereas, only few of industries have installed effluent treatment plant and moreover, only fraction of that number of industries have their effluent treatment plants in operating condition.

2.4.2 Non Point or Diffused Sources of Pollution

Just opposite to the point source the diffused sources are unspecified, numerous in numbers and contribution of each is of less significance. Though, in combination the resultant contribution is significant. This pollution is original in the catchment area of the river and transported regularly or occasionally by leaching, drainage and surface water off during monsoon. The pollutants originated from diffused sources are topsoil, organic matter, plant residues, nutrients, organic chemicals, toxicants, microorganisms etc. The important diffused pollution sources contributing to river Yamuna are Agricultural pollution sources, Dumping of garbage and dead bodies, Immersion of idols and Pollution due to in-stream uses of water.

2.5 WATER QUALITY ISSUES IN YAMUNA RIVER

Most of the rivers including River Yamuna are spiritually regarded as mother. People from all over the country visit various stretches of this river to take holy dip in river water to purge away their sins. Thus, the river portrays Indian culture and traditions. Deteriorate water quality and quantity of Yamuna River hurts the sentiments of Indian masses besides having several adverse impacts on life process in the river. The issues related with water quality of Yamuna River are described as follows:

2.5.1 High Organic Contents

River Yamuna receives significantly high amount of organic matter, which is generally, originates from domestic sources. For biodegradation, this organic waste requires oxygen, causing significant depletion of dissolved oxygen in river water. The oxygen depletion not only affects biotic community of the river but also affects its self-purification capacity. This problem is critical in the river stretch between Delhi. In Delhi stretch, the load of organic matter is so high that it consumes the entire dissolved oxygen available in river water.

2.5.2 High Nutrients

The organic matter after biodegradation release nutrients in the water. High nutrients concentration leads to Eutrophication, a condition characterized by significant diurnal variation in dissolved oxygen concentration and excessive algal grown.

2.5.3 Excessive Presence of Pathogens

Continuous flow of sewage waste, dumping of animal dead bodies etc. and instream uses of water like bathing, cattle wading etc. contribute significant load of pathogens in the river water making it unsuitable for drinking and bathing purposes.

2.5.4 Accumulation of Pollutants in the Catchment Area

Organic, inorganic and toxic pollutants generated from agricultural and industrial sources are accumulated near the source during dry seasons and get mixed with river water posing threat to aquatic life during monsoon or percolated to ground water and making water unfit for human consumption.

2.5.5 Aesthetic Value

Yamuna river losing its aesthetic value, glory due to severe odour that releases to the surrounding environment from the anaerobic activities occurring in the river strata and the ugly surface look contributed by blackish water, floating of garbage, plastic bags, dead bodies of animals. The religious activities and tourism are greatly affected because of these transformed characteristics of river water.

2.5.6 Deforestation in the Catchment Area

Forest cover in the catchment area of Yamuna is vanishing rapidly. This leads to soil erosion with the rainfall. This result mixing of high amount of silt, mud etc. in the river water, which in turn increases the turbidity. The turbidity of river water is also increased due to direct influx of domestic and industrial wastewater. Increased turbidity has an impact on the productivity of water body besides affecting biotic life of aquatic system.

2.5.7 Reduction in the Quantity of Water

The fresh water of Yamuna River is over exploited for irrigation use, drinking and industrial uses resulting very little or sometimes no water in the river at certain locations during summer season. The water scarce condition is so severe that to avoid percolation and evaporation losses, the Delhi's share of Yamuna water transported through WJC and added back into the river through Drain. All this leads to stagnation of water and formation of dry zones in the drainage area of the river. Non-availability of fresh water hampers the purification capacity of the river and causes increase in concentration of pollutants in the river water.

2.5.8 Use of River Stream for Transportation of Water

The Delhi stretch of Yamuna River is being used for transportation of water from one water body to another for irrigation purpose by Haryana and Uttar Pradesh. This transportation activity may dilute or add the pollutants affecting the water quality of river.

2.5.9 Discharges from Sewage Treatment Plants into the River

Sewage treatment plants (STP's) have been constructed at various urban centers to conserve the water quality of Yamuna River. The treated, untreated or partially treated sewage from these STP's generally discharged directly or through carrier drain into the river. Prior to installation of STP's the sewage of urban centers was discharged and get mixed with river water at various locations in the wide stretch of river through long & slow transportation system.

After installation of STP alongwith swift collection and transport system, the sewage from urban centers concentrated at few places, where STP's are located. The connection of STP with the river sometimes poses great threat to water quality during non-operation of STP due to unavoidable reasons e.g. power failure, mechanical problems or maintenance of plants. In such cases the collected sewage is generally bypassed and discharged into the river at few locations without any treatment. Such problem is very significant in those stretches of river where the STP's are located upstream of the river. The discharges from these STP's located upstream from water abstraction point have impact on the water quality making it unsuitable for various human activities occurring downstream of these STP's.

Chapter 3

METHODOLOGY

3.1 INTRODUCTION

Control of water pollution has reached primary importance in developed and a number of developing countries. The prevention of pollution at source, the precautionary principle and the prior licensing of wastewater discharges by competent authorities have become key elements of successful policies for preventing, controlling and reducing inputs of hazardous substances, nutrients and other water pollutants from point sources into aquatic ecosystems. Such water pollutants include substances that are toxic at low concentrations, carcinogenic, mutagenic, teratogenic and/or can be bio-accumulated, especially when they are persistent. In order to reduce inputs of phosphorus, nitrogen and pesticides from non-point sources (particularly agricultural sources) to water bodies, environmental and agricultural authorities in an increasing number of countries are stipulating the need to use best environmental practices.

Water quality criteria are developed by scientists and provide basic scientific information about the effects of water pollutants on a specific water use. Water quality criteria for various uses of fresh water are shown in Table 3.1. They also describe water quality requirements for protecting and maintaining an individual use. Water quality criteria are based on variables that characterize the quality of water and/or the quality of the suspended particulate matter, the bottom sediment and the biota. Many water quality criteria set a maximum level for the concentration of a substance in a particular medium (i.e. water, sediment or biota) which will not be harmful when the specific medium is used continuously for a single, specific purpose. For some other water quality variables, such as dissolved oxygen, water quality criteria are set at the minimum acceptable concentration to ensure the maintenance of biological functions.

Water quality criteria often serve as a baseline for establishing water quality objectives in conjunction with information on water uses and site-specific factors. Water quality objectives aim at supporting and protecting designated uses of freshwater, i.e. its use for drinking-water supply, livestock watering, irrigation, fisheries, recreation or other purposes, while supporting and maintaining aquatic life and/or the functioning of aquatic ecosystems.

Many chemical substances emitted into the environment from anthropogenic sources pose a threat to the functioning of aquatic ecosystems and to the use of water for various purposes. The need for strengthened measures to prevent and to control the release of these substances into the aquatic environment has led many countries to develop and to implement water management policies and strategies based on, amongst others, water quality criteria and objectives. There had been rapid urbanization and industrialization development in Yamuna basin after 70's, which is still ongoing. All these developments are water dependable and the water requirement is met from the River Yamuna.

Table 3.1: Primary water quality criteria for various uses of fresh water

S.No.	Designated water use	Class	Criteria
1	Drinking water source without conventional treatment but after disinfections	A	• Total coliform organisms MPN/100mL shall be 50 or less. • pH between 6.5 and 8.5 • Dissolved oxygen 6 mg/l or more • Biochemical oxygen demand 2 mg/l or Less
2	Outdoor bathing	B	• Total coliform organisms MPN/100ml shall be 500 or less • pH between 6.5 and 8.5 • Dissolved oxygen 5 mg/l or more • Biochemical oxygen demand 3 mg/l or Less

3	Drinking water source with conventional treatment followed by disinfection	C	• Total coliform organisms MPN/ 100ml shall • Total coliform organisms MPN/ 100ml shall • pH between 6 and 9 • Dissolved oxygen 4 mg/l or more • Biochemical oxygen demand 3 mg/l or Less
4	Propagation of wild life, fisheries	D	• pH between 6.5 and 8.5 • Dissolved oxygen 4 mg/l or more • Free ammonia (as N) 1.2 mg/l or less
5	Irrigation, industrial cooling, con-trolled waste disposal	E	• pH between 6.0 and 8.5 • Electrical conductivity less than 2250 micro mhos/cm • Sodium absorption ratio less than 26 • Boron less than 2mg/l

3.2 STUDY AREA

The sampling stations for river and major drains joining River Yamuna were selected on the basis of the need and potential of water quality impact or pollution load transported respectively. The present survey of polluting sources and river water quality has been made in this particular middle reach. The problem of water quality deterioration has become more severe due to high load of point pollution in to the middle reach. The water quality monitoring of the river at different river length has been made. A river stretch of 280 km starting from Okhla Barrage, Delhi to Jeewni Mandi Agra has been surveyed to assess the water quality deterioration in this stretch. However, due to heavy abstraction from and discharge of pollutants into the river system, there are critical segments, which require pollution abatement measures to improve the water quality of the river. The monitoring of pollution outfall into this stretch has also been made. The sampling locations of Yamuna along with major outfalls of drains are depicted in Fig. 3.1 & Fig 3.2. These segments under study with the causes of pollution are:

Okhla to vrindavan	**:** Domestic wastewater from Delhi and industrial and domestic effluent from Saharanpur, Ghaziabad, Noida, etc.
Vrindavan to Mathura	**:** Domestic wastewater and industrial effluent from dyeing and printing industry of Vrindavan and Mathura.
Mathura to Agra	**:** Domestic wastewater from Agra.

3.2.1 River locations

1) Okhla Barrage D/s (OB)

Okhla Barrage is 0.0 Km Yamuna at d/s of Kalindi Barrage near Police Check post. Okhla Barrage is referred as prime location of river (or reference location in the whole text of the report) from where 280 km stretch of the river has been surveyed up to Okhla to Agra for Water Quality deterioration assessment.

2) Asgarpur- (AP)

Yamuna at Asgarpur is 6 Km downstream of Okhla Barrage. The location of the river is around 3 km downstream after confluence of Shahdara drain on the left bank of the river.

3) Hodal (HO)

Yamuna near Hasanpur Village at Pontoon bridge and 124 km downstream from Okhla Barrage. The sampling location was on the right bank of the river.

4) Vrindavan - Mathura upstream (MU)

Yamuna at Vrindavan (Kesi Ghat) is 173 km downstream from Okhla barrage, Delhi. The sampling location was on the right bank of the river, but downstream of Kalideh STP (0.5 mld).

5) Gokul Barrage (GB)

Yamuna at downstream of Mathura city near Gokul village at Gokul barrage and 193 km from Okhla barrage, Delhi. The sampling location was on the left bank of the river and downstream of barrage (Reservoir). This location of the river received all the pollution outfalls such as treated wastewater from the four STPs of Mathura city.

6) Sikandara (SD)

Yamuna near Sikandara waterworks intake is 247 Km downstream from Okhal Barrage, Delhi. The sampling location was on the right bank of the river and located upstream of Taj city.

7) Jeewini Mandi (JM)

Yamuna near old waterworks intake is 280Km downstream from Okhla Barrage The sampling location was on the right bank of the river and located just before prechlorination unit in the river intake channel itself.

3.2.2 Drain / Pollution Outfalls Locations

1) Shahdara Drain (SHD)

Shahdara Drain is joining to the river Yamuna system 1 km downstream of Kalindi barrage at Okhla. The drain carrying wastewater from east Delhi area and some part of the U.P. area and joining to the river Yamuna on its left bank. The location of the drain sampling was just before joining to the river system.

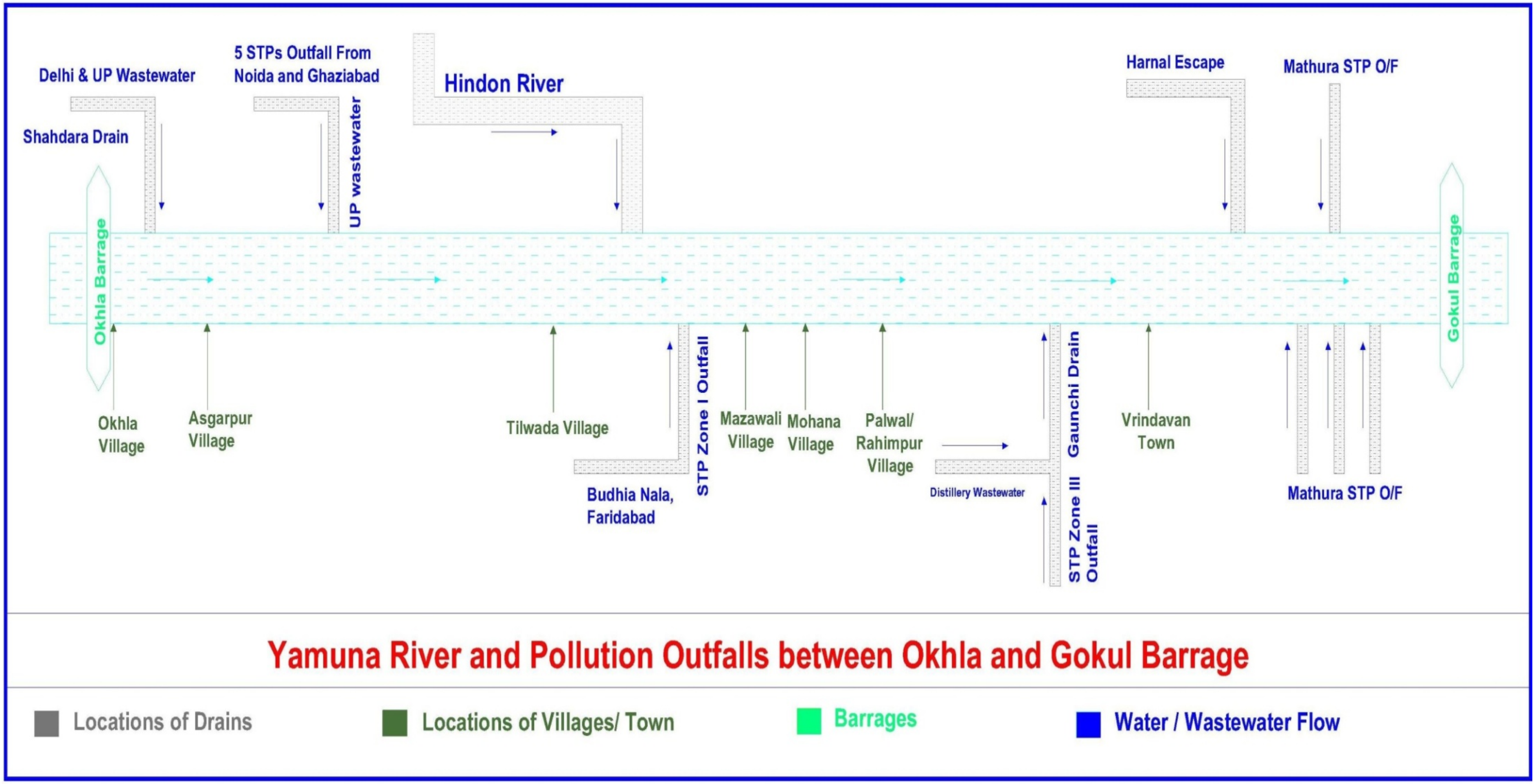

Fig 3.1: Yamuna river and pollution outfalls between Okhla and Gokul barrage

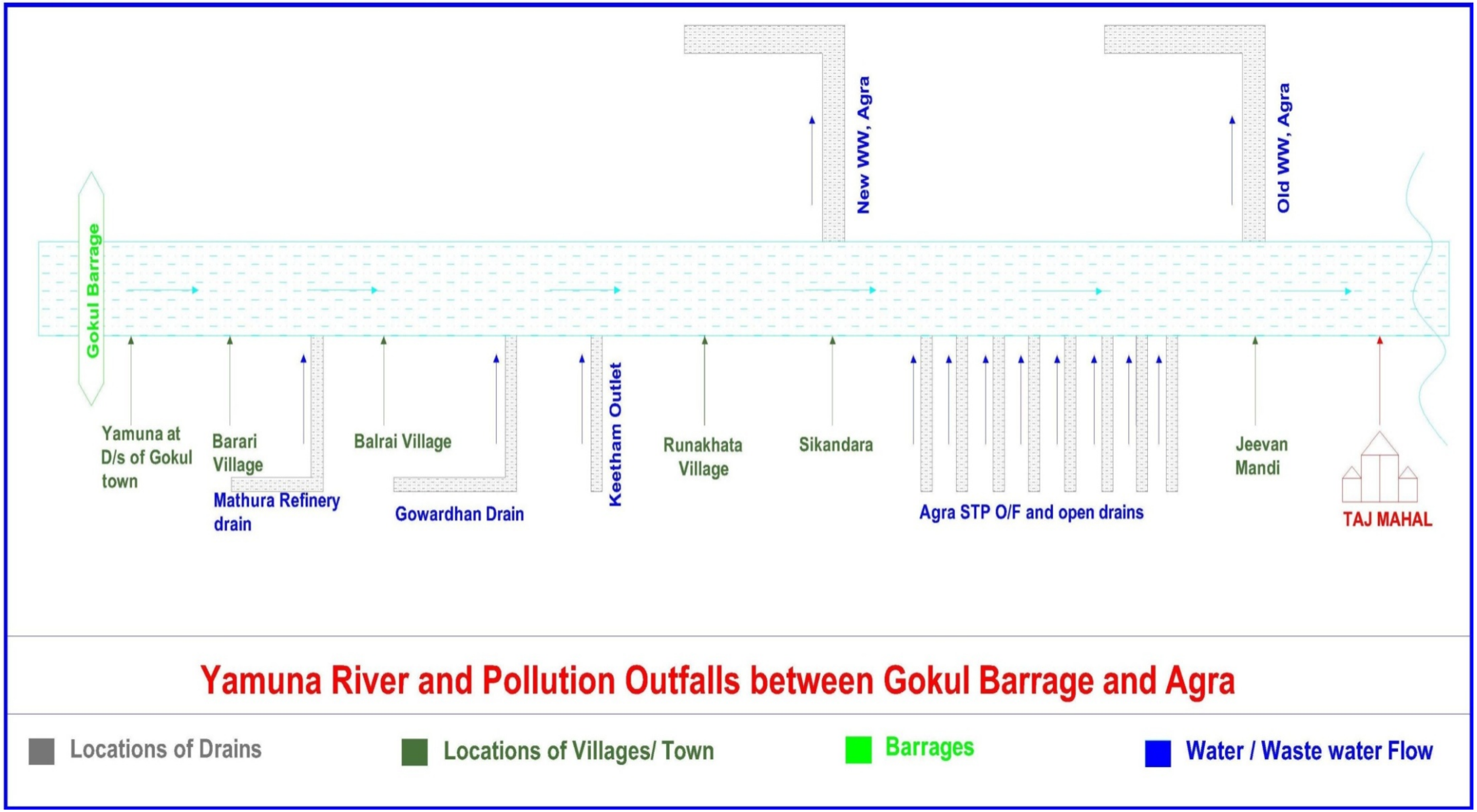

Fig 3.2: Yamuna river and pollution outfalls between Gokul barrage and Agra

2) Noida Drain (NOD)

Noida Drain is joining to the river system of Yamuna about 17 km downstream of Okhla barrage. The drain carrying wastewater from Gaziabad and Noida area and joining to the river Yamuna on its left bank. The location of the drain sampling was just before joining to the river system.

3) Hindon River (HND)

Hindon River is joining to the river system of Yamuna about 38 km downstream of Okhla barrage and carrying wastewater from Saharanpur, Gaziabad, Noida and other U.P. area and joining to the river Yamuna on its left bank. The location of the sampling of the river Hindon on the express highway bridge or Greater Noida road just 3-5 km before joining to the Yamuna river system.

4) Faridabad Drain (Known as Bodhia nala) (FBD)

Faridabad Drain is joining to the river system 39 km downstream from Okhla barrage. The confluence point is at just upstream of Tilwada village near Amipur village and downstream of Captain farm. The drain carries wastewater from Himatpur, Faridabad, and also carries STP outfall Zone I of Faridabad and joining to the river Yamuna on its right bank. The location of the drain sampling was just before joining to the river system.

5) Gaunchi Drain (GAD)

Gaunchi Drain is joining to the Yamuna river system about 132 Km d/s from Okhla Barrage (Kalindi) and carrying wastewater from Faridabad, and also carries STP outfall Zone III having designed capacity of 50 mld and Ashoka distillery wastewater. The drain joining to the river Yamuna on its right bank after traveling few kilometer downstream of Hasanpur village (Hodal). The drain was found dry at the time of survey. This needs further investigations.

6) Mathura Drains (MUD)

Mathura Drains are from four STPs outfalls joining to the river Yamuna. Three outfalls joining to the river on its right bank and one is joining on its left bank from Lohwan STP and these outfall joining just before Gokul Barrage and accumulating wastewater on the big reservoir formed by the barrage. The location of sampling of all four outfalls was made on the outlet of STPs (treated wastewater) joining to the river system. The details of these outfall and their characteristics was given in the following table.

7) Refinery Drain (RED)

Refinery Drain is joining to the river system about 204 km downstream from Okhla barrage. The confluence point is near Barari/Balrai village and downstream of Mathura refinery. The drain carries wastewater from Mathura refinery and joining to the river Yamuna on its right bank after traveling 5-6 km from the factory. The location of the drain sampling was just before joining to the river system.

8) Agra Drains (AGD)

There are several drains joining between Sikandara waterworks and Jeewni Mandi Waterworks. However, major eight drains were considered for its pollution contribution during the survey. The details of these outfall and their characteristics was given in the following table.

3.3 SAMPLING AND MONITORING

3.3.1 Sampling procedure

The samples were collected from the right and left bank of all the river locations. Additional samples from the five impact locations i.e. drains/pollution outfalls such as Shahdara drain, Noida drain, Faridabad drain, Mathura STPs outfalls, Refinery drain, Gowardhan drain, and Agra STP outfalls and open drains were also collected. The samples were collected in clean containers after rinsing with the river water. The drain samples were collected from the outfall region just before joining the river system. All the samples were properly labeled and preserved. Flow measurement in each drain was carried out following the area float method correcting with the 80% of surface flow of each drain. The field measurements (or Insitu measurement) like Water temperature, dissolved oxygen, and Total Alkalinity were done on the spot. The samples then transported to the laboratory as soon as possible for further analysis.

River water samples were collected from the midstream (½ width of river) or from the well mixed zone at all the river locations from a depth of about 0.2 meters. Additional samples were also collected at impact locations from one-fourth (¼) width of the river towards out fall side. Samples were also collected from the drain locations after their well mixing with river. In-situ measurements were made on all the river/stream locations. These are pH, Water Temperature, Dissolved oxygen, and Total Alkalinity. The Dissolved Oxygen measurement by titrametric method (manual method) was carried out. The collected samples are preserved either in ice or by chemicals, depending upon the parameters and transported to the laboratories as early as possible for the analysis.

Table 3.2: Sampling type

	Sample Type	**Bottle Type**	**Volume**	**Preservation**
Water samples for chemical analysis	Physico-chemical composition	PE carboy	2 L	Cooled in ice
	Ammonia / TKN	G NM	1 L	2 ml H_2So_4
Drain samples for physico-chemical analysis:	Physico-chemical composition	PE Carboy	2 L	Cooled in Ice
	Ammonia-N / TKN/ Organic-N/ NO2-N, NO3-N	G NM	1 L	2 ml H_2So_4

3.3.2 Analysis of samples

The samples were preserved in the field and analyzed within 24 hrs of its collection for the parameters like pH, Conductivity, TDS, COD, BOD, and all Nitrogen parameters such TKN, NH3-N, NO2-N, NO3-N etc. to avoid any degradation. All the precautions as per the standard procedures were followed in sampling and analysis. Analyses of most of the parameters have been carried out using Standard Method (APHA, 2000). Details of frequency of monitoring, type and number of parameters studied are briefed in Table 3.3.

Table 3.3: Parameters measured for monitoring

S.No	Parameter	Analysis Method	Reference
1	Water Temperature	Thermometer	APHA, 2000
2	Turbidity	Nephelometric	APHA, 2000
3	Total Dissolved Solid	Gravimetric	APHA, 2000
4	pH	pH meter	APHA, 2000
5	DO	Winkler's method	APHA, 2000
6	BOD	5 day BOD at 20C	APHA, 2000
7	COD	Dichromate reflux	APHA, 2000
8	Ammonia	Distillation followed by colorimetric method (Nesselerization)	APHA, 2000
9	Conductivity	Conductivity meter	APHA, 2000
10	Heavy Metals	Atomic Absorption Spectrophotometer	APHA, 2000

Chapter 4

WATER QUALITY OF YAMUNA RIVER UPTO OKHLA

4.1 INTRODUCTION

Economic growth in all over the country has been vigorous, especially in the so-called newly industrializing countries. Nearly all new development activity creates stress on the "pollution carrying capacity" of the environment. Many hydrological systems in developing regions are, or are getting close to, being stressed beyond repair. Industrial pollution, uncontrolled domestic discharges from urban areas, diffuse pollution from agriculture and livestock rearing, and various alterations in land use or hydro infrastructure may all contribute to non-sustainable use of water resources, eventually leading to negative impacts on the economic development of country. Municipal wastewater is typically generated from domestic and industrial sources and may include urban run-off. Domestic wastewater is generated from residential and commercial areas, including institutional and recreational facilities. In the rural setting, industrial effluents and storm water collection systems are less common (although polluting industries sometimes find the rural environment attractive for uncontrolled discharge of their wastes). In rural areas the wastewater problems are usually associated with pathogen-carrying fecal matter. Industrial wastewater commonly originates in designated development zones or, as in many developing countries, from numerous small-scale industries within residential areas.

4.2 WATER QUALITY OF YAMUNA BETWEEN HATHNIKUND AND WAZIRABAD BARRAGE

People from all over the country visit various stretches of Yamuna River to take holy dip in river water to purge away their sins. Thus, the river portrays Indian culture and traditions. Yamuna River water quality and quantity degradation hurts the sentiments of Indian masses besides having several adverse impacts on life process in the river. The issues related with water quality of Yamuna River are high organic contents, high nutrients, excessive presence of pathogens, accumulation of pollutants in the catchment area, aesthetic value, deforestation in the catchment area, reduction in the quantity of water and discharges from sewage treatment plants into the river.

As the water quality standards are not remain same all over the stretch of the river. Therefore, it necessary to determine or have knowledge of the water quality of river before it enters the study area i.e. Okhla barrage in Delhi. Upto the Paonta Sahib (Himachal Pradesh) Yamuna contain sufficient flows and enters Hathnikund/Tajewala barrage in Haryana. At this barrage, large amount of water extracted out from the river in western and eastern canal for irrigation as shown in Fig 4.1. Major source of pollution in Yamuna after water extraction are Yamuna Nagar, Karnal, Panipat, Sonepat, Kundli on the right bank of the river which discharges domestic wastewater as well as industrial wastewater. Concentration of the different parameters measured by CPCB at the various major polluting drain and river location between Tajewala and Wazirabad barrage are shown in Table no. 4.1 and 4.2 respectively and shown in Fig 4.2

Table 4.1: Wastewater quality characteristics of pollution outfall drains joining to major pollution outfalls between Tajewala barrage and Wazirabad Barrage in the River Yamuna (April 2009)

Drain Locations	pH	TDS (mg/l)	TSS (mg/l)	COD (mg/l)	BOD (mg/l)	NH_3 (mg/l)
Yamuna Nagar Final Drain before discharge to WJC	6.56	834	186	605	207	25
STP Treated water Drain Yamuna Nagar	6.94	614	83	102	20	45

Munak Escape(Drain no. 2) U/S Panipat Refinery	7.74	286	-	17	4	0.6
Munak Escape (Drain no 2) at Panipat Highway	7.96	854	-	38	15	3.41
Munak Escape (Drain no.2) A/C Panipat Drain at Shimla Gujran village	7.49	1680	221	287	73	31
Panipat Drain b/c Drain no. 2 at Shimla – Dadola Village	7.62	1844	257	302	96	28
STP Treated Wastewater Drain, Panipat	8.14	2946	145	288	84	19
Panipat Drain before discharge of STP WW	7.62	1632	141	228	71	-
STP Treated Wastewater Drain, Sonepat	7.89	1250	66	183	57	51
Drain no. 6, at Jatheri Mod, Sonepat	7.69	1090	54	185	55	53

Wastewater from Yamuna nagar drain joins Western Yamuna Canal. The wastewater goes to dhanaura escape. The escape is also carries fresh water if the discharge regulated from Yamuna Nagar. Presently, there was no fresh water discharge observed in the escape. Contributions of pollution load in terms of volume of wastewater from the Hathnikund to Dhanura escape are 139 MLD and between u/s of Munak escape to Wazirabad Barrage are 160 MLD containing 28.7 and 15.36 tonnes per day of BOD load respectively.

At 164 km downstream of Tajewala barrage, Munak Escape joins the river and carrying wastewater from Panipat Industrial units, Panipat Refinery, and Panipat town sewage (treated/untreated). During its travel, a drain from Refinery joins first then a drain from Babarpur village joins and a drain from Panipat town having industrial and domestic (treated and untreated from Panipat city and STP outfall) wastewater joins Munak escape. The drain carries wastewater from Sonepat town (Industrial + domestic) through Drain no. 6. The Drain no. 6 siphoned at Akbarpur and travels parallel to drain no. 8. From this point drain no. 6 flows towards Delhi and join Supplementary drain which finally meeting to River Yamuna through Nazafgarh drain downstream Wazirabad Barrage. Drain no. 8 carry freshwater from Western Yamuna Canal to feed water in the River near Palla village (Delhi-Haryana Border).

The water quality of River Yamuna in terms of organic pollution had been quite good from origin till Palla. Pollution load of river increased after Munak escape joins the river Yamuna, which carries highly polluted industrial and domestic waste water. No organic pollution was observed in the river up to confluence of Munak Escape.

Table 4.2: Water Quality Characteristics of River Yamuna and Canal between Hathnikund and Wazirabad Barrage (April 2009)

River Locations	pH	Conductivity (Micro mhos/cm)	TDS (mg/l)	COD (mg/l)	BOD (mg/l)	NH3 (mg/l)	DO (mg/l)
Yamuna at Hathnikund Barrage	7.67	294	-	14	02	BDL	9.0
Yamuna at Kalanur	7.94	414	264	05	02	BDL	-
Yamuna at Bidoli (Karnal Road Bridge)	-	-	-	-	-	-	-
Yamuna at Kairana Brdge (Panipat Road Bridge)	-	-	-	-	-	-	-

Yamuna at Hathwala	7.64	3960	2512	102	28	15.6	0.0
Yamuna at Sonepat-Baghpat Road Bridge	-	-	-	-	-	-	-
Yamuna at Palla	7.64	351	238	09	03	0.68	8.32

Though, there was a gradual increase in BOD from river stretch between origin to upstream Delhi. However, the average BOD values have been well below the designated best use criteria till Palla village. The BOD level increased significantly afterwards and average BOD values were not confirming the standard.

Results of the different physio-chemical parameters measured by CPCB in 2011 at different drains locations and river locations joining river Yamuna in the stretch of Hathnikund barrage to Wazirabad barrage are shown in Table 4.3 and 4.4 respectively, which clearly indicates the increase in the concentration of various parameters.

4.3 WATER QUALITY OF YAMUNA BETWEEN WAZIRABAD AND OKHLA BARRAGE

The Delhi stretch of Yamuna is largely defined as its 22 km course from Wazirabad to Okhla barrages. Yamuna in Delhi is barely 2 per cent of its entire length but according to CPCB it contributes over 70 per cent of total pollution load. Monitoring data of CPCB shows that pollution measured in terms of BOD load has increased 2.5 times from 1980-2005. BOD load, which was 117 tonnes per day (tpd) in 1980 increased to 276 tpd in 2005. The river has no fresh water flow for virtually nine months. Delhi impounds water at the barrage constructed at Wazirabad, what that flows subsequently are only sewage and waste. Within Delhi for most of the year, at joining of Najafgarh Drain and upstream of Okhla barrage DO levels falling to around zero.

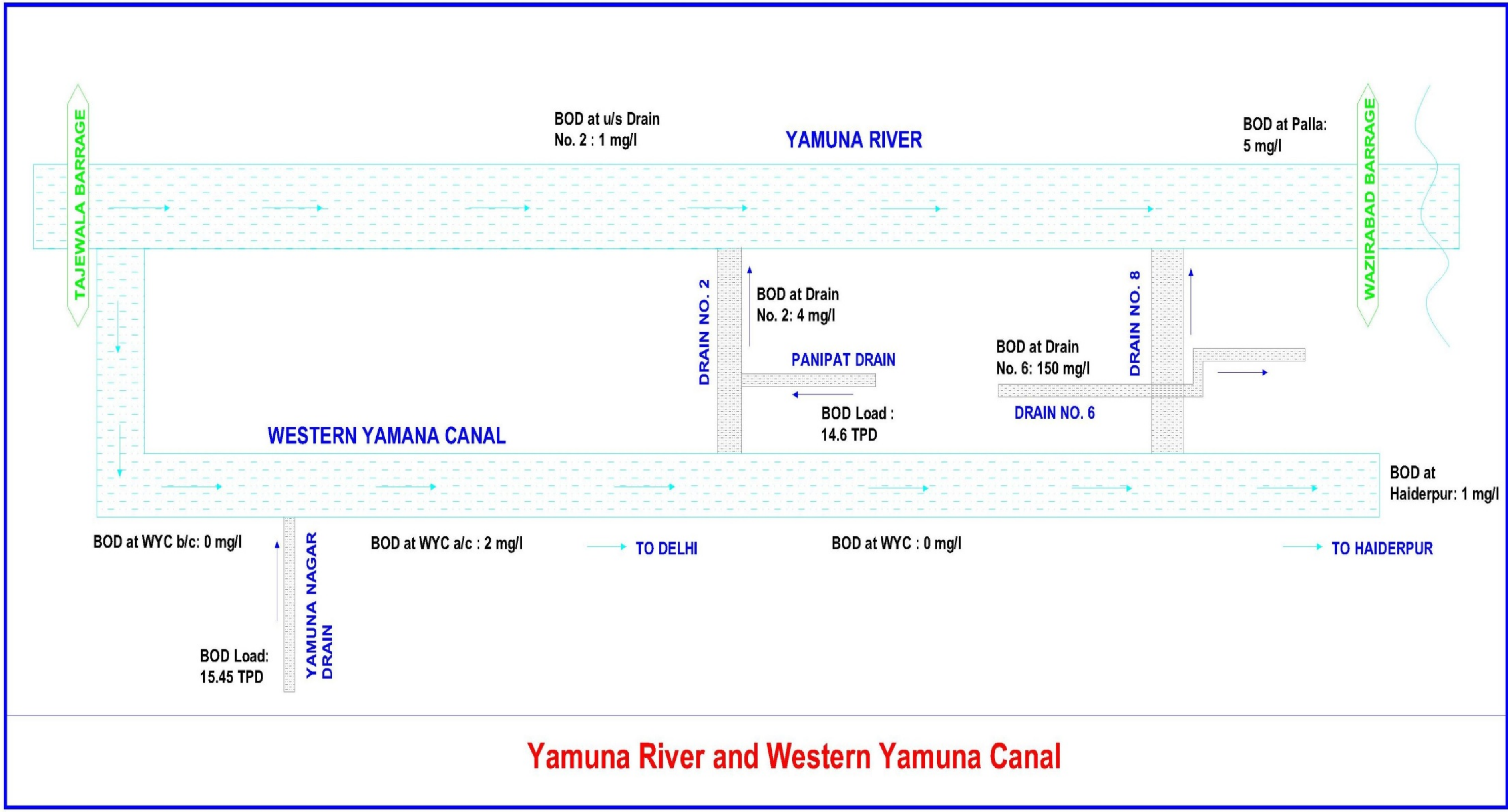

Fig 4.1: Yamuna River and Western Yamuna Canal

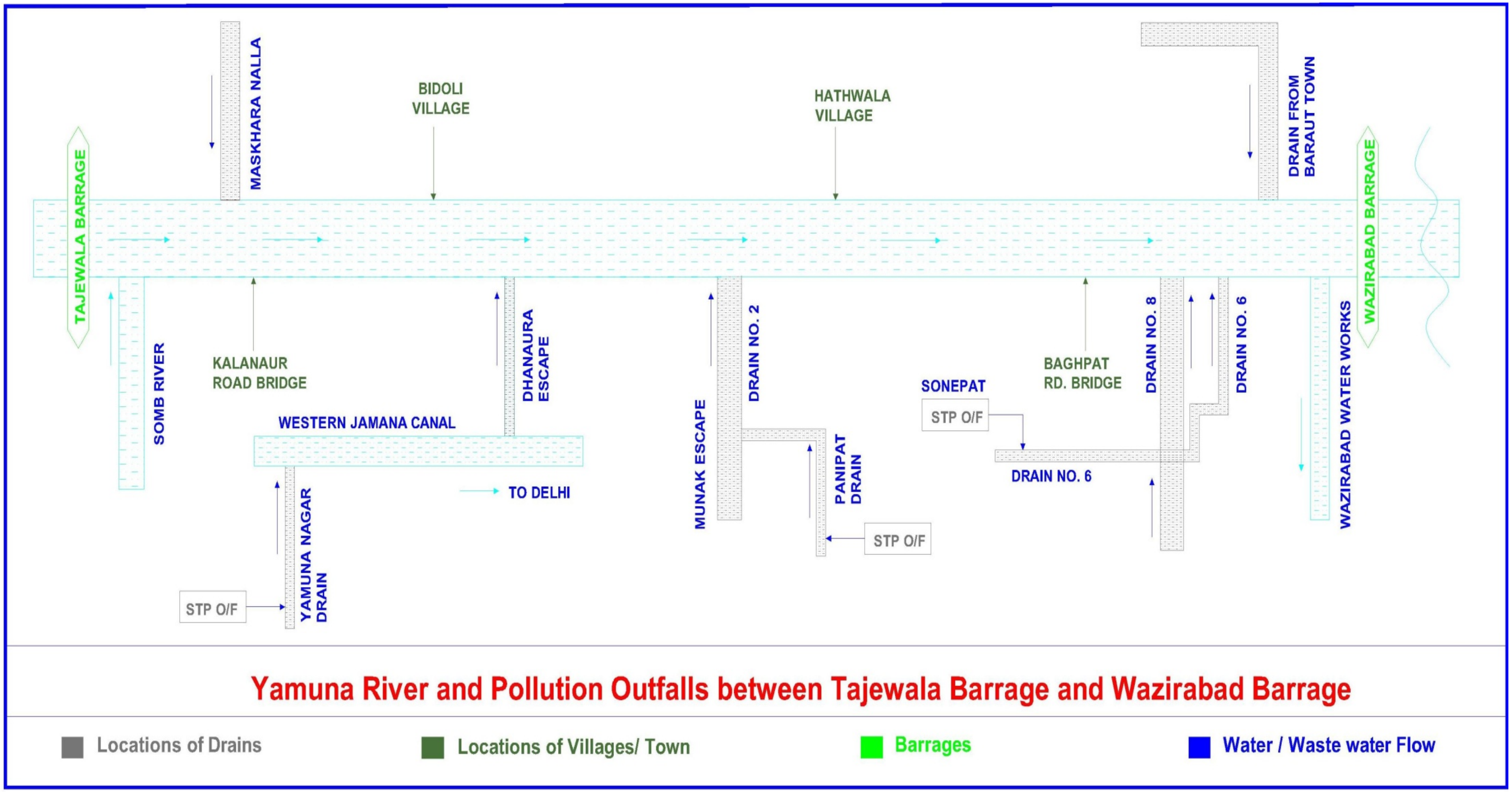

Fig 4.2: Yamuna river and pollution outfalls between Tajewala barrage and Wazirabad barrage

Table 4.3: Wastewater quality characteristics of pollution outfall drains between Tajewala barrage and Wazirabad Barrage in the River Yamuna (March 2011)

Drain Locations	pH	TDS (mg/l)	Conductivity (Micro mhos/cm)	COD (mg/l)	BOD (mg/l)	NH_3 (mg/l)
Maskhara Nallha at Dhaulaher	7.30	474	753	51	5	2.64
WYC, Yamunanagar	7.9	196	325	10	2	0.15
Munak Escape(Drain no. 2) U/S Panipat Refinery	8	200	335	BDL	BDL	0.1
National Woolen/Toll Plaza at Panipat	8.1	204	339	BDL	1	0.75
Panipat Refinery out let, Drain-2	8.5	206	335	9	3	0.15
Munak Escape (Drain no.2) A/C Panipat Drain at Shimla Gujran village	8.4	280	421	8	4	0.31
Village Khojkipur, Drain-2, Panipat	7.90	290	456	12	02	0.50
Bilaspur Village, Drain-2, Panipat	8.10	266	421	10	2	0.83
VillageDadola, Drain-2, Panipat	7.8	-	-	291	139	16
U/S River Yamuna, Panipat	8.4	236	384	BDL	1	0.11

Yamuna river d/s Panipat city	8.0	-	456	10	2	0.83

Table 4.4: Water Quality Characteristics of River Yamuna and Canal between Hathnikund and Wazirabad Barrage (March 2011)

River Locations	pH	Conductivity (Micro mhos/cm)	TDS (mg/l)	COD (mg/l)	BOD (mg/l)	NH_3 (mg/l)
Yamuna at Kalanour, Haryana, Border	7.9	484	300	11	3	0.21
Drain No. 8 at National Highway	7.86	1689	-	BDL	1	0.27
Drain No. 6	7.81	1682	288	252	150	20
Palla (Delhi – Haryana Border)	8.1	-	-	11	4	0.26
Water intake point at Wazirabad	8.13	1586	-	14	2	0.84

This is true even during monsoon. Total Waste water Generation of Delhi is 3800 MLD and Sewage treatment capacity of Delhi is 2433 MLD out of which 1546 MLD sewage is treated. Major sources of pollution of Yamuna in Delhi are untreated domestic wastewater and untreated industrial effluents reaching the river through a network of drains.

Delhi discharges to treated/untreated waste water through 26 drains as shown in Table 4.5. Out of which, 18 drains directly fall into Yamuna River and wastewater of remaining 8 drains get discharge into canals. The calculation taken being 720 (water production) X (0.8) + 100 (Private ground water abstraction). Treatment was done only on around 1546 MLD of sewage.

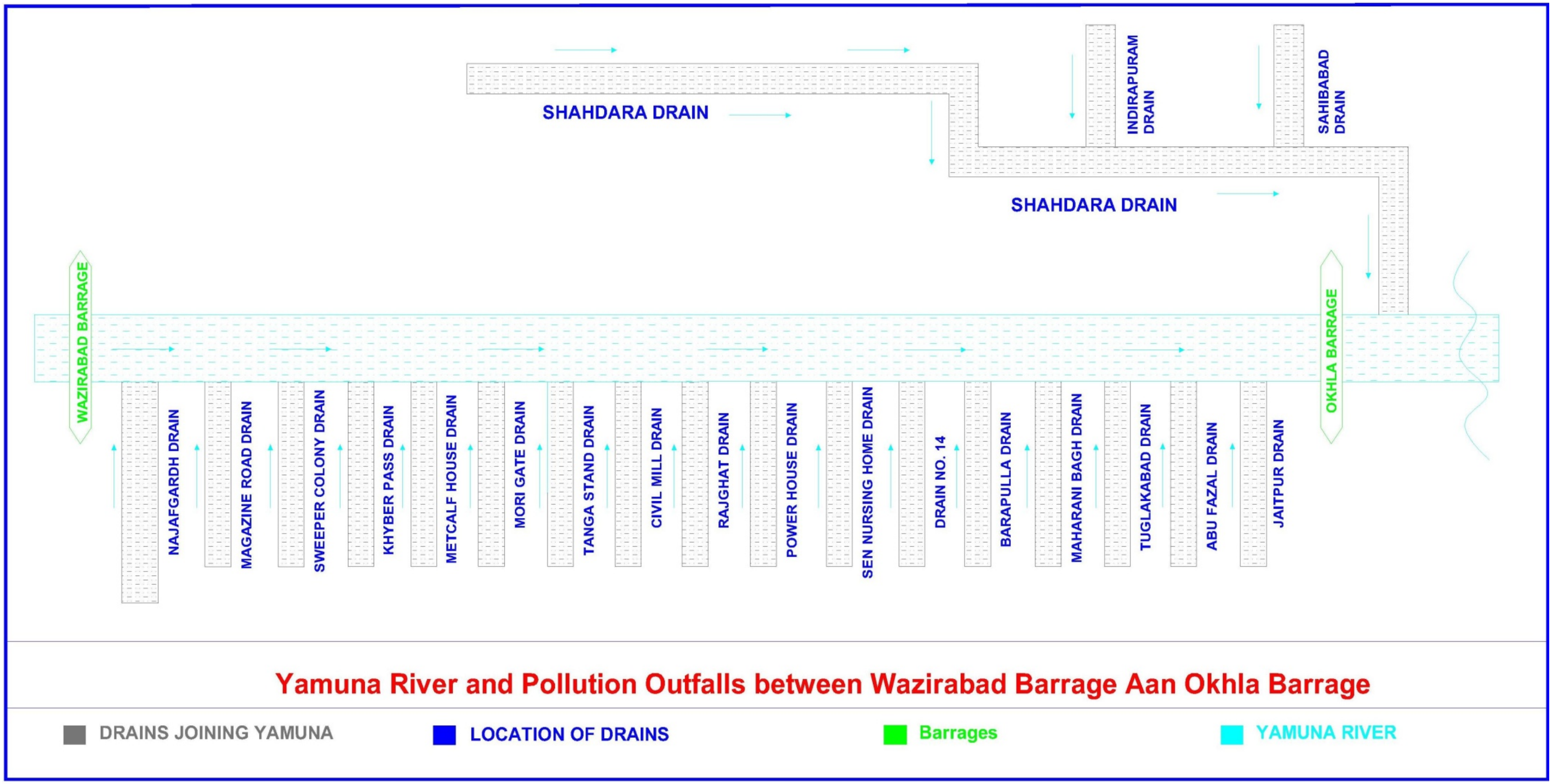

Fig 4.3: Yamuna river and pollution outfalls between Wazirabad barrage and Okhla barrage

Thus untreated sewage to the tune of 1518 MLD, or about 50 per cent, falls into the river Yamuna and is the major cause of river pollution. Other sources of pollution in Yamuna in Delhi are religious activity and immersion of idols, diffuse pollution (agricultural runoffs; dead body dumping and cattle washing) and undetected and untreated pesticide residues leave a toxic mark all across the river. In the critically, polluted stretch of Yamuna river from Wazirabad to Okhla in Delhi confluence, there was significant fluctuations in dissolved oxygen level from Nil to well above saturation level. This reflects presence of organic pollution load and persistence of eutrophic conditions in the river.

Table 4.5: Drains joining river Yamuna and canal

S.No.	Location of Drains	Discharge (m^3/sec)	BOD load (Tonnes/day)
Drains Joining Yamuna River			
1	Najafgarh + Supplementary Drain	24.92	89.03
2	Magzine Road Zone	0.15	1.94
3	Sweeper Colony Drain	0.06	0.54
4	Khyber Pass Drain	0.07	0.03
5	Metcalf House Drain	0.06	0.25
6	ISBT + Mori Gate Drain	0.49	3.95
7	Tonga Stand Drain	0.08	1.15
8	Civil Mill Drain	0.46	4.05
9	Raj Ghat Drain	0.15	0.32
10	Delhi Gate (Power House Drain)	0.76	10.68
11	Sen Nursing Home Drain	0.75	6.45
12	Drain No. 14	0.13	0.17
13	Barapulla Drain	0.14	13.93

14	Maharani Bagh Drain	0.47	4.59
15	Abu Fazal Drain	0.19	0.63
16	Jaitpur Drain	0.16	2.04
17	Tuglakabad Drain	1.14	5.90
18	Shahdara Drain	8.20	42.12
Drains Joining Canals			
19 (a)	Abandoned Agra Canal at Okhla Vihar (only Yamuna River Water)	3.25	14.61
19 (b)	Abandoned Agra Canal at Kalindi Kunj (After Receiving city Waste)	9.33	52.10
19 (c)	Input of Wastewater in Abandoned canal (19a-19b)	6.39	33.05
20	Sarita Vihar Drain	0.65	17.74
21	H Block Ali Village Drain	0.02	0.25
22	E block Ali Village Drain	0.02	0.39
23	C Block Ali Village Drain	0.02	0.28
24	B block Ali Village Drain	0.04	0.59
25	Tehkhand Drain	0.28	3.08
26	Molarband Drain	0.20	2.79

Najafgarh drain of NCT – Delhi is the biggest polluter of River Yamuna, which contributes about 26% to 33% of total BOD load and 48% to 52% of total discharge that joins Yamuna River in Delhi by various drains. There are 70 sub drains that join main Najafgarh Drain. The study indicated that the total BOD load received by Najafgarh Drain through sub-drains was 136 TPD, whereas the BOD load at the terminal end of the Najafgarh Drain was 89 TPD only. This reduction may be contributed by biodegradation, deposition of settle able material at the bottom and diversion of drain water for irrigation etc.

Najafgarh drain is the biggest of all the drains followed by supplementary drain and shahdara drain and contains approximately 44% of the total waste water that falls in Yamuna River in Delhi. After receiving waste water from the Najafgarh drain, characteristics of Yamuna River changes dramatically and most of the parameters exceed the water quality standards. Except the Drains, water samples were also analysed at different river locations, are shown in Table 4.6. Table 4.6 shows the results of all the 23 drains joining river Yamuna and canal in Delhi with their flow and BOD load. Values of BOD, COD and DO are way away from the respective permissible limits. The water quality violates the standard for C class of river water for all the parameters except for pH.

Table 4.6: Water Quality Characteristics of River Yamuna between Wazirabad Barrage and Okhla Barrage (February-October 2011)

Locations	Monitoring Date	pH	COD (mg/l)	BOD (mg/l)	SS (mg/l)	Discharge (M^3/Sec.)	BOD Load (T/day)
General Standard*		***5.5-9.0***	***250***	***30***	***100***	**-**	**-**
1. NAJAFGARH + SUPPLEMETARY DRAIN	02.02.2011	7.3	264	70	157	22.62	136.81
	03.03.2011	7.4	200	91	125	26.09	205.13
	06.04.2011	7.8	153	48	138	22.63	93.85
	09.05.2011	7.6	197	61	75	25.84	136.19
	02.06.2011	7.2	141	33	113	21.21	60.47
	05.07.2011	7.4	123	28	254	24.68	59.71
	03.08.2011	7.5	166	46	504	26.86	106.75
	06.09.2011	7.2	111	36	321	27.7	86.16
	05.10.2011	6.8	114	33	222	25.28	72.08
2. MAGZINE ROAD DRAIN	02.02.2011	7.1	909	314	583	0.11	2.98
	03.03.2011	7.3	710	321	369	0.14	3.88
	06.04.2011	7.5	585	213	280	0.13	0.08
	09.05.2011	7.3	897	397	143	0.2	6.86
	02.06.2011	6.9	531	201	330	0.12	2.08
	05.07.2011	7.2	560	197	317	0.09	1.53
	03.08.2011	7.0	581	235	274	0.11	2.23
	06.09.2011	6.9	371	132	172	0.16	1.82
	05.10.2011	7.0	515	227	426	0.07	1.37

3. SWEEPER COLONY DRAIN	02.02.2011	7.3	508	139	51	0.03	0.36
	03.03.2011	7.3	170	60	87	0.07	0.36
	06.04.2011	7.4	336	94	90	0.08	0.65
	09.05.2011	7.3	242	60	61	0.07	0.36
	02.06.2011	7.0	93	22	32	0.06	0.11
	05.07.2011	7.1	124	40	54	0.08	0.28
	03.08.2011	7.3	72	27	51	0.07	0.16
	06.09.2011	7.1	104	45	49	0.09	0.35
	05.10.2011	6.9	122	80	120	0.05	0.35
4. KHYBER PASS DRAIN	02.02.2011	7.4	142	33	180	0.13	0.37
	03.03.2011	7.3	24	7	15	0.03	0.02
	06.04.2011	7.5	17	3	44	0.03	0.01
	09.05.2011	7.5	67	12	36	0.02	0.02
	02.06.2011	7.3	24	2	24	0.04	0.01
	05.07.2011	7.4	40	8	57	0.06	0.04
	03.08.2011	7.2	17	3	374	0.04	0.01
	06.09.2011	7.4	30	7	88	0.05	0.03
	05.10.2011	7.3	12	4	41	0.04	0.01
5. METCALF HOUSE DRAIN	02.02.2011	7.3	481	132	46	0.05	0.57
	03.03.2011	7.2	65	21	66	0.09	0.16
	06.04.2011	7.6	101	31	33	0.05	0.71
	09.05.2011	7.5	98	31	50	0.09	0.24
	02.06.2011	7.3	63	17	38	0.08	0.12
	05.07.2011	7.2	80	16	64	0.05	0.07
	03.08.2011	7.3	17	7	19	0.06	0.04
	06.09.2011	7.4	51	10	16	0.13	0.11
	05.10.2011	7.31	37	8	14	0.06	0.04
6. ISBT + MORI GATE DRAIN	02.02.2011	7.3	338	101	138	0.49	4.28
	03.03.2011	7.3	531	190	462	0.54	8.86
	06.04.2011	7.6	206	60	117	0.51	2.64
	09.05.2011	7.5	322	152	106	0.63	8.27
	02.06.2011	7.2	174	68	87	0.61	3.58
	05.07.2011	7.1	140	45	123	0.45	1.75
	03.08.2011	7.3	78	30	62	0.64	1.66
	06.09.2011	7.4	78	27	39	0.54	1.26
	05.10.2011	7.10	147	61	102	0.39	2.06

7. TONGA STAND DRAIN	02.02.2011	7.2	749	302	326	0.08	2.09
	03.03.2011	7.3	409	179	160	0.07	1.08
	06.04.2011	7.4	802	269	376	0.09	2.09
	09.05.2011	7.3	394	185	32	0.1	1.60
	02.06.2011	6.8	613	228	360	0.13	2.56
	05.07.2011	7.2	380	136	275	0.07	0.82
	03.08.2011	7.3	365	134	401	0.09	1.04
	06.09.2011	7.4	209	73	91	0.07	0.44
	05.10.2011	7.29	365	100	182	0.03	0.26
8. KAILASH NAGAR DRAIN	02.02.2011	7.2	1094	339	622	0.05	1.46
	03.03.2011	7.3	554	201	291	0.06	1.04
	06.04.2011	7.4	796	285	398	0.08	1.97
	09.05.2011	7.3	581	181	103	0.06	0.94
	02.06.2011	6.8	289	97	101	0.10	0.84
	05.07.2011	7.2	422	113	298	0.12	1.17
	03.08.2011	7.3	-	-	-	-	-
	06.09.2011	7.4	201	84	99	0.19	1.38
	05.10.2011	7.06	431	165	380	0.06	0.86
9. CIVIL MILL DRAIN	02.02.2011	7.1	385	140	105	0.3	3.63
	03.03.2011	7.3	588	156	407	0.23	3.10
	06.04.2011	7.3	227	84	128	0.18	1.31
	09.05.2011	-	-	-	-	-	-
	02.06.2011	7.1	356	118	240	0.19	1.94
	05.07.2011	-	-	-	-	-	-
	03.08.2011	7.5	76	26	30	0.01	0.02
	06.09.2011	7.4	50	12	65	0.14	0.15
	05.10.2011	7.41	56	18	20	0.05	0.08
10. RAJGHAT DRAIN	02.02.2011	7.3	115	43	27	0.17	0.63
	03.03.2011	7.2	78	21	17	0.04	0.07
	06.04.2011	7.5	74	23	22	0.03	0.06
	09.05.2011	7.5	98	32	17	0.02	0.06
	02.06.2011	-	-	-	-	-	-
	05.07.2011	-	-	-	-	-	-
	03.08.2011	-	-	-	-	-	-
	06.09.2011	7.2	67	9	19	0.12	0.09
	05.10.2011	-	-	-	-	-	-

11. DELHI GATE (POWER HOUSE) DRAIN	02.02.2011	7.2	573	139	156	-	-
	03.03.2011	7.3	240	92	209	0.75	5.96
	06.04.2011	7.5	315	93	165	0.76	6.11
	09.05.2011	7.5	286	72	72	0.67	4.17
	02.06.2011	7.0	368	114	139	1.30	12.80
	05.07.2011	7.3	338	85	317	2.08	15.28
	03.08.2011	7.2	243	107	187	2.38	22.00
	06.09.2011	7.3	132	36	74	4.25	13.22
	05.10.2011	7.3	219	67	160	4.43	25.64
12. SEN NURSING HOME DRAIN	02.02.2011	7.1	534	162	465	0.54	7.56
	03.03.2011	7.3	407	108	283	0.65	6.07
	06.04.2011	7.2	263	91	136	0.98	7.71
	09.05.2011	7.4	456	166	134	0.45	6.45
	02.06.2011	7.2	144	30	59	1.01	2.62
	05.07.2011	7.5	190	61	87	0.53	2.79
	03.08.2011	7.4	136	52	85	0.97	4.36
	06.09.2011	7.3	171	35	181	0.94	2.84
	05.10.2011	7.26	436	150	275	0.89	11.53
13. DRAIN NO.14	02.02.2011	7.4	295	88	33	0.19	1.44
	03.03.2011	7.3	66	21	12	0.22	0.40
	06.04.2011	7.4	25	2	29	0.08	0.01
	09.05.2011	7.7	58	7	30	0.04	0.02
	02.06.2011	7.6	89	24	60	0.04	0.08
	05.07.2011	7.6	44	14	35	0.21	0.25
	03.08.2011	7.7	56	12	17	0.06	0.06
	06.09.2011	7.3	36	4	19	0.22	0.08
	05.10.2011	7.67	33	6	31	0.14	0.07
14.BARAPULLA DRAIN	02.02.2011	7.5	288	84	88	1.39	10.09
	03.03.2011	7.2	219	87	107	1.47	11.05
	06.04.2011	7.3	203	61	133	1.56	8.22
	09.05.2011	7.6	145	39	21	1.67	5.63
	02.06.2011	7.3	142	42	59	1.54	5.59
	05.07.2011	7.2	144	51	77	1.49	6.57
	03.08.2011	7.4	142	58	52	1.24	6.21
	06.09.2011	7.2	172	47	205	4.69	19.05
	05.10.2011	7.35	180	86	101	1.29	9.59

15. MAHARANI BAGH DRAIN	02.02.2011	7.1	754	253	421	0.43	9.40
	03.03.2011	7.2	468	193	283	0.36	6.00
	06.04.2011	7.5	410	156	370	0.35	4.72
	09.05.2011	7.3	424	116	51	0.35	3.51
	02.06.2011	7.2	262	78	189	0.41	2.76
	05.07.2011	7.2	265	64	170	0.4	2.21
	03.08.2011	7.1	329	113	244	0.41	4.00
	06.09.2011	7.2	183	57	142	0.53	2.61
	05.10.2011	7.24	303	115	232	0.45	4.47
16. ABU FAZAL DRAIN	02.02.2011	7.7	275	68	85	0.17	1.00
	03.03.2011	7.2	227	67	66	0.13	0.75
	06.04.2011	7.9	210	65	62	0.12	0.67
	09.05.2011	7.8	92	29	22	0.13	0.33
	02.06.2011	7.9	161	37	53	0.17	0.54
	05.07.2011	7.9	120	29	47	0.19	0.48
	03.08.2011	7.6	17	5	66	0.84	0.36
	06.09.2011	7.6	83	25	141	1.1	2.38
	05.10.2011	7.8	128	37	64	0.18	0.58
17. JAITPUR DRAIN	02.02.2011	7.3	473	152	212	0.18	2.36
	03.03.2011	7.3	393	137	149	0.17	2.01
	06.04.2011	7.9	614	188	321	0.16	2.60
	09.05.2011	7.4	351	100	143	0.17	1.47
	02.06.2011	7.3	373	96	166	0.16	1.33
	05.07.2011	7.4	398	102	313	0.18	1.59
	03.08.2011	7.4	253	105	169	0.24	2.18
	06.09.2011	7.4	215	56	93	0.33	1.60
	05.10.2011	7.29	241	109	94	0.24	2.26
18.TUGLAKABAD DRAIN	02.02.2011	7.5	268	66	253	1.18	6.73
	03.03.2011	7.2	296	85	256	0.86	6.32
	06.04.2011	7.3	291	92	425	0.84	6.68
	09.05.2011	7.6	377	84	113	0.78	5.66
	02.06.2011	7.4	205	38	185	0.73	2.40
	05.07.2011	7.5	399	145	339	0.85	10.65
	03.08.2011	7.4	154	42	164	0.8	2.90
	06.09.2011	7.3	101	29	130	0.78	1.95
	05.10.2011	7.53	182	47	417	0.81	3.29

19.SHAHDARA DRAIN	02.02.2011	7.1	290	99	214	11.91	101.87
	03.03.2011	7.1	360	107	265	11.76	108.72
	06.04.2011	7.5	304	103	276	10.92	97.18
	09.05.2011	7.3	237	51	138	7.46	32.87
	02.06.2011	7.3	167	42	108	6.97	25.29
	05.07.2011	7.3	234	68	752	21.47	126.14
	03.08.2011	7.3	147	35	252	19.65	59.42
	06.09.2011	7.3	415	100	599	22.95	198.29
	05.10.2011	7.27	194	59	211	6.37	32.47
20a. ABANDONED AGRA CANAL AT OKHLA VIHAR (ONLY RIVER WATER)	02.02.2011	7.5	146	37	36	2.24	7.16
	03.03.2011	7.2	126	35	33	2.59	7.83
	06.04.2011	7.9	80	22	61	2.39	4.54
	09.05.2011	7.6	28	6	14	2.73	1.42
	02.06.2011	7.8	110	28	50	0.89	2.15
	05.07.2011	7.8	8	2	107	4.06	0.70
	03.08.2011	-	-	-	-	-	-
	06.09.2011	-	-	-	-	-	-
	05.10.2011	-	-	-	-	-	-
20b. ABANDONED AGRA CANAL AT KALINDI KUNJ (AFTER RECEIVING WASTE)	02.02.2011	7.4	303	129	119	7.81	87.05
	03.03.2011	7.1	156	45	29	8.44	32.81
	06.04.2011	7.5	73	23	41	8.29	16.47
	09.05.2011	7.6	136	30	89	8.29	21.49
	02.06.2011	7.4	490	163	251	4.84	68.16
	05.07.2011	7.5	49	17	59	9.47	13.91
	03.08.2011	7.3	188	79	118	4.69	32.01
	06.09.2011	7.3	118	32	20	3.83	10.59
	05.10.2011	7.3	204	64	112	3.38	18.69
20c. INPUT OF WASTE WATER IN ABANDONED AGRA CANAL (20b-20a)	02.02.2011	-	-	-	-	5.57	79.89
	03.03.2011	-	-	-	-	5.85	23.26
	06.04.2011	-	-	-	-	5.9	27.71
	09.05.2011	-	-	-	-	5.56	20.07
	02.06.2011	-	-	-	-	3.95	66.01
	05.07.2011	-	-	-	-	5.41	13.21
	03.08.2011	-	-	-	-	4.69	32.01
	06.09.2011	-	-	-	-	3.83	10.59
	05.10.2011	-	-	-	-	3.38	18.69

21. SARITA VIHAR DRAIN	02.02.2011	7.3	2130	623	941	0.70	37.68
	03.03.2011	7.1	2047	444	1345	0.75	28.77
	06.04.2011	7.6	664	168	455	0.76	11.03
	09.05.2011	7.5	702	174	266	0.66	9.92
	02.06.2011	7.6	116	31	43	0.69	1.85
	05.07.2011	7.4	500	145	454	0.39	4.89
	03.08.2011	7.3	499	160	335	0.36	4.98
	06.09.2011	7.3	198	58	125	0.46	2.31
	05.10.2011	7.3	565	231	322	0.46	9.18
22.TEHKHAND DRAIN	02.02.2011	7.3	688	208	450	0.23	4.13
	03.03.2011	7.2	664	219	444	0.25	4.73
	06.04.2011	7.5	450	129	453	0.26	2.90
	09.05.2011	7.4	426	154	124	0.22	2.93
	02.06.2011	7.4	397	121	189	0.24	2.51
	05.07.2011	7.5	419	161	269	0.21	2.92
	03.08.2011	7.5	333	114	184	0.2	1.97
	06.09.2011	7.4	212	55	126	0.26	1.24
	05.10.2011	7.5	375	144	197	0.21	2.61
23.MOLARBAND DRAIN	02.02.2011	7.4	472	121	274	0.26	2.72
	03.03.2011	7.2	280	77	136	0.30	2.00
	06.04.2011	7.7	235	76	153	0.33	2.17
	09.05.2011	7.4	410	163	54	0.31	4.37
	02.06.2011	7.5	413	168	280	0.2	2.90
	05.07.2011	7.4	190	74	137	0.27	1.73
	03.08.2011	7.2	193	77	107	0.37	2.46
	06.09.2011	7.3	136	36	34	0.31	0.96
	05.10.2011	7.6	289	80	138	0.28	1.94

In order to restore the quality of river, the Government of India (GoI) initiated the Yamuna Action Plan (YAP) in the1993 and later YAP II in the year 2004 with the objective to stop drains from dumping wastewater into the river and to intercept and divert sewage (CPCB, 2006). The river was supposed to be cleaned by ensuring no-entry of untreated sewage. Due to the inadequate infrastructure for waste water collection and other operational problems, even the current STP capacity is underutilized. The pollution of the river directly linked to the inefficient water planning and management in Delhi.

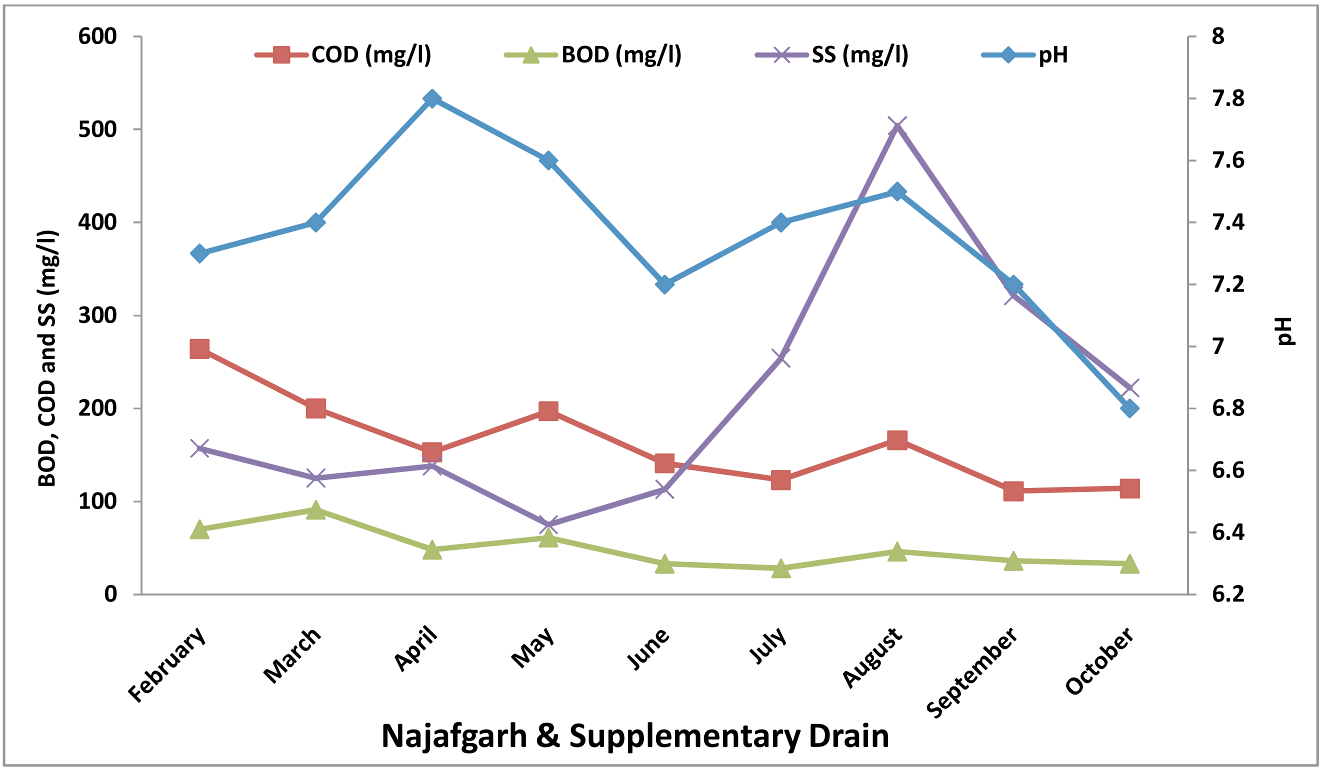

Fig 4.4: Physio-chemical result of Najafgarh & Supplementary Drain

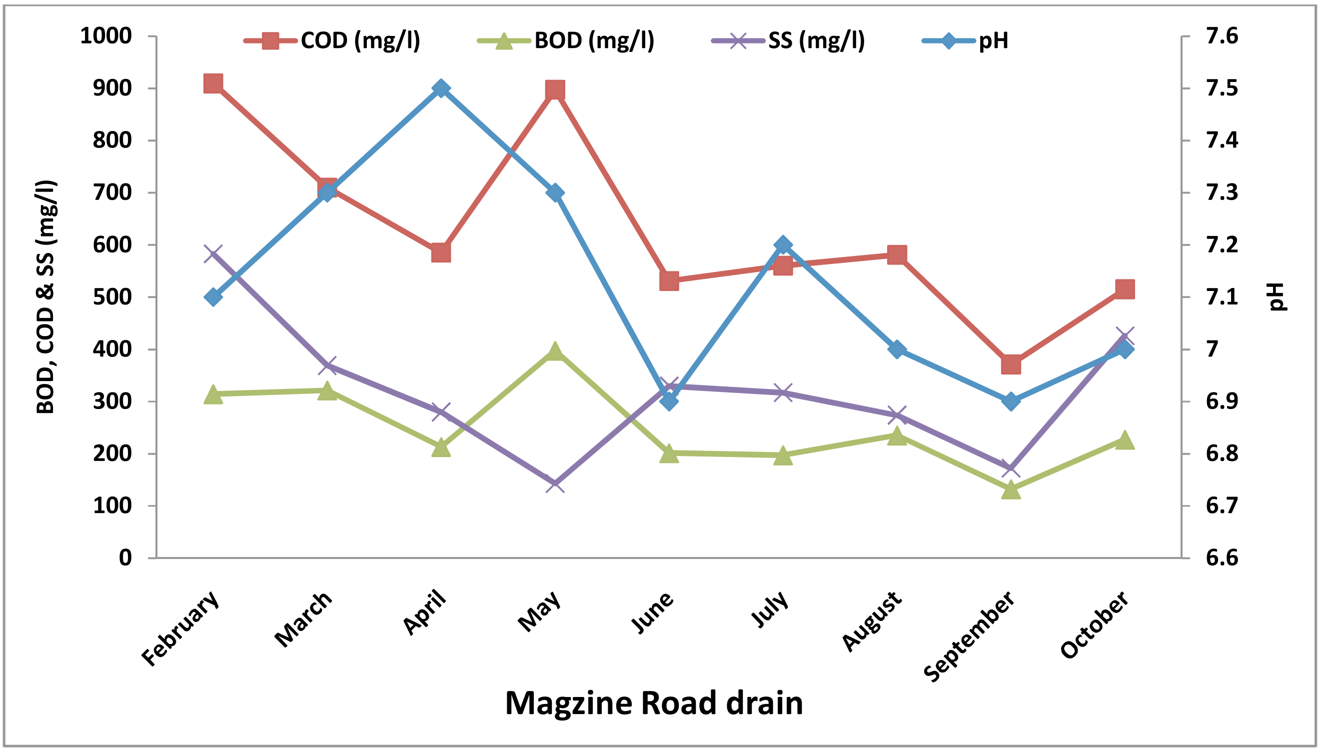

Fig 4.5: Physio-chemical result of Magzine road Drain

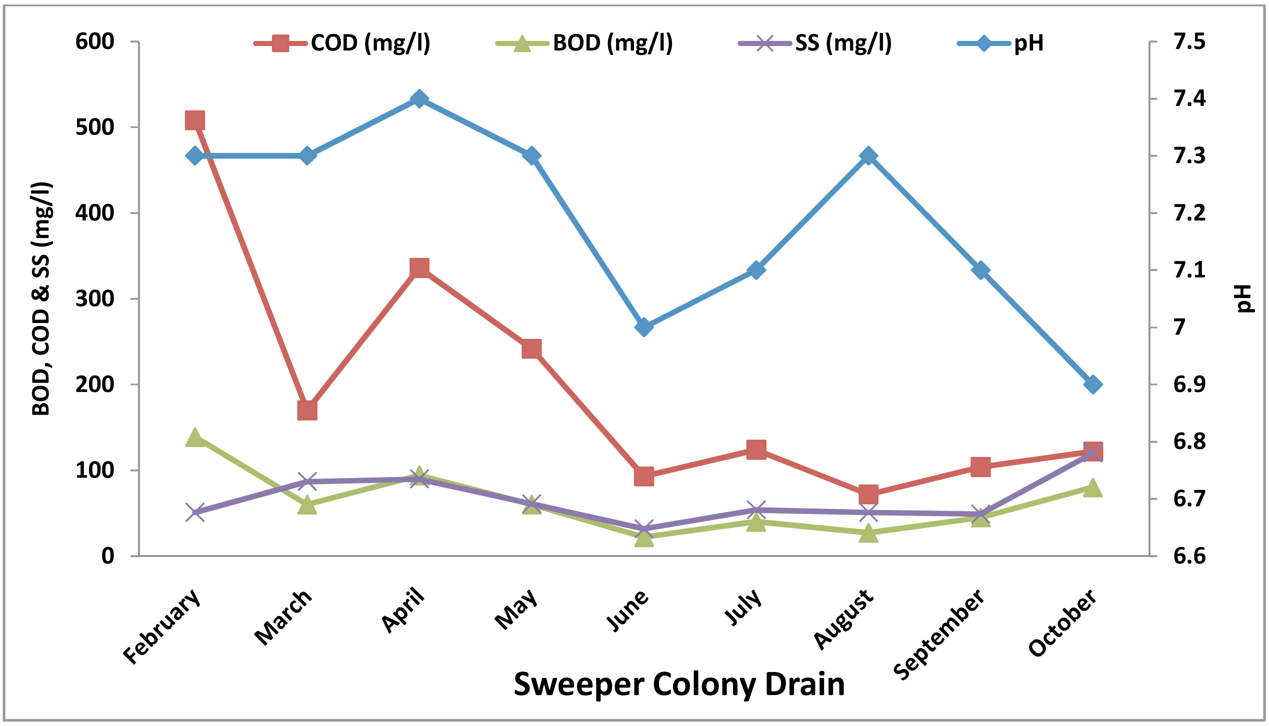

Fig 4.6: Physio-chemical result of Sweeper Colony Drain

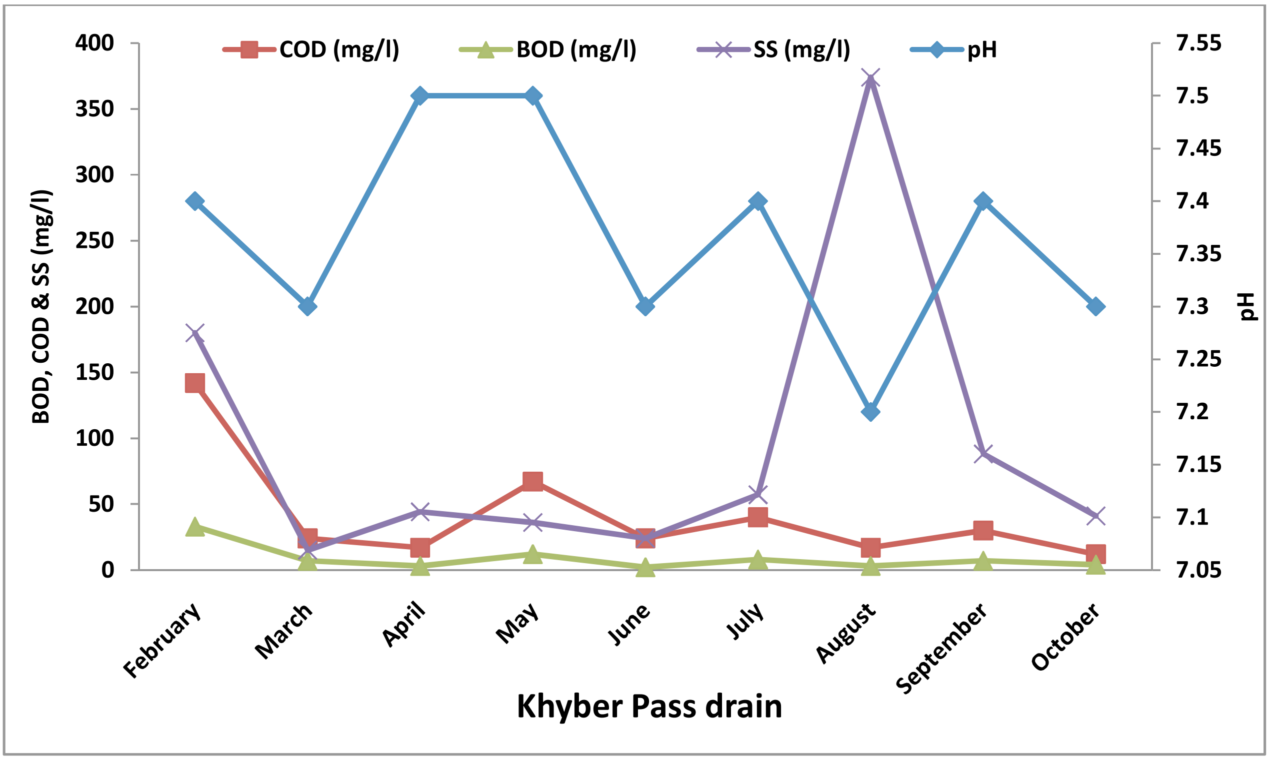

Fig 4.7: Physio-chemical result of Khyber pass Drain

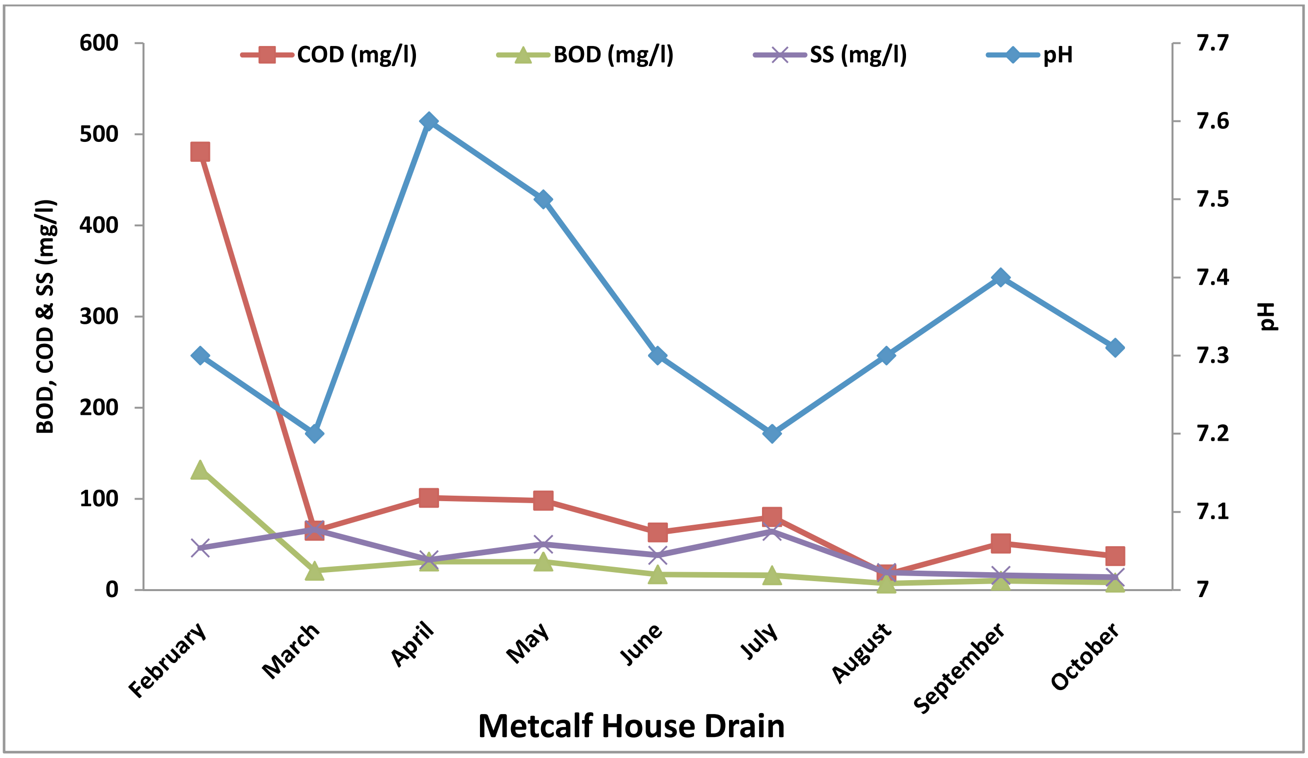

Fig 4.8: Physio-chemical result of Metcalf House Drain

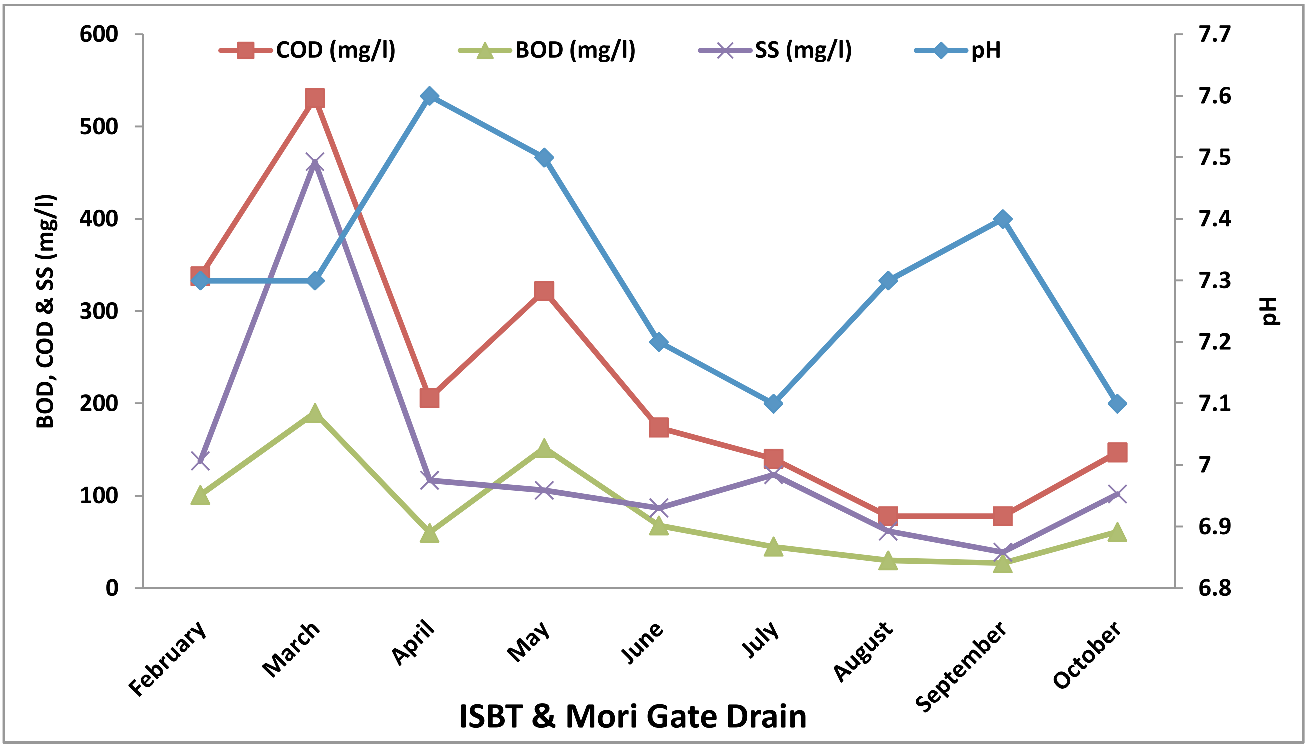

Fig 4.9: Physio-chemical result of & Mori Gate Drain

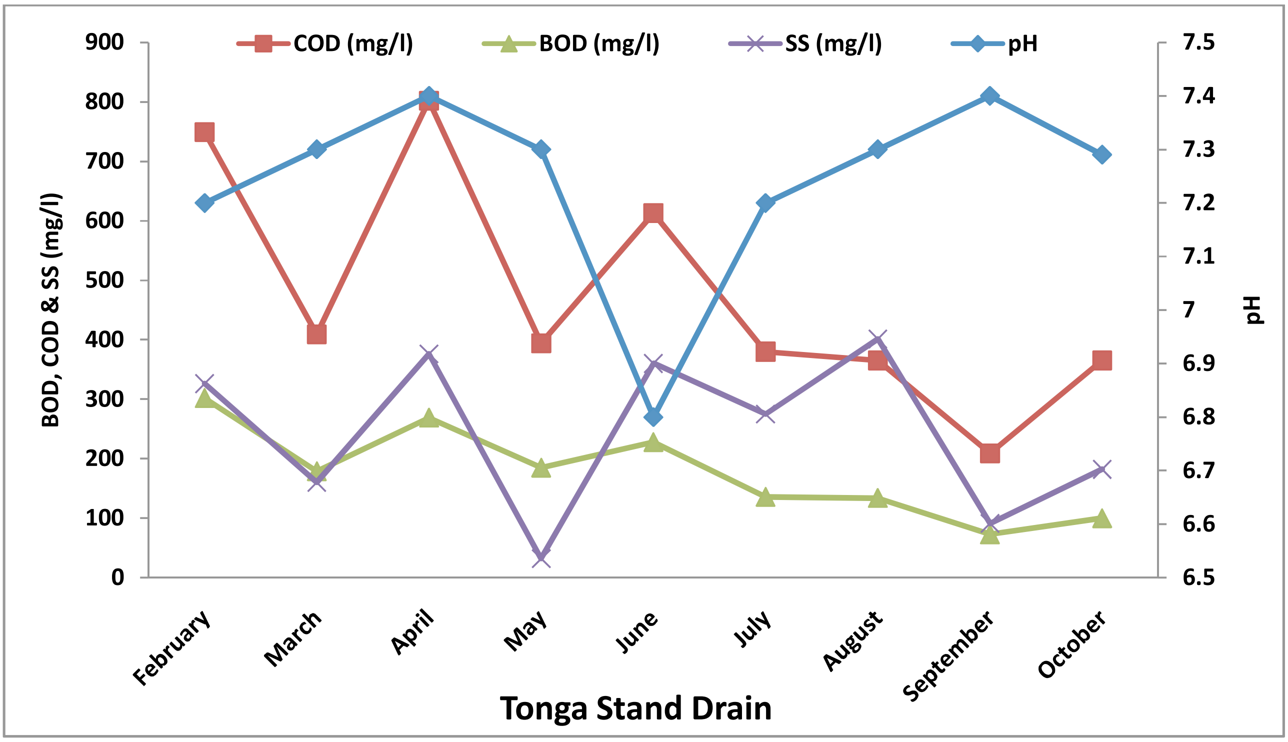

Fig 4.10: Physio-chemical result of Tonga Stand Drain

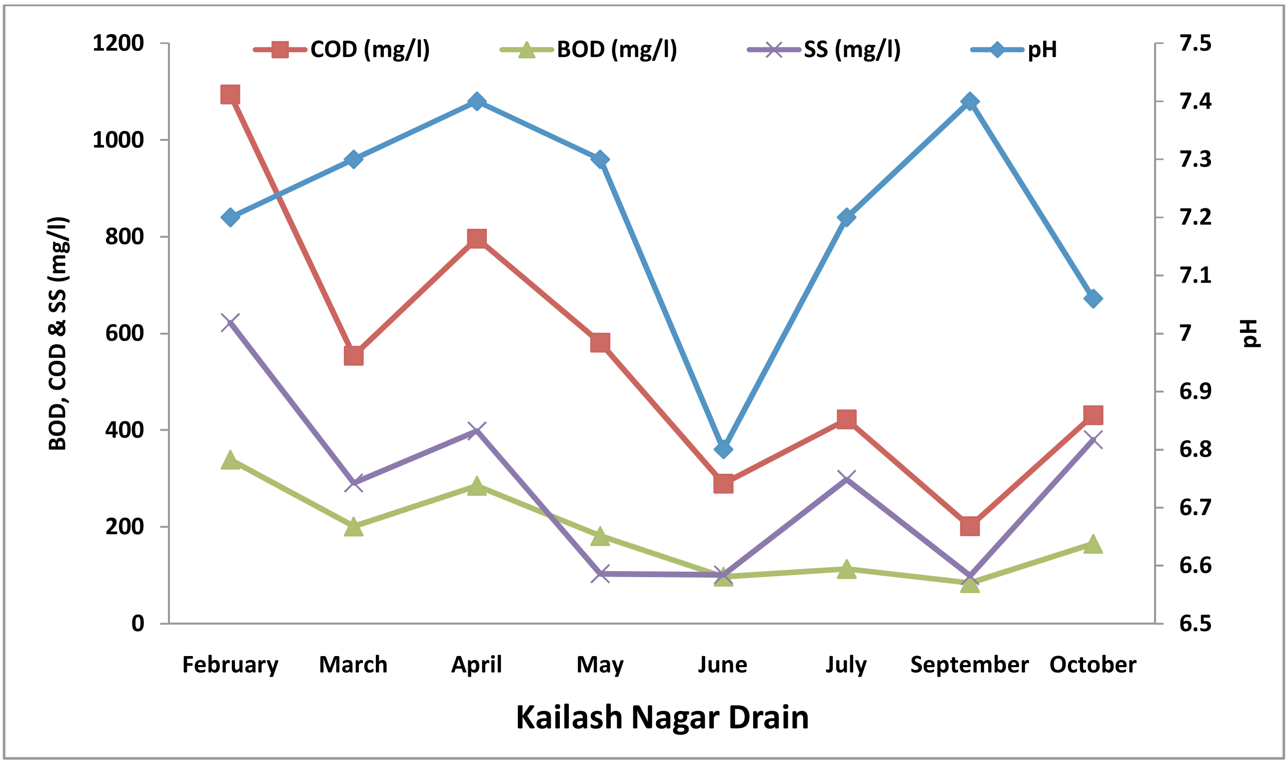

Fig 4.11: Physio-chemical result of Kailash Nagar Drain

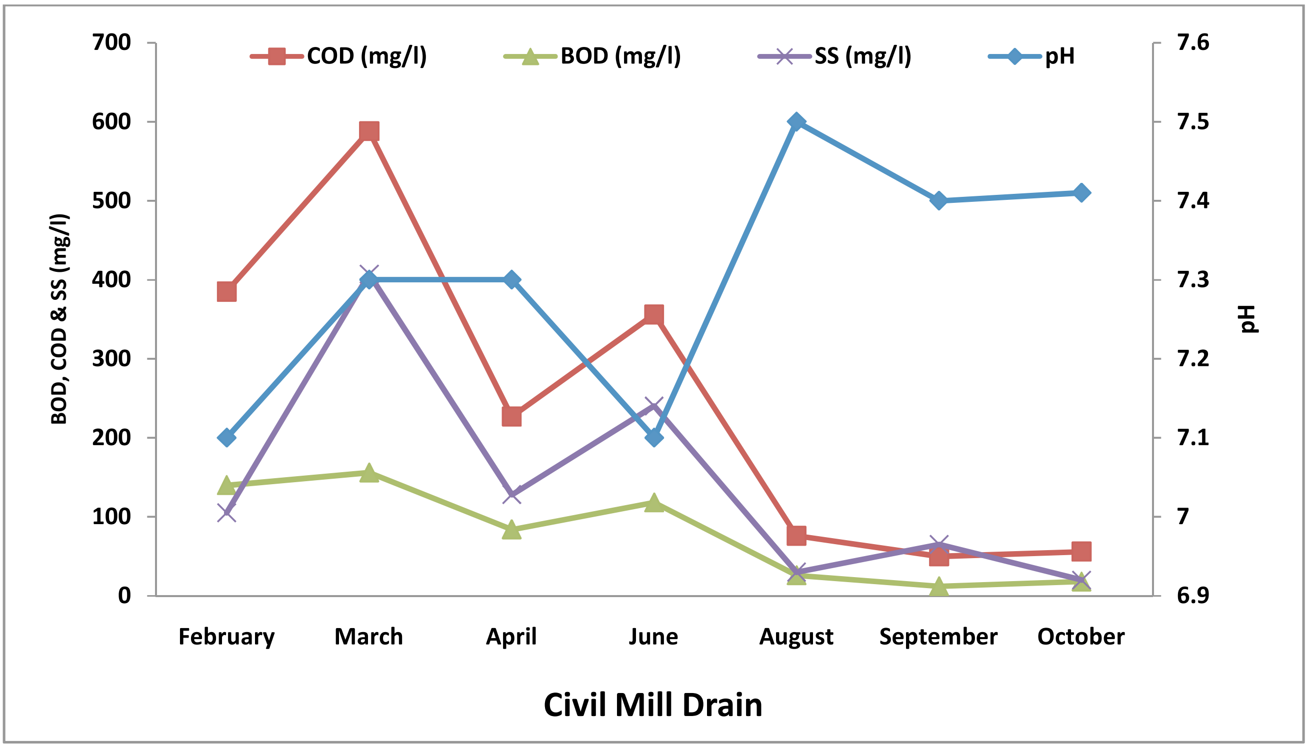

Fig 4.12: Physio-chemical result of Civil Mill Drain

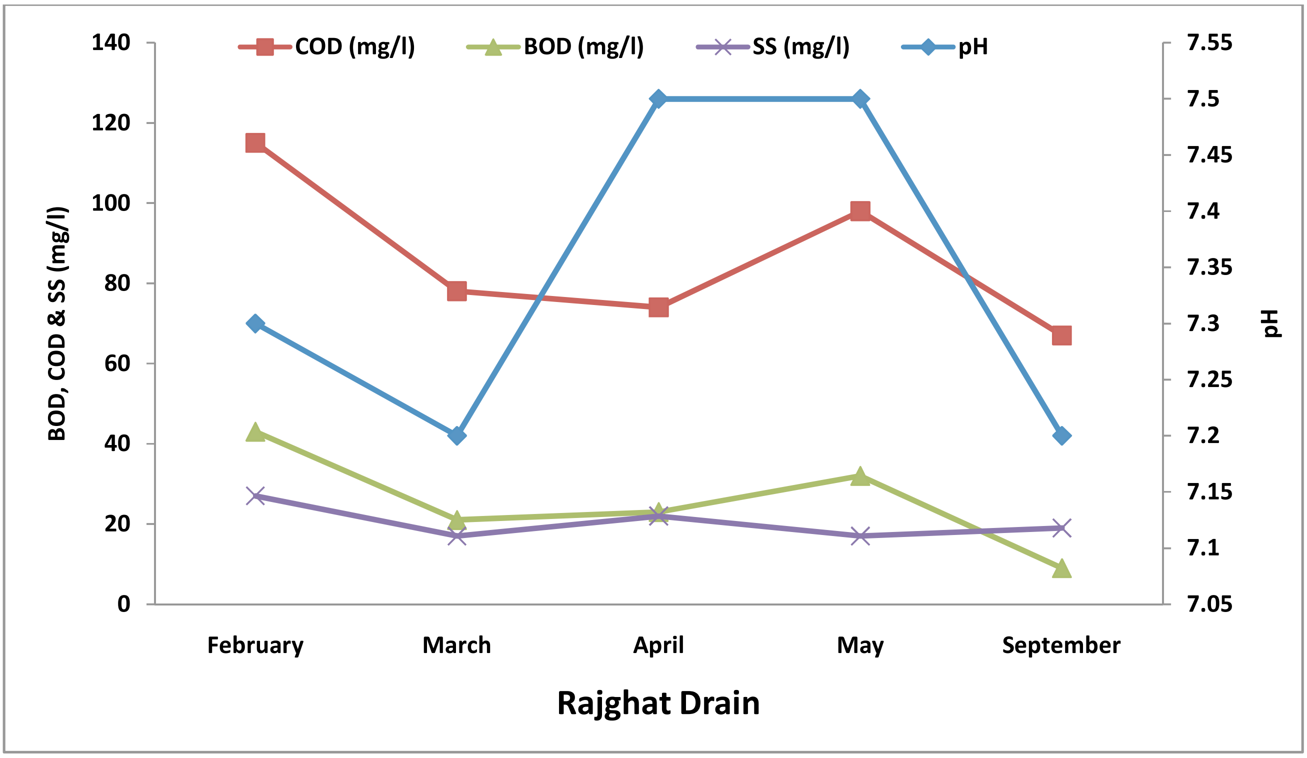

Fig 4.13: Physio-chemical result of Rajghat Drain

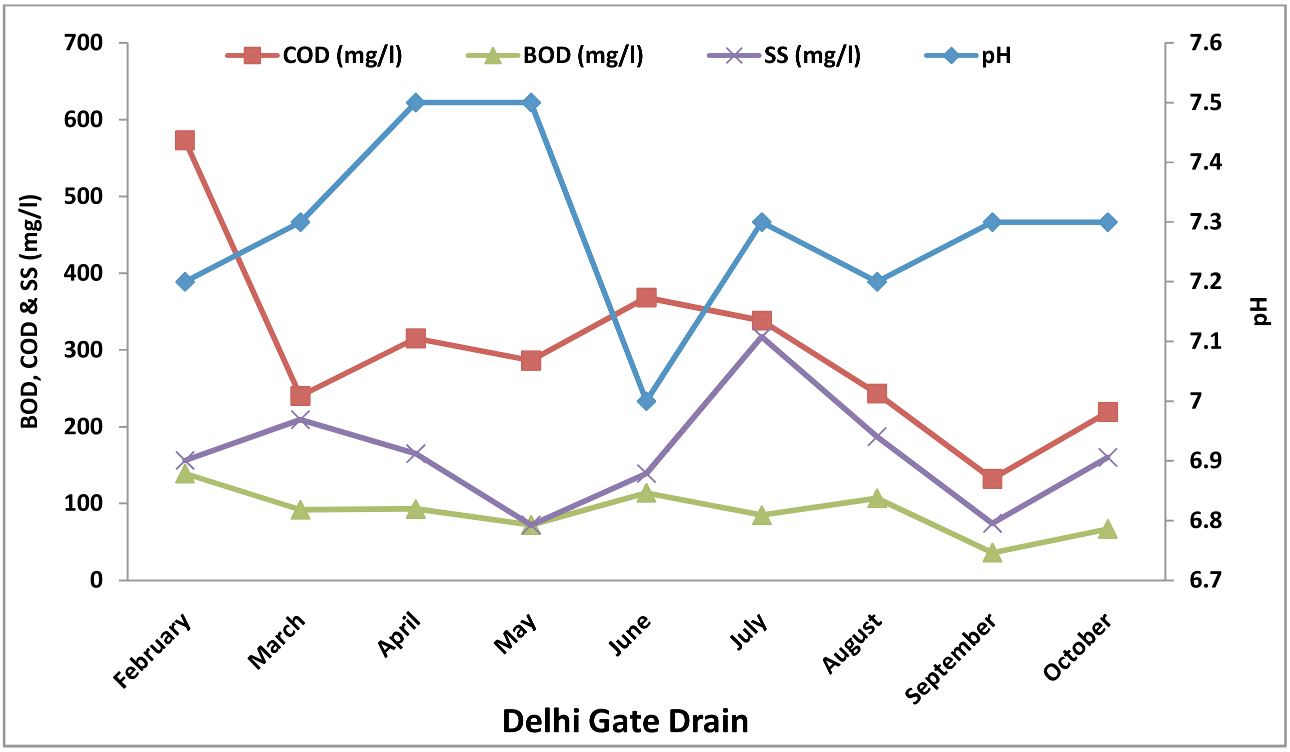

Fig 4.14: Physio-chemical result of Delhi Gate Drain

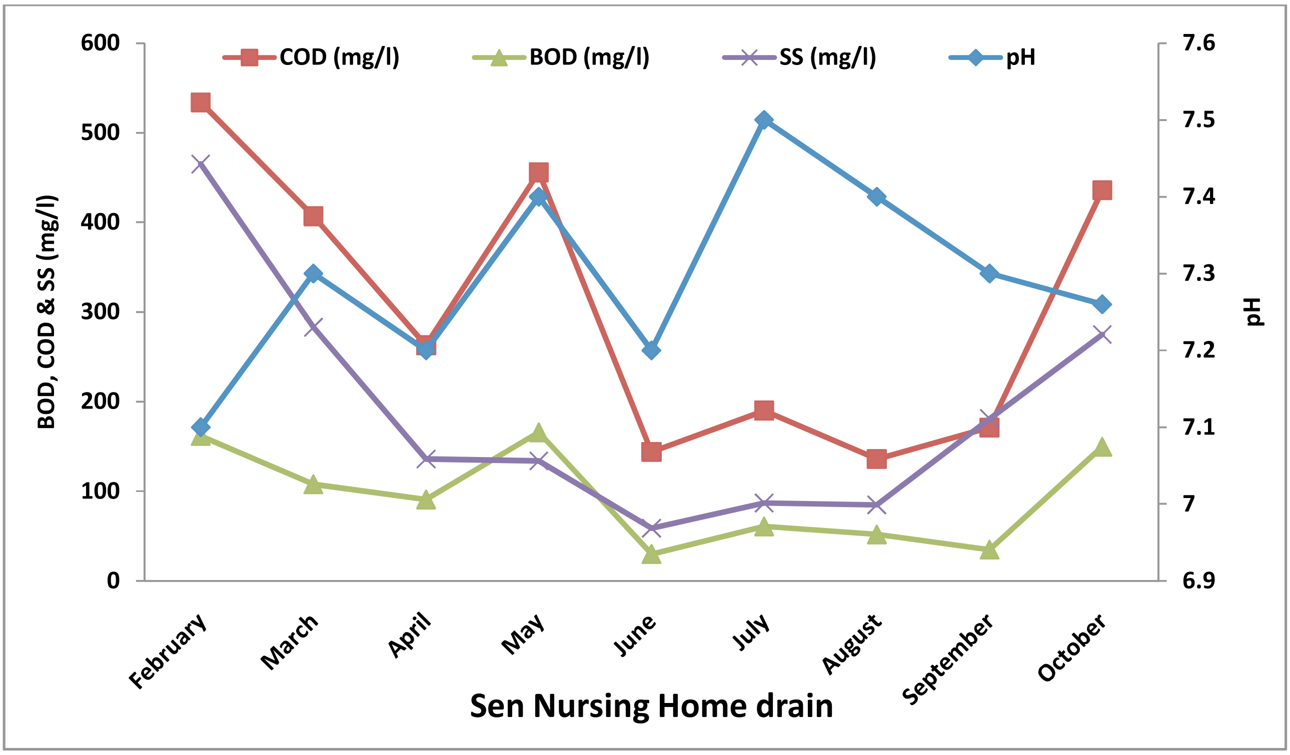

Fig 4.15: Physio-chemical result of Sen Nursing Home Drain

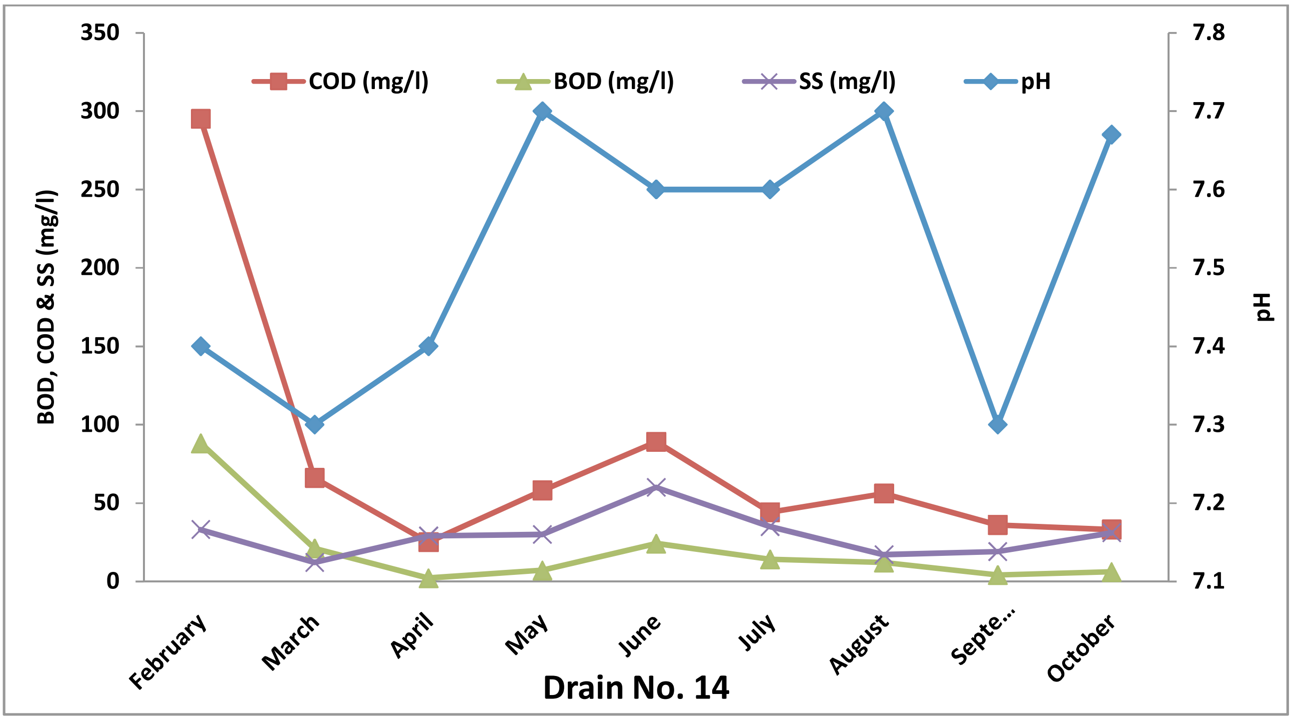

Fig 4.16: Physio-chemical result of Drain No. 14

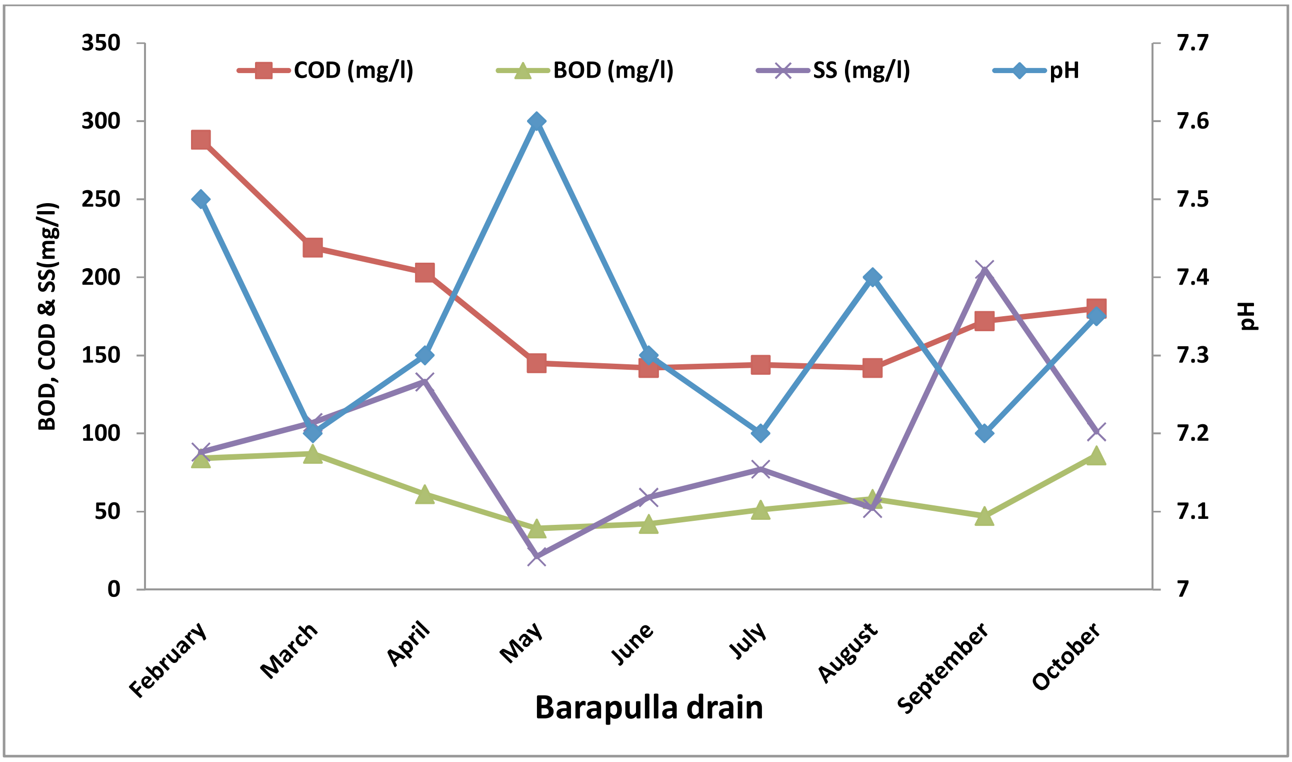

Fig 4.17: Physio-chemical result of Barapulla Drain

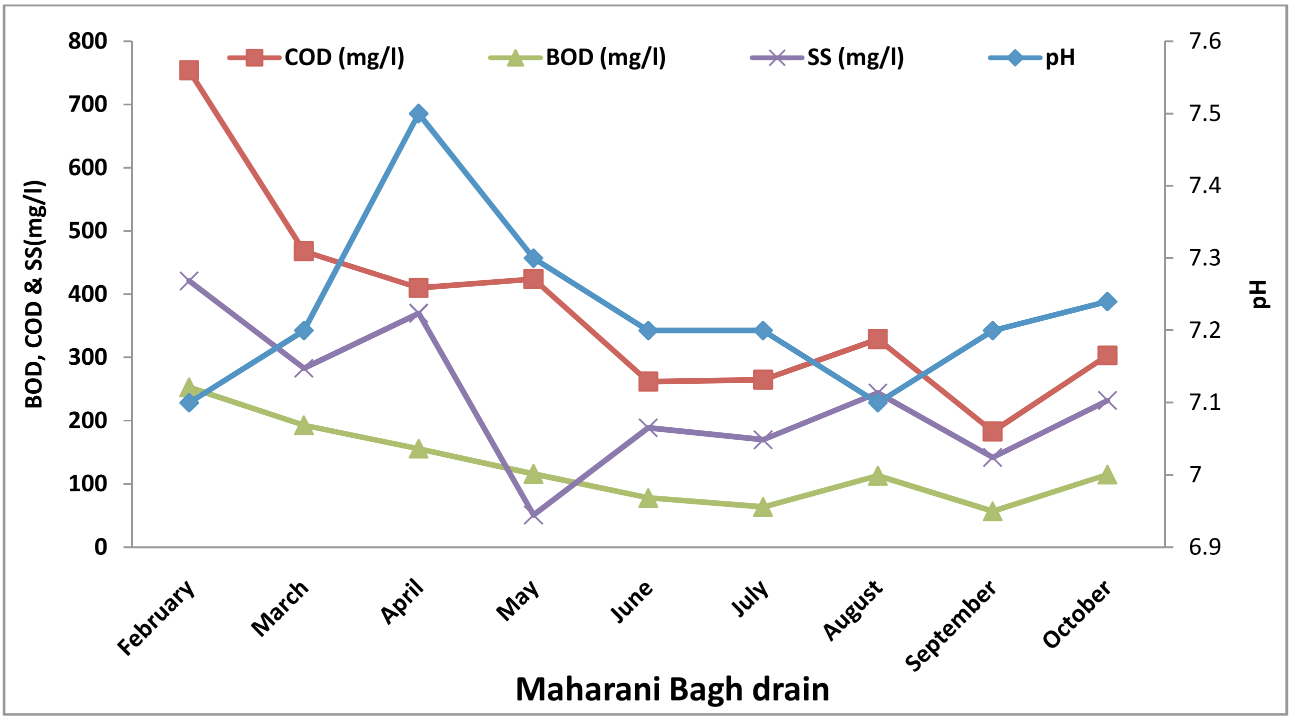

Fig 4.18: Physio-chemical result of Maharani Bagh Drain

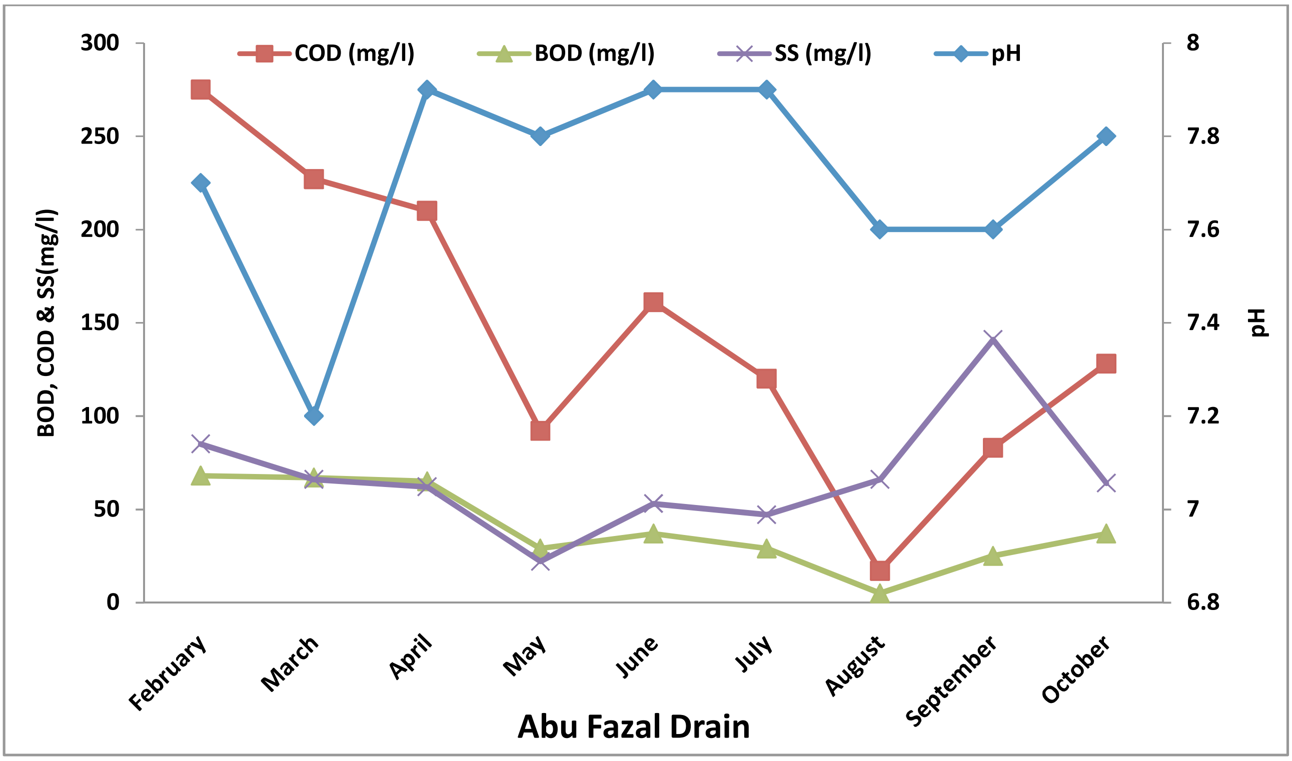

Fig 4.19: Physio-chemical result of Abu Fazal Drain

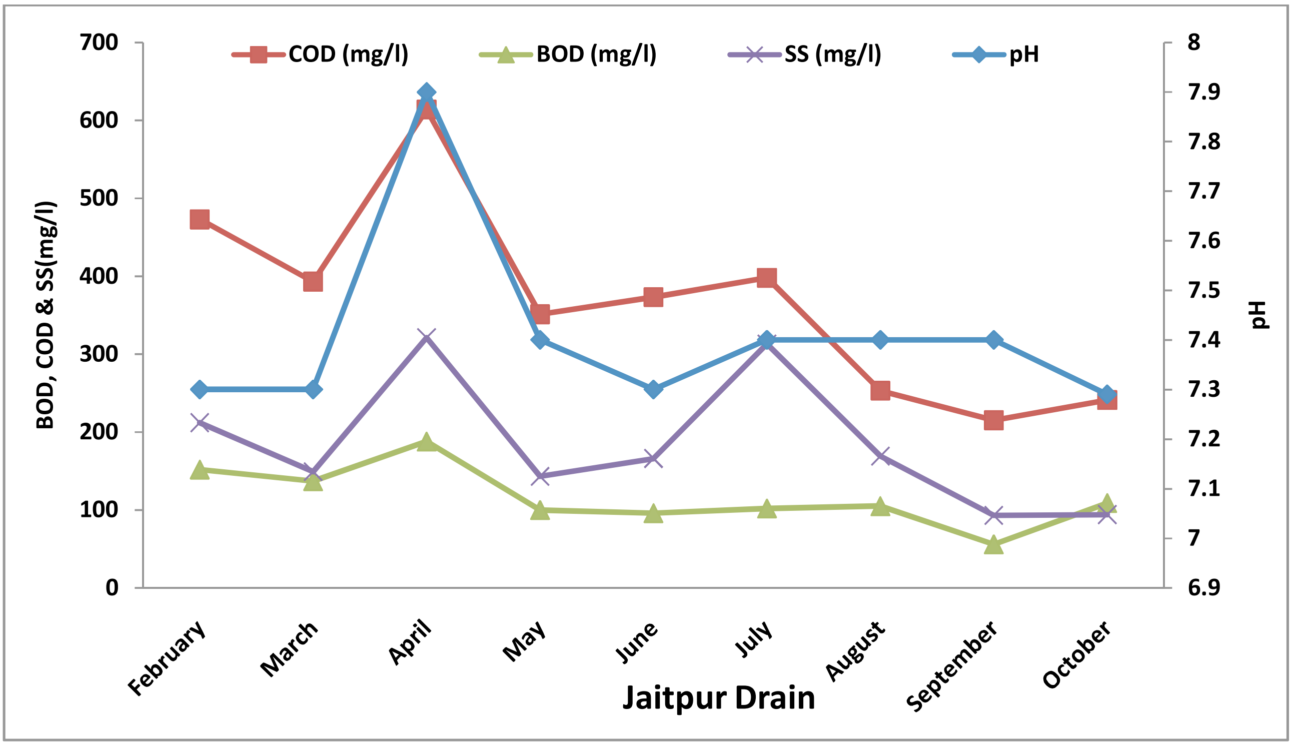

Fig 4.20: Physio-chemical result of Jaitpur Drain

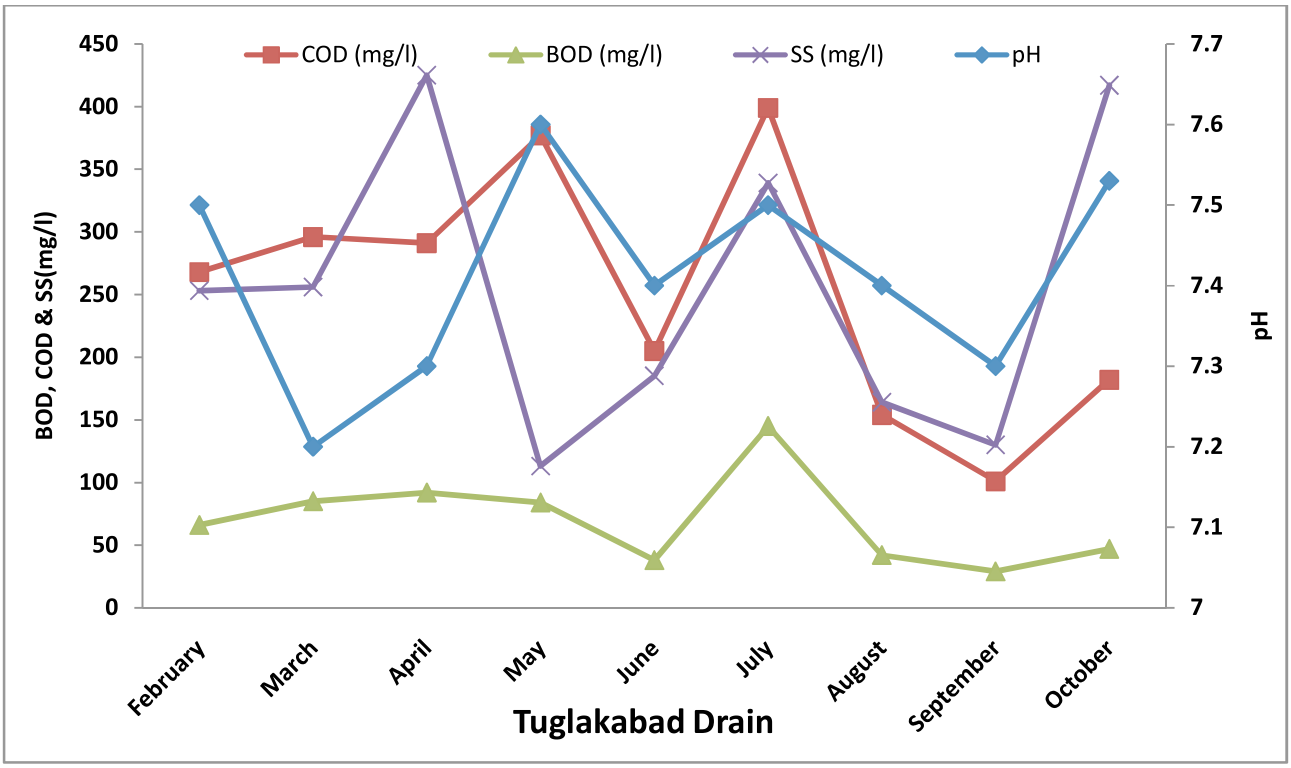

Fig 4.21: Physio-chemical result of Tuglakabad Drain

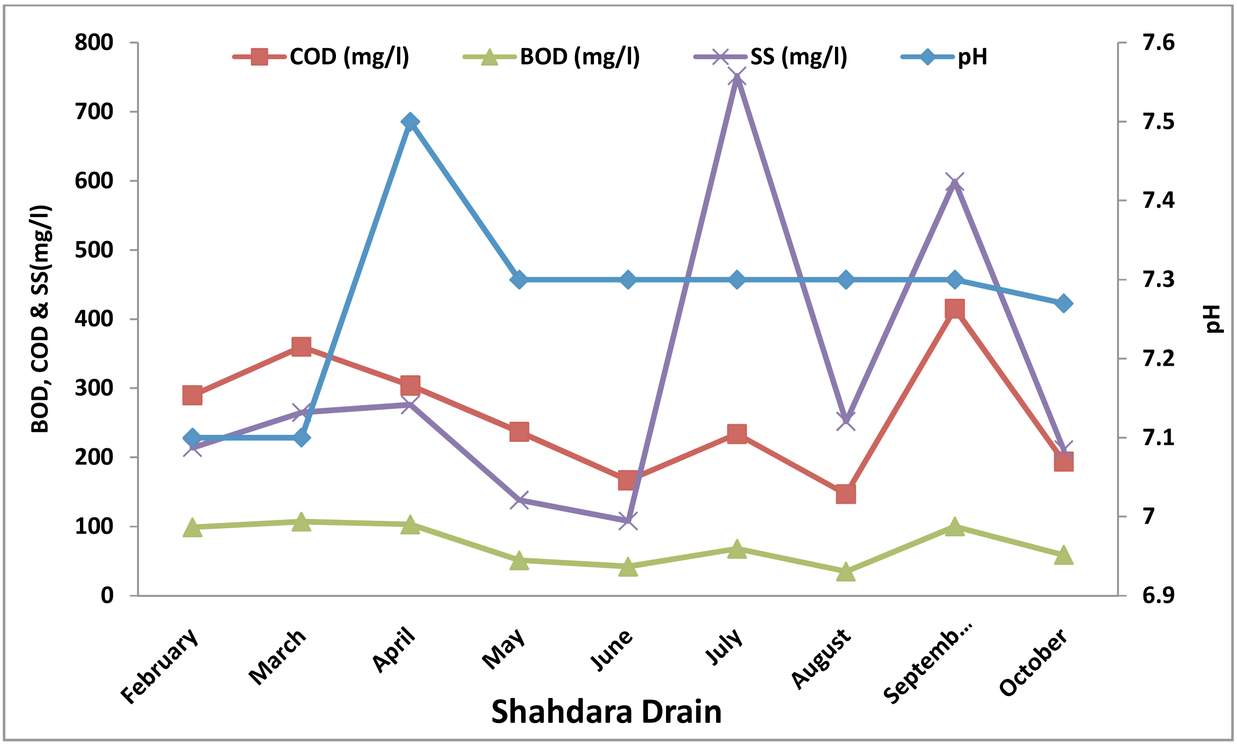

Fig 4.22: Physio-chemical result of Shahdara Drain

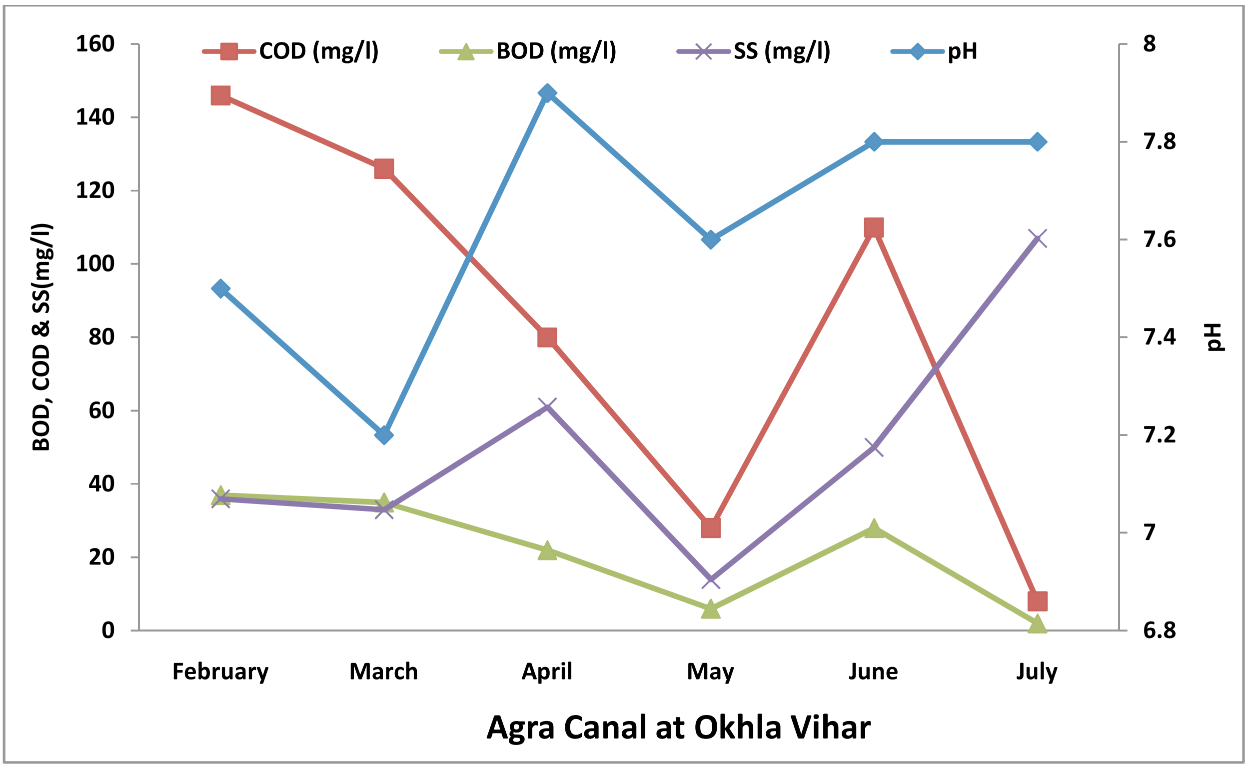

Fig 4.23: Physio-chemical result of Agra canal at Okhla Vihar

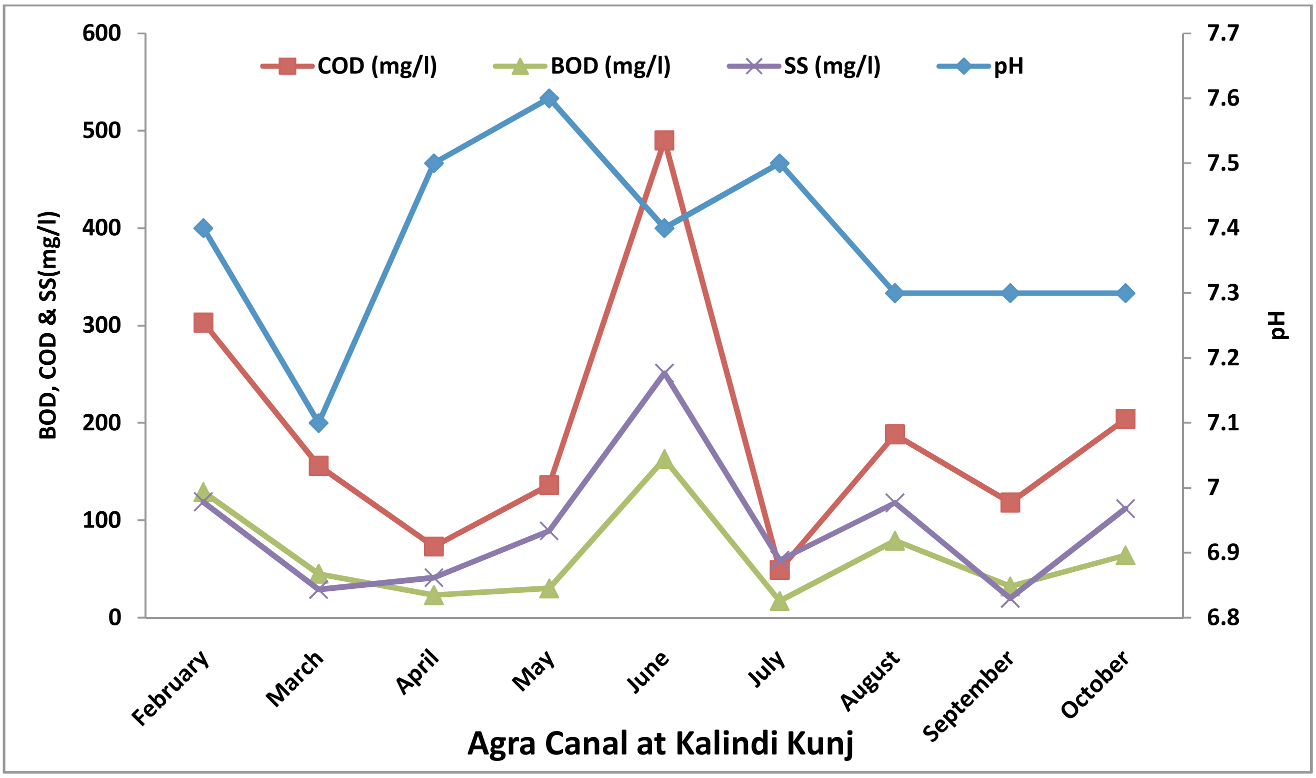

Fig 4.24: Physio-chemical result of Agra Canal at Kalindi Kunj

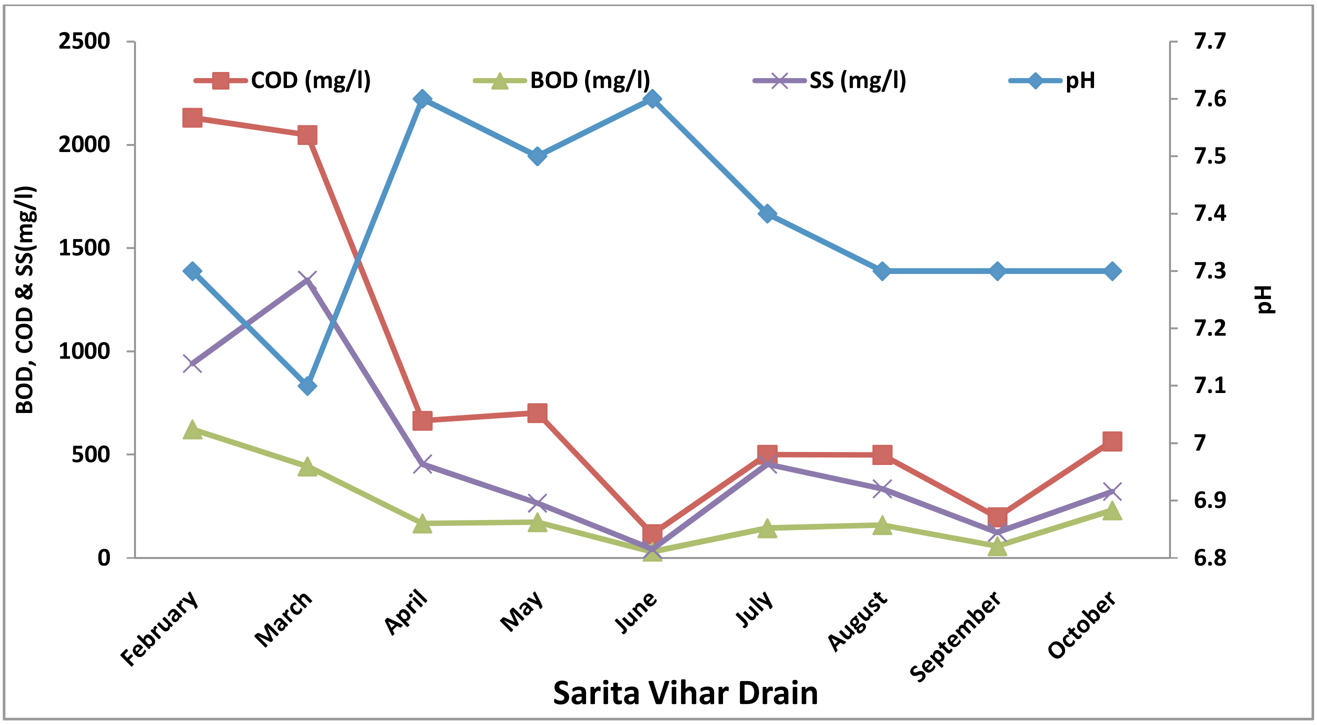

Fig 4.25: Physio-chemical result of Sarita Vihar Drain

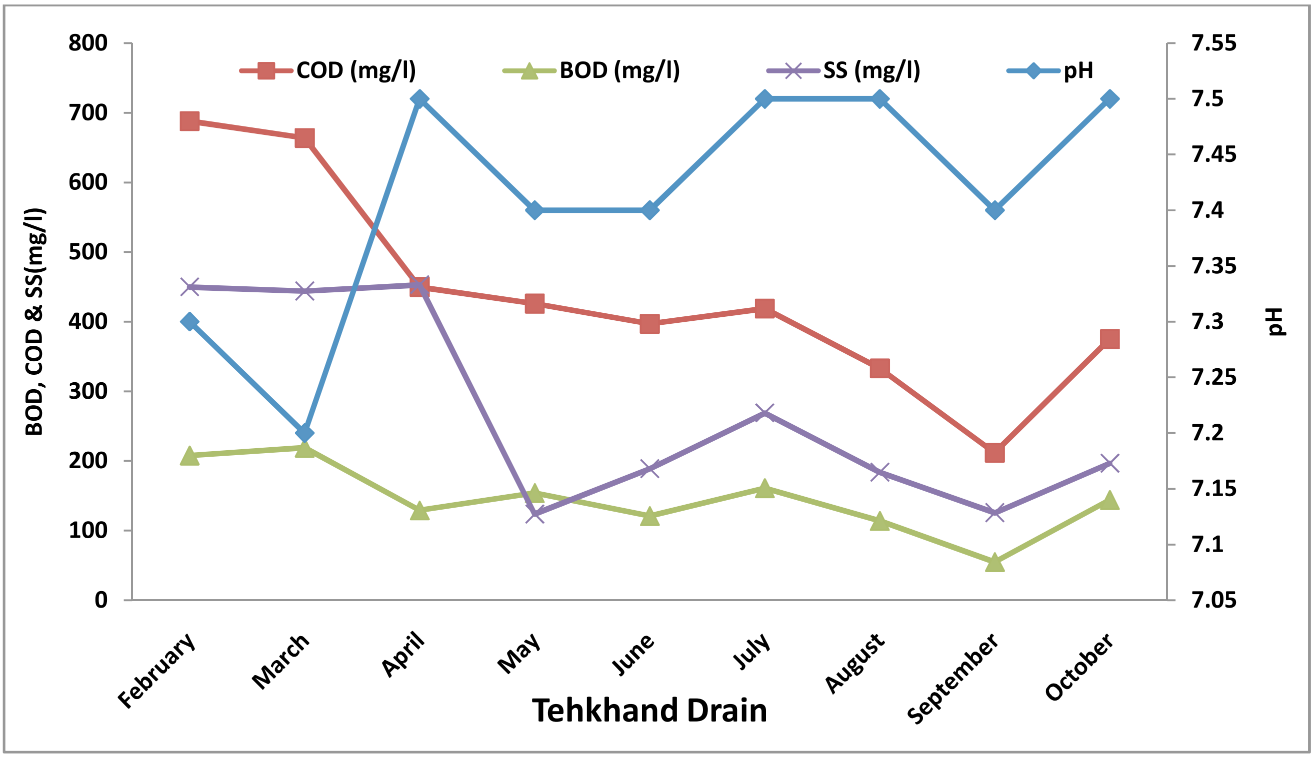

Fig 4.26: Physio-chemical result of Tehkhand Drain

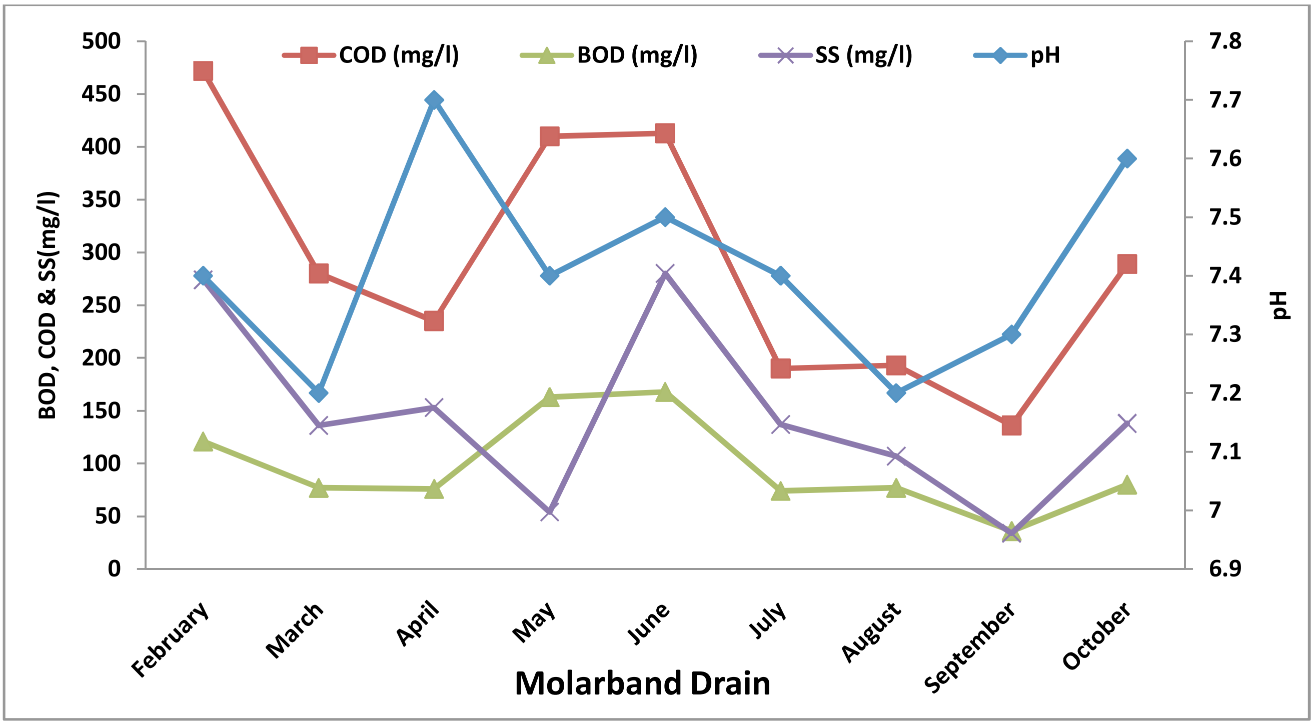

Fig 4.27: Physio-chemical result of Molarband Drain

The growth in the sewage treatment plant and common effluent treatment plant capacity has not kept pace with the increase in population and number of industries in Delhi. Treatment capacity has almost increased 8 fold in last 40 years whereas; waste water generation has grown 12 fold in the same period. STPs in Delhi are being created and remain under utilised. Around 50 per cent waste water joins Yamuna untreated nullifying the effort and money, spent on treatment of the rest. The actual functioning of STPs and the treatment standards are such that even treated water remains grossly polluted in the context of coli forms, micro-nutrients and pesticides.

Chapter 5

WATER QUALITY STUDY OF YAMUNA FROM OKHLA TO AGRA

5.1 INTRODUCTION

The increasing world population tends to concentrate in urban communities. In densely populated areas the sanitary collection, treatment and disposal of wastewater flows are essential to control the transmission of waterborne diseases. They are also essential for the prevention of non-reversible degradation of the urban environment itself and of the aquatic systems that support the hydrological cycle, as well as for the protection of food production and biodiversity in the region surrounding the urban area. For rural populations, which still account for 75 per cent of the total population, concern for public health is the main justification for investing in water and sanitation improvement.

Technology, particularly in terms of performance and available waste-water treatment options, has developed in parallel with economic growth. However, technology cannot be expected to solve each pollution problem. Typically, a wastewater treatment plant transfers 1 m^3 of wastewater into 1-2 liters of concentrated sludge. Wastewater treatment systems are generally capital-intensive and require expensive, specialized operators. Therefore, before selecting and investing in wastewater treatment technology it is always preferable to investigate whether pollution can be minimized or prevented. For any pollution control programme, there is a need to made an analysis of cost-effectiveness and compared with all conceivable alternatives.

In order to determine the pollution level and source of the stream most rewarding activity is to conduct the watershed survey. Watershed survey uses to determine the screening for pollution problems, identifying potential sources of pollution, identifying sites for monitoring, helping interpret biological and chemical information, educating the local community about potential pollution sources and the stressors affecting the stream and its watershed and providing a blueprint for possible community restoration efforts such as cleanups and tree plantings.

Detailed monitoring of all the locations was carried out mentioned in Figure 3.1 & 3.2 and physicochemical testing was carried out as per the standards of APHA-AWWA. DO, pH were tested at the sampling location and the other parameters mentioned in Table 3.3 were tested in the laboratory. The results obtained from the physicochemical analysis of the water and wastewater sample collected from the each location including river, drains and STPs are compared with each other, in order to determine the increase in pollution level of river.

5.2 OKHLA BARRAGE

Yamuna at Okhla Barrage is referred as prime location of river or reference location for the study from where 280 km stretch of the river has been surveyed up to Agra for determination of water quality deterioration. At the Okhla barrage most of water diverted into Agra canal for the irrigation purpose in the state of Haryana and Uttar Pradesh and marginal discharge allowed to flow downstream of Okhla barrage in Yamuna river. From the Okhla barrage 101 cusec of water enters downstream of barrage, which is lesser than the minimum flow required to maintain the sufficient flow in the river.

Water samples collected from the downstream of the barrage even doesn’t meet the water quality criteria of class “C” of river water. The water quality at this location reflects the impact of discharge of treated, partially treated effluents from Okhla Sewage treatment Plant, other drains joining the river/canal and Hindon-cut. Fig 5.1 and 5.2 shows the Yamuna River at the upstream and downstream of the Okhla barrage respectively with the Shahdara drain and Agra canal.

5.3 SAHADARA DRAIN

Sahadara Drain is joining to the river Yamuna River 1 km downstream of Kalinin barrage at Okhla. Drain carrying wastewater from east Delhi area & some part of the U.P. area and joining to the river Yamuna on its left bank. The location of the drain sampling was just before joining to the river system. This drain discharge approximately 550 MLD of wastewater into Yamuna with high BOD and COD and causes the maximum damage to river due to the lesser flow. Fig 5.3 shows the Shahdara drain in east Delhi carrying mainly plastic and other solid waste thrown by nearby colonies, which makes it hard for the sewage to flow and increase the organic and inorganic impurities. Similar to downstream of Wazirabad, at downstream of Okhla barrage the water flows in the river is the drain water of domestic & industrial origin contributed mainly by Sahadara drain. Wastewater from the Indirapuram drain also enters into Shahdara drain, which receive the waste water from the Indirapuram and adjoining areas including commercial and industrial waste and discharges about 165 MLD of wastewater in to Shahdara drain.

5.4 ASGARPUR VILLAGE

Yamuna at Asgarpur is 6 Km downstream of Okhla Barrage. The location of the river is around 5 km downstream after confluence of Shahdara drain on the left bank of the river. Water samples collected from this location is totally devoid of oxygen and even at the 5 km downstream of Shahdara drain, water quality of the river is approximately similar to the drain. Agricultural practices consist of green vegetables are common in the river bed around the location with the river water having the characteristics of waste water. Fig 5.4 shows the Yamuna at Asgarpur village and Fig 5.5 show the agricultural practices the above said location.

5.5 WASTEWATER FROM NOIDA AND GHAZIABAD

Noida Drain is joining to the river system of Yamuna about 17 km downstream of Okhla barrage. Drain carrying wastewater from Ghaziabad and Noida area and joining to the river Yamuna on its left bank. The location of the drain sampling was just before joining to the river system. Fig 5.6 shows the Noida drain at the point of sampling. During the survey it was found that Noida drain was flowing in two channels and the measured flow of the Noida drain was 520 MLD of bigger section and 100 MLD of the smaller section.

Noida drain receives the waste water from two STPs of Noida located at sector -54 and sector-50 and wastewater from commercial and industrial sector and the samples were collected from the inlet and outlet of both STPs. Fig 5.7 shows the various treatment units of the STPs of both the plants. Capacities of STPs of Noida are 23 MLD and 33 MLD and functioning of both the plants based upon Sequential Batch Reactor (SBR) treatment. Process flow chart of both the STPs is shown in Fig5.34. It was observed that both the plants are not running on their full capacities and large amount of waste water being discharges into drains without any treatment.

Noida drain also receives the waste water from the STPs located at Indirapuram and Vijay Nagar, in Ghaziabad district. Capacity of the Indirapuram and Vijay Nagar STPs are 56 MLD and 73 MLD respectively. But the total capacities of both the plants are not under utilization, as the STPs not receiving the adequate flow. Earlier both the STPs were operating using the Upflow Anaerobic Sludge Blanket Reactor (UASB) technique of water treatment. But due to the lack of production of the gas from the plant and undesirable results of the outlet samples, both the plants are now upgraded to the SBR technique of the wastewater treatment. Fig 5.35 shows the process flow chart of both the STPs located at Indirapuram and Vijay Nagar.

Using the SBR technique plants will operate on automatic process of wastewater diversion from one unit to other unit with the power backup in order to operate the plant on full scale. Waste water samples were also collected from the inlet and outlet of the both the STPs. Fig 5.9 shows the various treatment units of the STPs at Indirapuram and Vijay Nagar.

Google Image

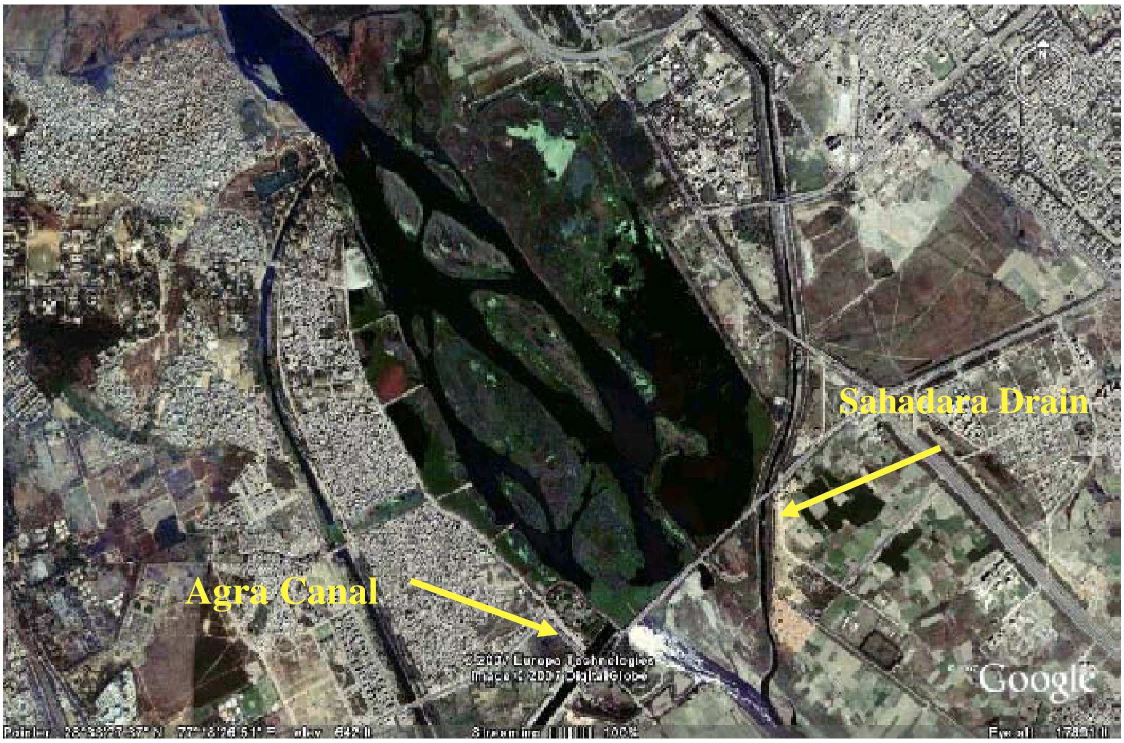

Fig 5.1: Yamuna at upstream of Okhla barrage

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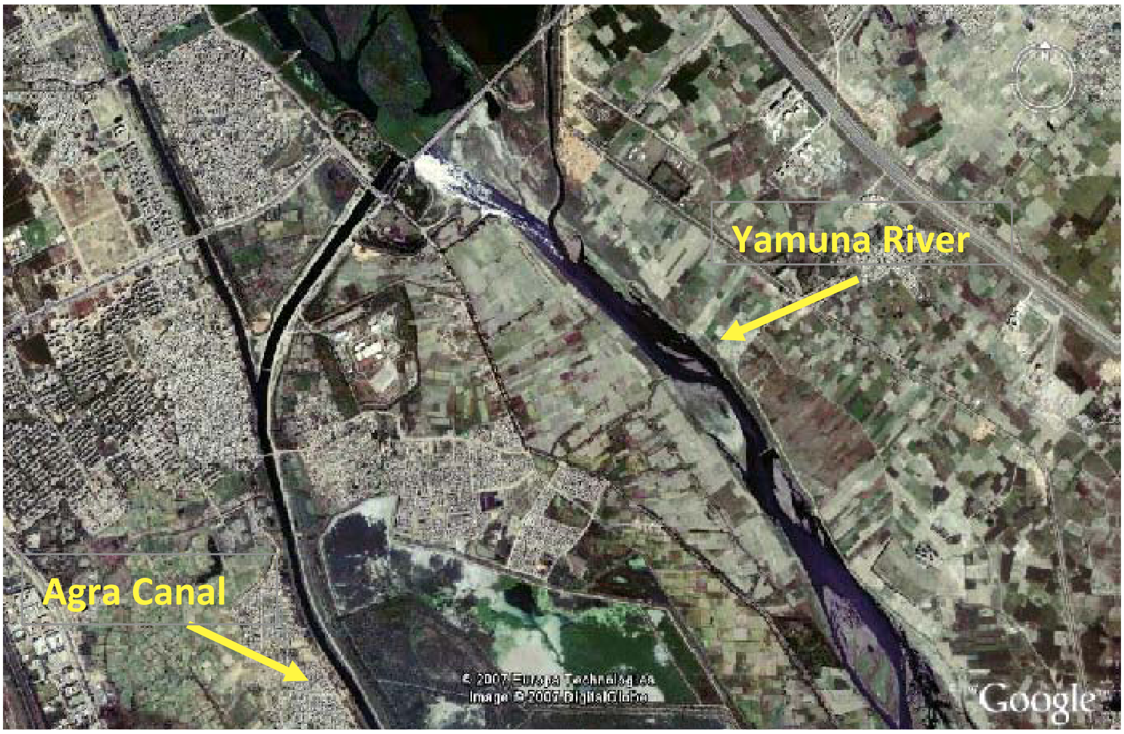


Fig 5.2: Yamuna at downstream of Okhla Barrage

Fig 5.3: Shahdara drain in East Delhi that drains into the river Yamuna at downstream of Okhla barrage

Fig 5.4: Yamuna River at Asgarpur village


Fig 5.5: Agricultural practices at Asgarpur village

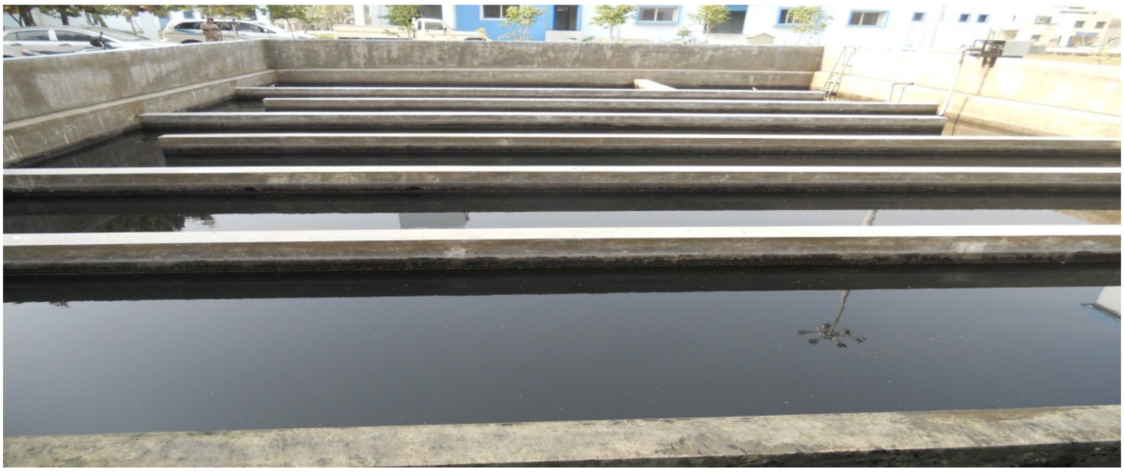

Fig 5.6: Noida Drain

Screens

Grit Chamber

SBR-I

SBR-II



Final Treatment

Fig 5.7: Various Treatment units of Noida STPs

5.6 HINDON RIVER

Hindon River is joining to the river system of Yamuna about 38 km downstream of Okhla barrage and carrying wastewater from Saharanpur, Gaziabad, Noida and other U.P. area and joining to the river Yamuna on its left bank. Location of the sampling point on Hindon River was on the express highway bridge or Greater Noida road just 3-5 km before joining to the Yamuna river system. Water samples collected from the river indicate its contamination with the partially / untreated wastewater from the drain wastewater mainly due to the lesser amount of flow in river and diversion of river water. Fig 5.8 shows the Hindon River below the express highway. During the field study the flow measured at the river 1210 MLD. Another drain enters into Hindon river, coming from the Pratap Nagar known as Pratap Nagar drain before the mixing of STP outlet. During the study, drains measured flow was about 30 MLD.

Fig 5.8: Hindon River

5.7 FARIDABAD DRAIN (BHUDIA NALLA)

Faridabad Drain is joining to the river system 39 km downstream from Okhla barrage. The confluence point is at just upstream of Tilwada village near Amipur village and downstream of Captain farm. The drain carries wastewater from Himatpur, Faridabad, and also carries STP outfall Zone I of Faridabad and joining to the river Yamuna on its right bank. The location of the drain sampling was just before joining to the river system.

Screens

Grit Chamber

UASB-I

UASB-II

Fig 5.9: Various Treatment units of Indirapuram and Vijay Nagar STPs

Fig 5.10 shows the Faridabad drain and the outlet of the Faridabad STP entering into drain. Total capacity of the STP located at Badshapur, Faridabad is 65 MLD. Out of the total capacity, 45 MLD of the wastewater treated through SBR technology of water treatment and rest 20 MLD of wastewater treated via oxidation pond only. But the treatment plant on average receiving 45-50 MLD of wastewater and from this oxidation pond running to its full capacity and rest was treated by SBR technique. Samples of the wastewater were collected from the inlet and both the outlets of the plant. Outlet sample of the plant from the Oxidation pond was found highly contaminated with algae and even the samples of the plant after the SBR and final treatment was not found meeting the standards. Fig 5.11 and 5.12 shows the both the outlet of the plant. Total flow of the Faridabad drain was measured in Badshapur Village before joining to the river and found out to be 121 MLD.

Another STP was installed and commissioned in Mirzapur of Faridabad district with the capacity of 45 MLD. Mirzapur STP is based on the UASB treatment followed by the oxidation pond. The STP at Mirzapur was found to be not running to its full potential and only about 24 MLD of wastewater treated in the plant. Originally the treated wastewater from Mirzapur STP was planned to be disposed of in nearby drain. Whereas, as of now the treated wastewater from the Mirazapur STP joins the Agra Canal, which is mainly used for the agricultural purposes. Fig 5.13 shows the Agra canal receiving the wastewater from the Mirzapur STP outlet.

5.8 HASANPUR VILLAGE (HODAL)

Yamuna crosses Hasanpur Village (Hodal) at Pontoon bridge and around 124 km downstream from Okhla Barrage. The sampling location was on the right bank of the river. Fig 5.14 shows the Yamuna at Hasanpur village. Hasanpur village located at the Haryana state border and after that Yamuna River enters into Uttar Pradesh. For the determination of the interstate pollution caused by the two states this is the very important location.

Fig 5.10: Faridabad Drain

Fig 5.11: Oxidation Pond of Faridabad STP

Lesser flow was observed in the river at this location during the field study. Flow measured in Yamuna was 1023 MLD. Water samples were collected from this location for the analysis, but as similar to the other location of the river, dissolved oxygen content was appeared nil.

5.9 GAUCHI DRAIN

Gaunchi Drain is joining to the Yamuna river system about 132 Km d/s from Okhla Barrage (Kalindi) and carrying wastewater from Faridabad, and also carries STP outfall Zone III having designed capacity of 50 MLD and Ashoka distillery wastewater. Drain joining to the river Yamuna on its right bank after traveling few kilometers downstream of Hasanpur village (Hodal). Wastewater samples were collected from the drain near Ballabgarh village and Fig 5.15 shows the Gauchi drain. Total flow of the drain measured was found to be 180 MLD. STP located near Ballabgarh village which discharges its treated effluent into Gauchi drain, was not running to its full capacity and STP was under operation using the UASB technique of the waste water treatment.

5.10 VRINDAVAN - MATHURA UPSTREAM

Yamuna at Vrindavan (Kesi Ghat) is 173 km downstream from Okhla barrage, Delhi. The sampling location was on the right bank of the river, but downstream of Kalideh STP having the capacity of 0.5 MLD. STP at Kalideh, which is 2 km away from the Yamuna River, based upon the oxidation pond type treatment process but was found non operational and drain was directly joining the river containing flow of 9.5 MLD.

There was another STP named Pagalbaba Sewage treatment plant having capacity of 4.5 MLD. This STP was also based upon treatment using oxidation pond. There were 8 oxidation ponds and all of the ponds were found full of plastic waste & sewage and anaerobic conditions were also prevailing in the ponds. Flow observed in the outlet of the plant was merely 2.2 MLD. Sewage pumping station for this plant located at Chatar thirth, Gyan budh and Mukherji Park.

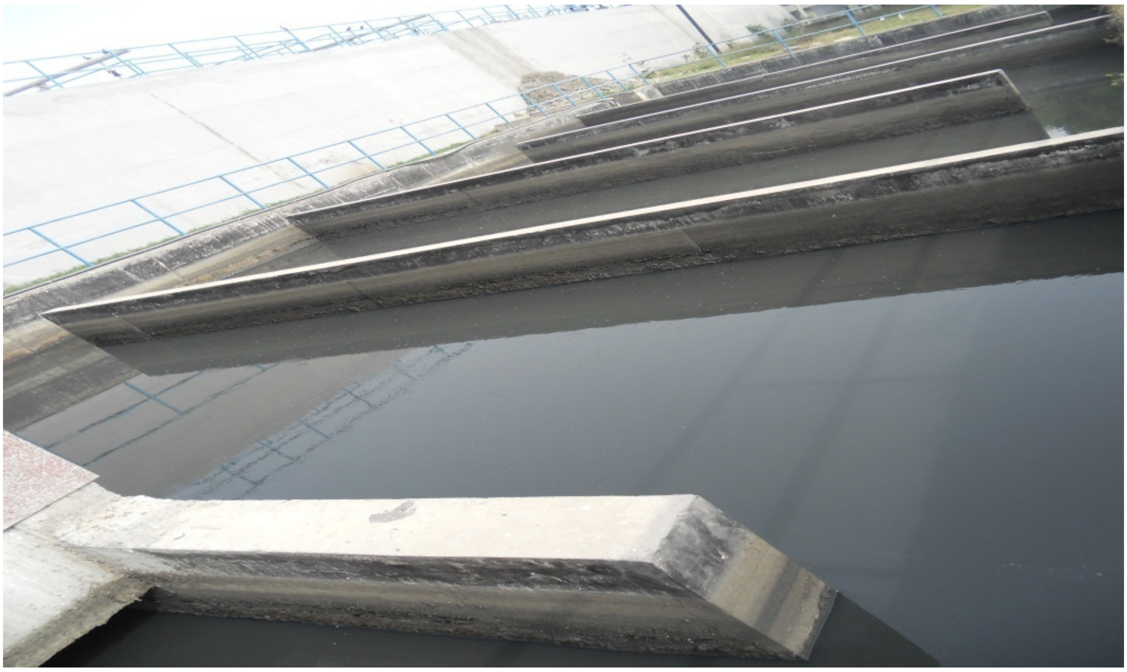


Fig 5.12: Outlet of the Faridabad STP after SBR treatment

Fig 5.13: Agra Canal receiving the waste water from the STP outlet.

Fig 5.14: Yamuna at Hasanpur village

Fig 5.15: Gauchi drain

5.16: Oxidation pond at Pagalbaba STP

5.17: Algal Oxidation pond at Pagalbaba STP

But none of these pumping stations were found operating which in turn causes the no utilization of STP. Fig 5.16 & 5.17 shows the oxidation pond at the Pagalbaba STP full of waste and algae. Another drain named Masani drain in Mathura was diverting in to STP of capacity 13.5 MLD from the Masani pumping station. Even this STP was not found operational to its full capacity. There were 8 oxidation ponds in STP and only four were operational. Calculated flow of the Masani drain joining the river Yamuna was approximately 30 MLD. Fig 5.18 shows the Masani drain joining river Yamuna.

5.11 GOKUL BARRAGE

Yamuna at downstream of Mathura city near Gokul village at Gokul barrage is 193 km from Okhla barrage, Delhi. The sampling location was on the left bank of the river and downstream of barrage (Reservoir). This location of the river received all the pollution outfalls such as treated wastewater from the four STPs of Mathura city. Flow at the upstream of the barrage was observed up to the height of 163.50 m and at the downstream of the barrage was up to the height of 159 m. Major part of the river water from the upstream of the barrage was diverted in to the water treatment plant which has the chlorine demand of 36 ppm. Ammonia was also found in the upstream of the barrage.

There was a provision of cascade aerator for the remove the ammonia and other gases present in the river water. Fig 5.18 shows the upstream of the Gokul barrage. At the downstream of the barrage only 1399 cusec of water is allowed to flow. Water is allowed to flow from the two gates, both at the maximum distance from each other. This leads to the channelization of the river in to two parts. Fig 5.19 shows the downstream of the Gokul barrage.

5.12 MATHURA DRAINS

Mathura drains collecting the wastewater from four STPs outfalls joining to the river Yamuna. Three outfalls joining to the river on its right bank and one are joining on its left bank from Lohwan STP and this outfall joining just before Gokul Barrage and accumulating wastewater on the big reservoir formed by the barrage. The location of sampling of all four outfalls was made on the outlet of STPs (treated wastewater) joining to the river system.

STP of Trans-Yamuna area of Mathura was found non-operational. Sewage pumping station was located at Bengul Ghat and found non-operation and leading to the bypass of the sewage directly in to river . This STP is based upon treatment utilizing oxidation pond. There were 8 oxidation pond ponds in the STP but all the ponds were found full of algae & garbage and solid waste dumping site were observed just adjacent to the oxidation ponds. Fig 5.20 shows the oxidation pond of Trans-Yamuna STP, Mathura and burning of solid waste. Water sample were only collected from the inlet of the STP as the outlets of the oxidation ponds was found dry as shown in Fig 5.21.

5.13 MATHURA REFINERY DRAIN

Refinery Drain (RED) is joining to the river system about 204 km downstream from Okhla barrage. The confluence point is near Barari/Balrai village and downstream of Mathura refinery. The drain carries wastewater from Mathura refinery and joining to the river Yamuna on its right bank after traveling 5-6 km from the factory. The location of the drain sampling was just before joining to the river system. Total flow of the drain measured near Barari/Balrai village was 21 MLD. Barari village is 0.5 km downstream of confluence of Refinery drain and about 205 km downstream from Okhla barrage. Fig 5.22 shows the refinery drain.

5.14 SIKANDRA

Sikandara (SD)–Yamuna near Sikandara waterworks intake is 247 Km downstream from Okhal Barrage, Delhi. The sampling location was on the right bank of the river and located upstream of Taj city. Sikandara water works is only 1 km away from the river and having capacity of 144 MLD**.** Fig 5.23 shows the water abstraction to Sikandara water works.

5.18: Masani drain joining the river Yamuna

Fig 5.19: Upstream of Gokul Barrage

Fig 5.20: Downstream of Gokul Barrage

Fig 5.21A: Oxidation pond of Trans-Yamuna STP, Mathura

Fig 5.21B: Outlets of Trans-Yamuna STP, Mathura

Fig 5.22: Refinery drain

5.15 AGRA DRAINS

There are several drains joining between Sikandara waterworks and Jeewni Mandi Waterworks. However, major eight drains were considered for its pollution contribution during the survey. There was an STP receiving the waste water from the Budi ka Nagla having the capacity of 2.25 MLD. This STP was found non operational. Fig 5.24 shows the diversion of waste water into Budi ka Nagla STP.

There was another STP at Jaganpura, Mathura having capacity of 14 MLD. Treatment process of this STP based upon the UASB technique followed by oxidation ponds. There were 8 oxidation ponds in the STP but only 4 ponds were under operation. Outlet of the STP was just few meters away from the river. Fig 5.25 shows the UASB at the Jaganpura STP. Wastewater samples were collected from the inlet and outlet of the plant.

Another drain named Rajwaha drain was found entering into Yamuna River. There was a pumping station at Rajwaha, Agra designed for the diversion of the waste water from the Rajwaha drian into Dhandupura STP. But pumping station was not found operating and waste water directly entering into the Yamuna River. Wastewater sample were collected from the drain before entering into river. Fig 5.26 shows the Rajwaha drain. Total flow of the drain was measured and found around 7 MLD.

There was a drain named Anurag Drain flowing through Anurag Nagar having flow of approximately 6.7 MLD. Waste water from the drain are meant to be diverted into Jaganpura STP through the sewage pumping station located Manohar Nagar. But the pumping station was not found operation to its full capacity and bypassing the sewage into Yamuna River.

Another drain known as Manohar Drain was flowing through Manohar nagar. Total flow of the Manohar Drain was found up to 9.85 MLD. Manohar Nagar sewage pumping station was designed to receive the wastewater from the above said both the drains and to divert the waste water to Jaganpura STP.

Fig 5.23: Water abstraction at Sikandara

Fig 5.24: Budi ka Nagla STP inlet.

Fig 5.25: UASB at the Jaganpura STP.

Fig 5.26: Rajwaha drain

But all the waste water was not found diverting in to sewage pumping station whereas, part of the drains found directly joining the river without any treatment. Wastewater samples were collected from the both the drain before entering into river. Fig 5.27 shows the Manohar Drain.

From all the drains of Agra, red fort drains is the biggest drain and causing the maximum pollution load in river Yamuna. This drain collects the waste water from several smaller drains and flows just adjacent to the Red fort and joins the river Yamuna just behind the Taj Mahal. Total flow of the drain measured was approximately 40 MLD. Drain was found full of plastic waste and other solid waste. Fig 5.28 shows the Red fort drain.

5.16 JEEWINI MANDI

Yamuna near old waterworks intake is 280 Km downstream from Okhla Barrage The sampling location was on the right bank of the river and located just before pre-chlorination unit in the river intake channel itself. Fig 5.29 shows the water intake pumping station of Jeewini water works. Along with the Jeewini water works at the downstream of the WTP, drains known as Narwa drain flows and diverted into Dhandupura STP. Flow of the Narwa drain measured was approximately 55.5 MLD. Fig 5.30 shows the Narwa drain.

Another STP known as Pilakher STP was installed and under operation in Agra, having capacity of 10 MLD. But the flow of the drain diverted in to STP for the treatment measured was approximately 2.4 MLD only. Method of treatment of the Pilakher STP was based upon the oxidation pond. There were 8 oxidation ponds in the STP shown in Fig 5.31. Samples were collected from the inlet and outlet of the STP. There was another STP in Agra having highest capacity of all the STP's of Agra is 78 MLD, known as Dhandupura STP. But the capacity of the plant under utilization was only 41 MLD. Treatment method of this STP was based upon the UASB technique followed by oxidation pond.

Fig 5.27: Manohar Drain

Fig 5.28: Red fort drain.

Fig 5.29: Jeewini Mandi Water Works

Fig 5.30: Narwa Drain

Fig 5.31: Oxidation pond at Pilakher STP

Fig 5.32: Grit Chamber and UASB at Dhandupura STP

Fig 5.33: UASB and Oxidation pond at Bhimnagri STP.

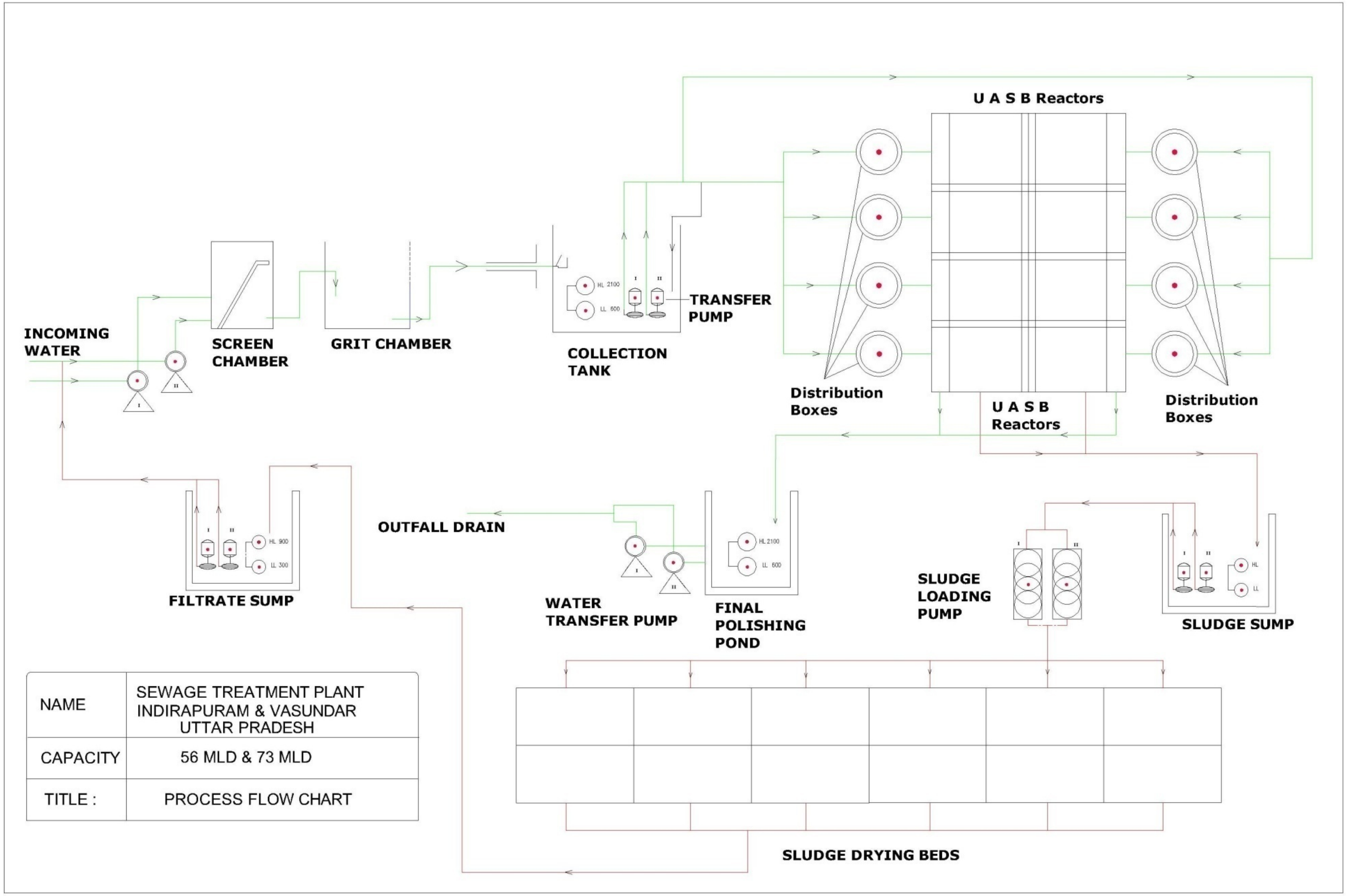


Fig 5.34: Process flow chart of Indirapuram and Vijay Nagar STP

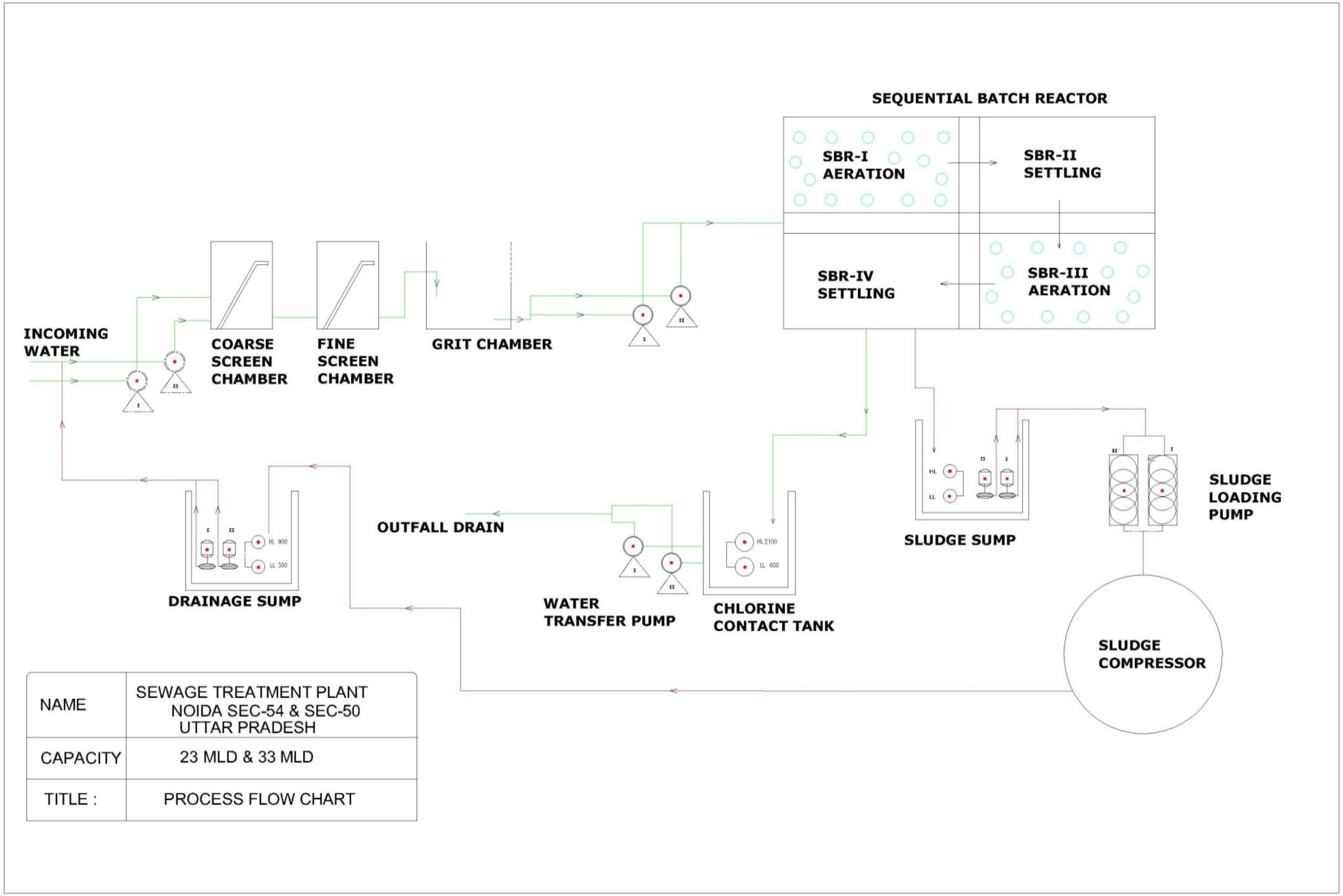


Fig 5.35: Process flow chart of Noida sec-54 and Sec-50 STP

There were 6 distribution boxes for the distribution of the waste water from the Grit chamber to the UASB reactors and 3 oxidation ponds for the final treatment of the waste water. Water from the outlet of the STP was disposed off partly for the irrigation and partly disposed into the Yamuna River. Fig 5.32 shows the grit chamber and UASB at Dhandupura STP. Samples were collected from the inlet and outlet of the STP for the physio-chemical analysis.

At the Deori road, Agra there was another STP known as Bhimnagri STP havinf capacity of 12 MLD. Treatment method of this STP was based upon the UASB technique followed by oxidation pond. But the full capacity of the plant was not under utilization as plant was receiving only 1 MLD of waste water. Fig 5.33 & 5.34 shows the UASB and oxidation pond of the Bhimnagri STP respectively. As the plant was not receiving the adequate flow, occurrence of algae was common in the oxidation ponds of the STP. One STP known as Bichpuri STP at Sadarban, Agra was under construction and design capacity of the plant was 35 MLD.

Chapter 6

RESULT AND DISCUSSION

Due to heavy abstraction from and discharge of pollutants into the river system, there are critical segments, which require pollution abatement measures to improve the water quality of the river. Total study area of the Yamuna River is divided into three segments and all the sources of water pollution causing pollution load in Yamuna were studied. These segments are:

1st Segment	:	Okhla to Faridabad
2nd Segment	:	Vrindavan to Agra

6.1 ANALYSIS OF 1ST SEGMENT OF STUDY AREA OF RIVER SYSTEM

Sahadara Drain is joining to the river Yamuna River 1 km downstream of Kalinin barrage at Okhla. Drain carrying wastewater from east Delhi area & some part of the U.P. mainly from Ghaziabad and Noida area and joining to the river Yamuna on its left bank. Indirapuram drain also falls into Shahdara drain and contributes around 165 MLD of waste water. Wastewater sample were collected from the drain just before joining the river system. Sample was highly foul in nature and devoid of oxygen. Values of the BOD and COD of the indirapuram drain were measured up to 73 mg/l and 198 mg/l respectively. Total load contributed by Sahadara drain into Yamuna River was measured to be 550 MLD. BOD and COD of the drain were found 148 mg/l and 430 mg/l respectively.

Noida Drain is joining to the river system of Yamuna about 17 km downstream of Okhla barrage. Apart from the domestic and industrial waste of Noida and Greater Noida, Noida drain receives the waste water from two STPs of Noida having total capacity of 56 MLD and STPs of Indirapuram and Vaishali having capacities of 56 MLD and 73 MLD respectively. Noida drain contributed 620 MLD of flow into river Yamuna. Fig 6.1 and 6.2 shows the variation in the various parameters of the different drains. Values of BOD and COD of Noida drain were 98 mg/l and 244 mg/l respectively and TSS was 265 mg/l.

Hindon River is joining to the river system of Yamuna about 38 km downstream of Okhla barrage and carrying wastewater from Saharanpur, Gaziabad, Noida and other U.P. area. Pratap Vihar drain joins the Hindon River and contributes 30 MLD of load. Water sample were collected from the drain and values of BOD and COD was found 118 g/l and 394 mg/l respectively. Total load contributed by Hindon in to Yamuna River was 1210 MLD. Even the water sample from the Hindon was found devoid of Oxygen. BOD and COD of the Hindon were measured above the prescribed standards.

Faridabad Drain known as Budhia nalla is joining to the river system 39 km downstream from Okhla barrage. The drain carries wastewater from Himatpur, Faridabad, and also carries STP outfall Zone I of Faridabad and joining to the river Yamuna and contributing about 121 MLD of wastewater into Yamuna River. Bhudia nalla receive the wastewater from Badshapur STP and Mirzapur STP having capacities of 65 MLD and 45 MLD respectively. Wastewater sample collected from the drain and the values of BOD and COD was found 148 mg/l and 531 mg/l respectively. Value of TSS and TDS of the drain were found to be 809 mg/l and 220 mg/l respectively.

Another drain named Gauchi drain is joining to the Yamuna river system about 132 Km d/s from Okhla Barrage (Kalindi) and carrying wastewater from Faridabad, and also carries STP outfall Zone III. STP Zone III consists of Ballabhgarh STP having capacity of 50 MLD. Wastewater sample collected from the drain before joining the river system and the values of BOD and COD was found 115 mg/l and 386 mg/l respectively. Fig 6.2 shows the BOD and COD of different drains. Total load contributed by Gauchi drain in Yamuna river system was found 180 MLD.

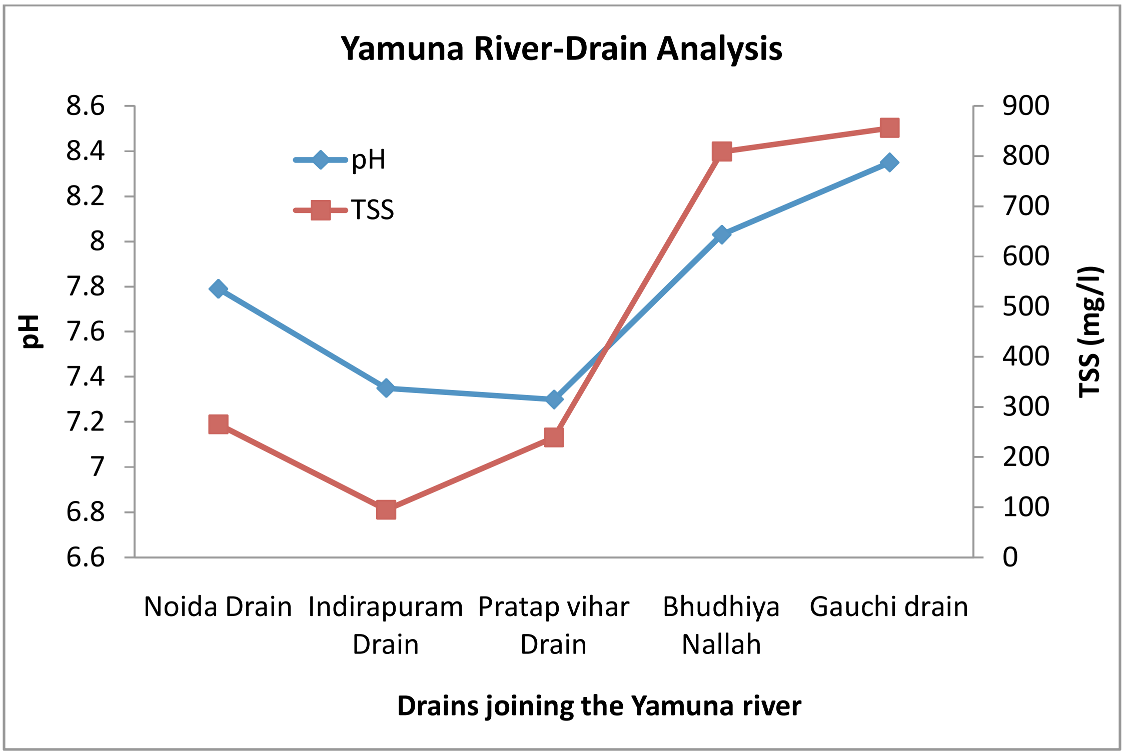


Fig 6.1: pH and TSS of various drains

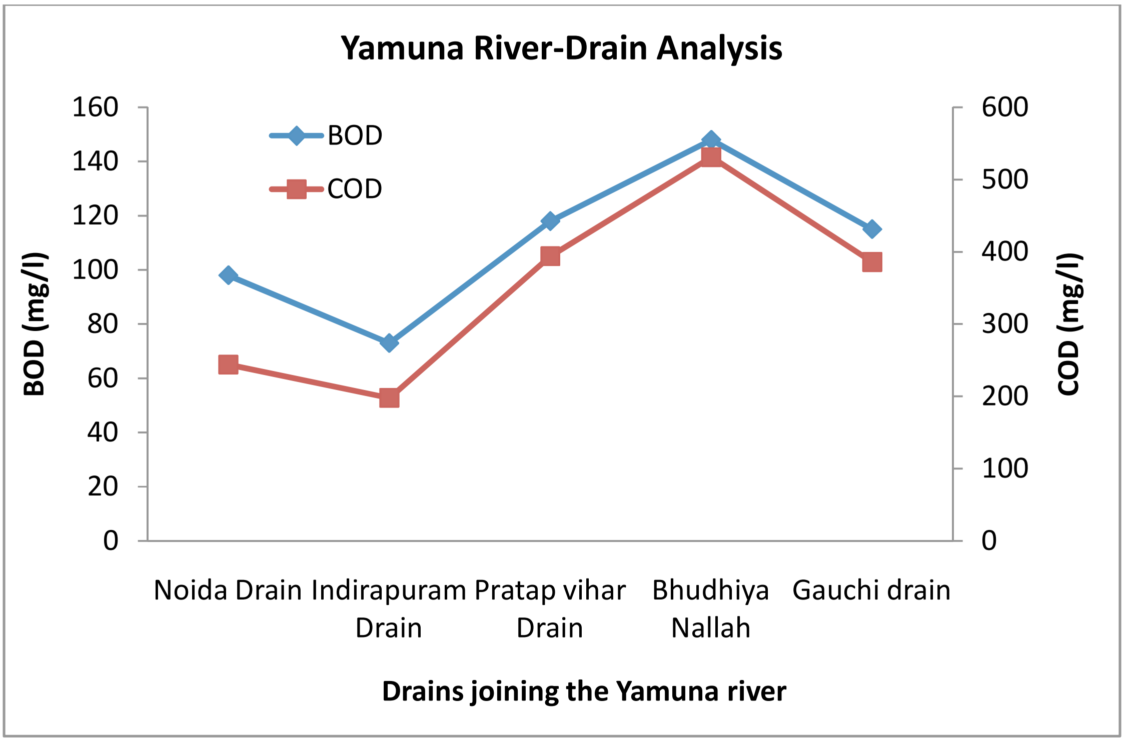


Fig 6.2: BOD and COD of various drains

There are two STP in Noida having capacity of 23MLD and 33 MLD located at Sector 54 and sector 50 respectively based upon SBR treatment technique. Water sample collected from the inlet and outlet of both the STP and results of the analysis are shown in Fig 6.3 and 6.4. BOD of both the Noida STP's was found 14 mg/l against the inlet BOD 165 mg/l and 126 mg/l, under waste water disposal standard and also values of COD of both the STP's was found within the prescribed limits i.e. 55 & 56 mg/l respectively. Values of TSS at the inlet of both the STP was found 126 mg/l and 82 mg/l, whereas at the outlet TSS reduced to 19 mg/l and 25 mg/l respectively. Fig 6.3 and 6.4 shows the results of Noida STP of sector-54 and sector-50 respectively. Results of Physio-chemical parameters are shown in table 6.1.

Samples of wastewater were also collected from the inlet and outlet of the two STP's of Ghaziabad located at Indirapuram and Vijay Nagar having capacity of 56 MLD and 73 MLD. Treatment method of both the STP's is modified to SBR from the UASB recently. BOD of the outlet samples of Indirapuram and Vijay Nagar STP were not found meeting the standard limits as found to be 52 mg/l and 47 mg/l respectively against the inlet BOD of 152 mg/l and 180 mg/l. Whereas COD of both the STP was found 122 mg/l and 132 mg/l against the inlet COD of 434 mg/l and 516 mg/l. Values of TSS of Indirapuram STP of inlet and outlet was 227 mg/l and 165 mg/l, whereas, values of TSS of inlet and outlet was 28 mg/l and 35 mg/l respectively. Fig 6.5 and 6.6 shows the result of Indirapuram and Vijay Nagar STP.

Table 6.1: Physic- chemical results of drains joining Yamuna in Segment 1

Sampling Location	pH	TSS (mg/l)	BOD (mg/l)	COD (mg/l)	TDS (mg/l)
Noida Drain	7.79	265	98	244	98
Indirapuram Drain	7.35	95	73	198	86
Pratap vihar Drain	7.3	239	118	394	130
Bhudhiya Nallah	8.03	809	148	531	220
Gauchi drain	8.35	856	115	386	128

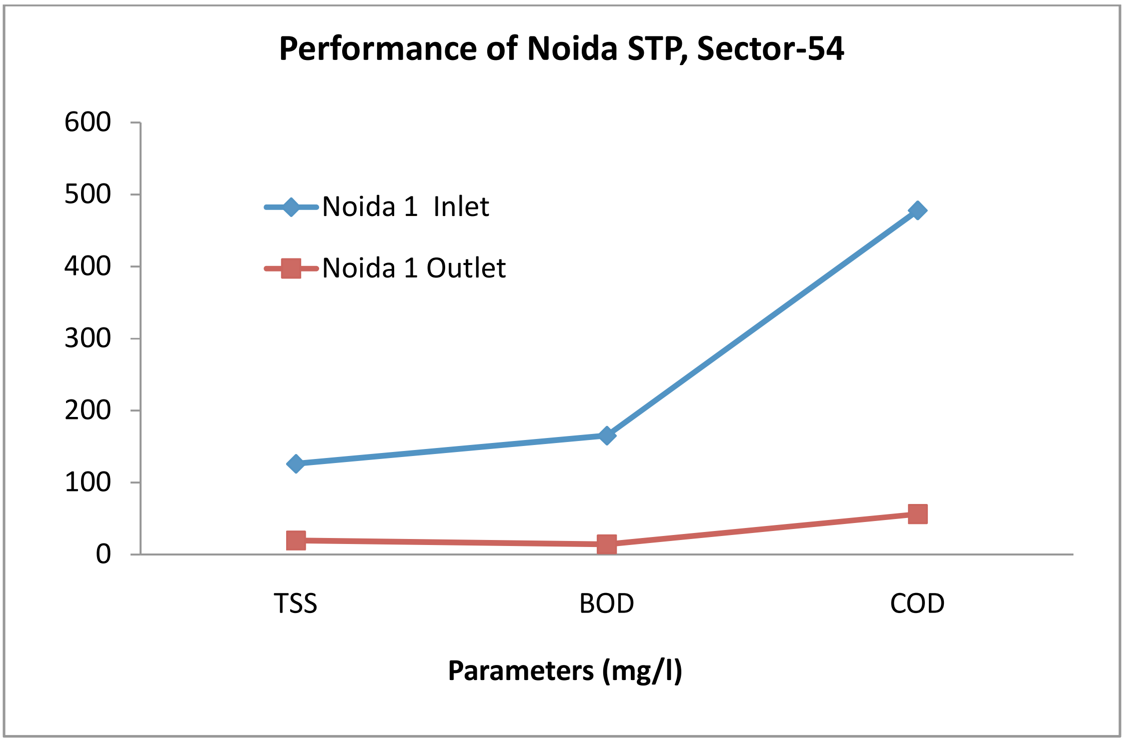


Fig 6.3: Performance of Noida STP, Sector-54

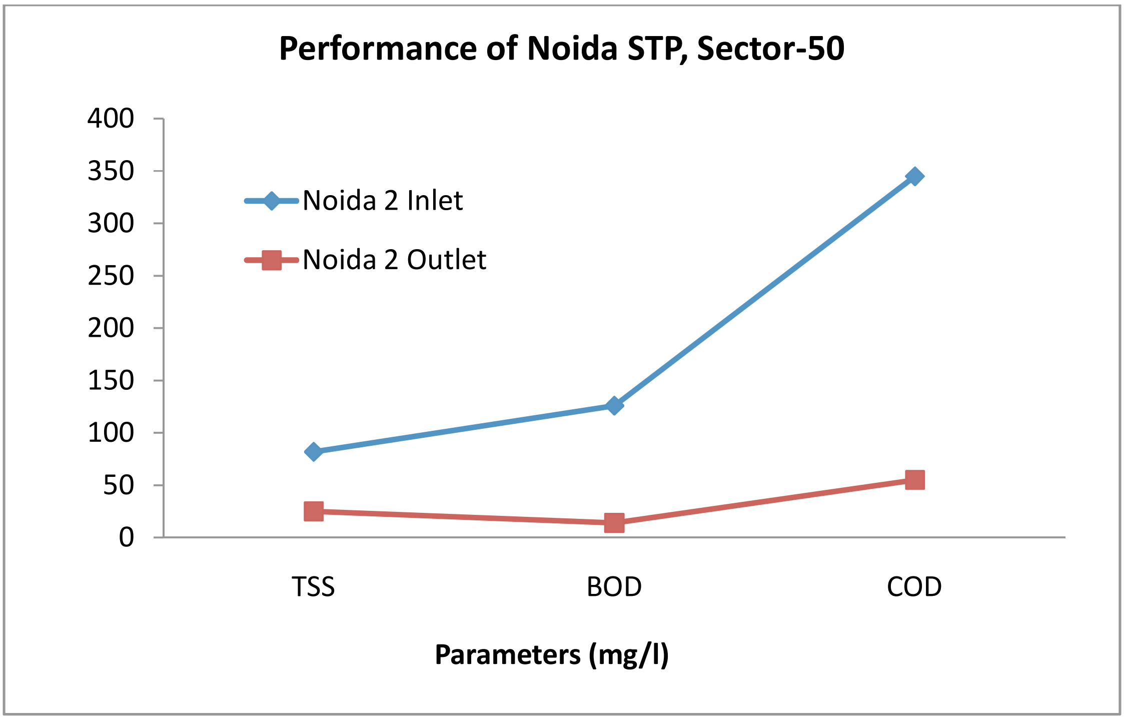


Fig 6.4: Performance of Noida STP, Sector-50

There are two main STP's in Faridabad, located at Badshapur and Mirzapur having capacity of 65 MLD and 45 MLD. Badshapur STP discharging its waste from two outlets. One outlet is from the 45 MLD of SBR treatments and other from the 20 MLD of oxidation pond. Fig 6.7 shows the result of analysis of Badshapur STP, where outlet1 represents the outlet from the SBR treatment and outlet 2 represent outlet from the oxidation pond treatment.

Values of BOD from the outlet 1 and outlet 2 of the STP were found 28 mg/l and 50 mg/l respectively. Values of COD and TSS from outlet 1 were found 73 mg/l and 30 mg/l respectively and from outlet 2 were found to be 118 mg/l and 63 mg/l. Values of parameters after the treatment via oxidation pond were not meeting the standards, whereas wastewater samples collected from the outlet of the SBR treatment are found within the prescribed standard limits, showing the better performance of SBR over oxidation ponds.

Samples were collected from inlet and outlet of another STP of Faridabad located at Mirzapur having capacity of 45 MLD. Method of treatment of STP based upon the UASB followed by oxidation pond. Values of BOD of Mirzapur STP from inlet and outlet were found 148 mg/l and 70 mg/l respectively and COD from inlet and outlet were 404 mg/l and 180 mg/l respectively. Values of TSS from inlet and outlet were 276 mg/l and 84 mg/l and TDS from inlet and outlet were found 181 and mg/l and 42 mg/l respectively as shown in Fig 6.8. Values of BOD and COD were found exceeding the standard limits due to the presence of large amount of organic matter into the final water and showing the ineffective performance of the STP. Sample of the STP was highly foul in nature and oil & grease was also present in the sample.

Wastewater samples were collected from another STP located at Ballabgarh in Faridabad. This STP was found operating and sample was collected from the outlet only. Values of BOD and COD was found very high even at the outlet i.e. 198 mg/l and 564 mg/l. Values of TSS and TDS were found to be 638 mg/l and 232 mg/l. Values of all the measured parameters were found exceeding the limits highly and shows that STP is discharging its waste without any treatment. Results of physio-chemical parameters of different STPs are shown in Table no. 6.2.

Table 6.2: Physic- chemical results of STPs in Segment 1

Sampling Location	pH	TSS (mg/l)	BOD (mg/l)	COD (mg/l)
Noida STP Sec 54 Inlet	7.64	126	165	478
Noida STP Sec 54 Outlet	7.89	19	14	56
Noida STP Sec 50 Inlet	7.82	82	126	345
Noida STP Sec 50 Outlet	7.73	25	14	55
Indirapuram STP Inlet	7.24	227	152	434
Indirapuram STP Outlet	7.34	28	52	122
Vijay Nagar STP Inlet	7.27	165	180	516
Vijay Nagar STP Outlet	7.46	35	47	132
Badshapur Faridabad STP Inlet	8.26	435	186	549
Badshapur Faridabad STP Outlet 1	8.05	30	28	73
Badshapur Faridabad STP Outlet 2	7.92	63	50	118
Mirzapur Faridabad STP Inlet	7.5	276	140	404
Mirzapur Faridabad STP Outlet	8.11	84	70	180
Ballabgarh STP Outlet	8.48	638	198	564

With the physico-chemical parameters, heavy metals were also tested for the each drains and river water samples. In almost all the samples of the STPs cadmium and chromium were absent. Whereas, copper was present in most of the tested samples of STPs and drains. Value of copper was found maximum in Badshapur STP i.e 0.35 mg/l followed by Yamuna water sample collected near Asgarpur village.

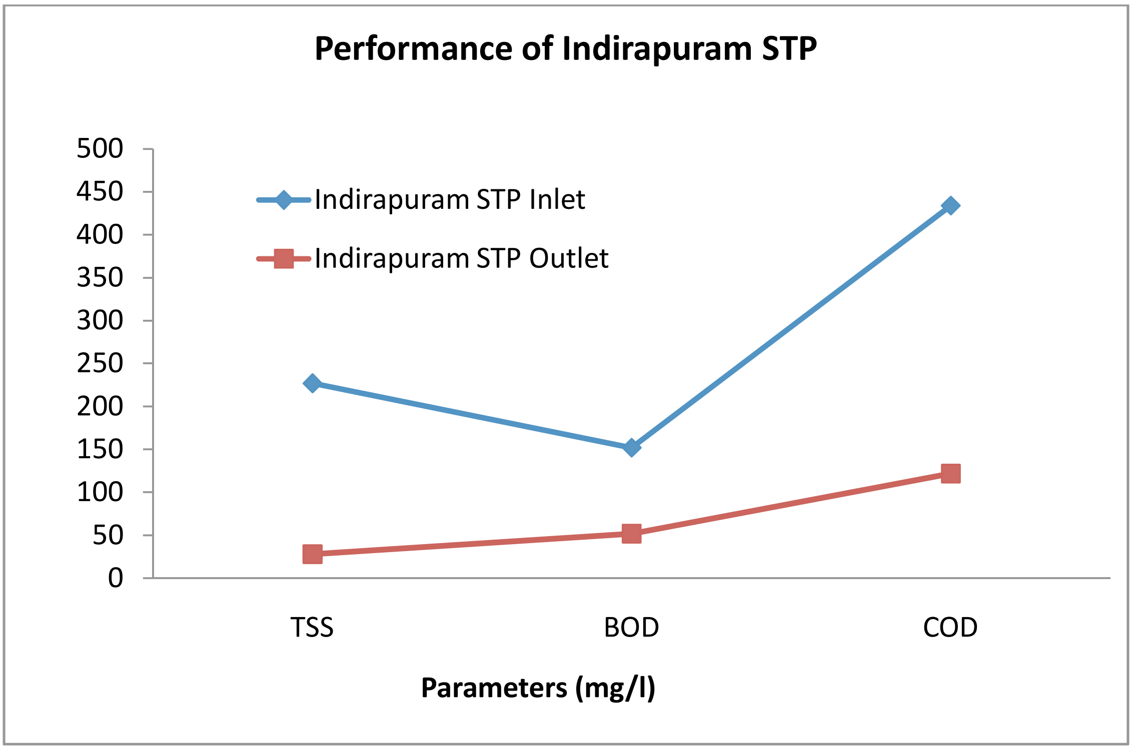


Fig 6.5: Performance of Indirapuram STP

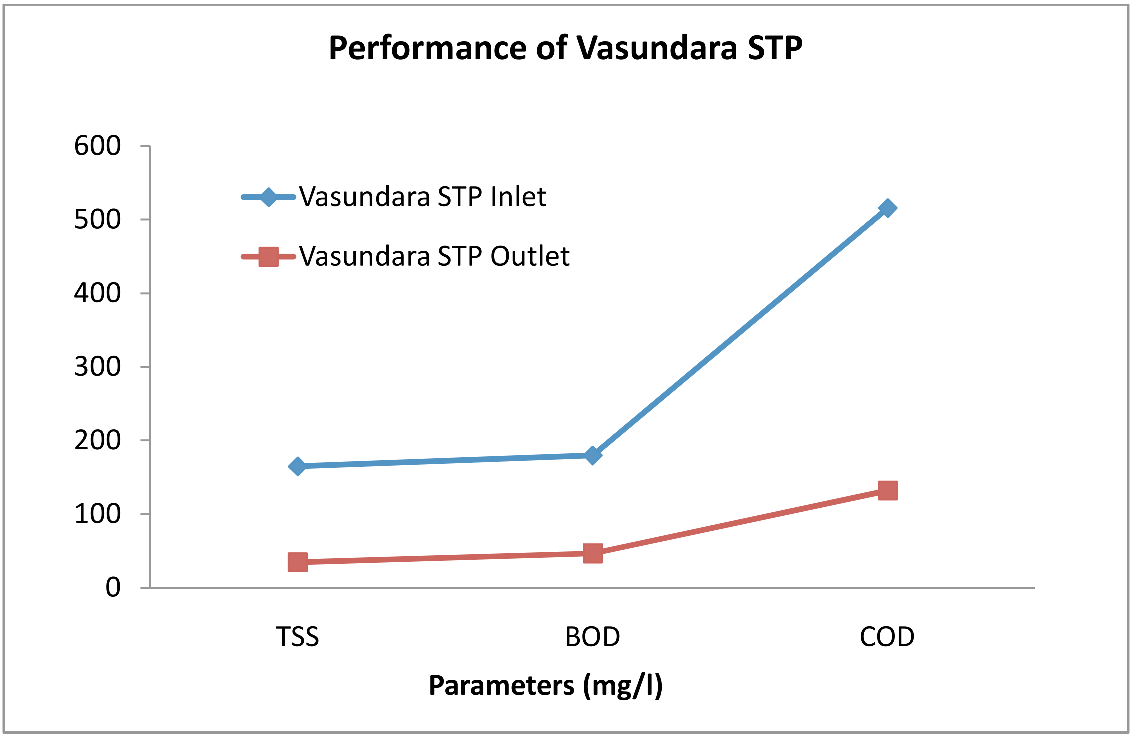


Fig 6.6: Performance of Vijay Nagar STP.

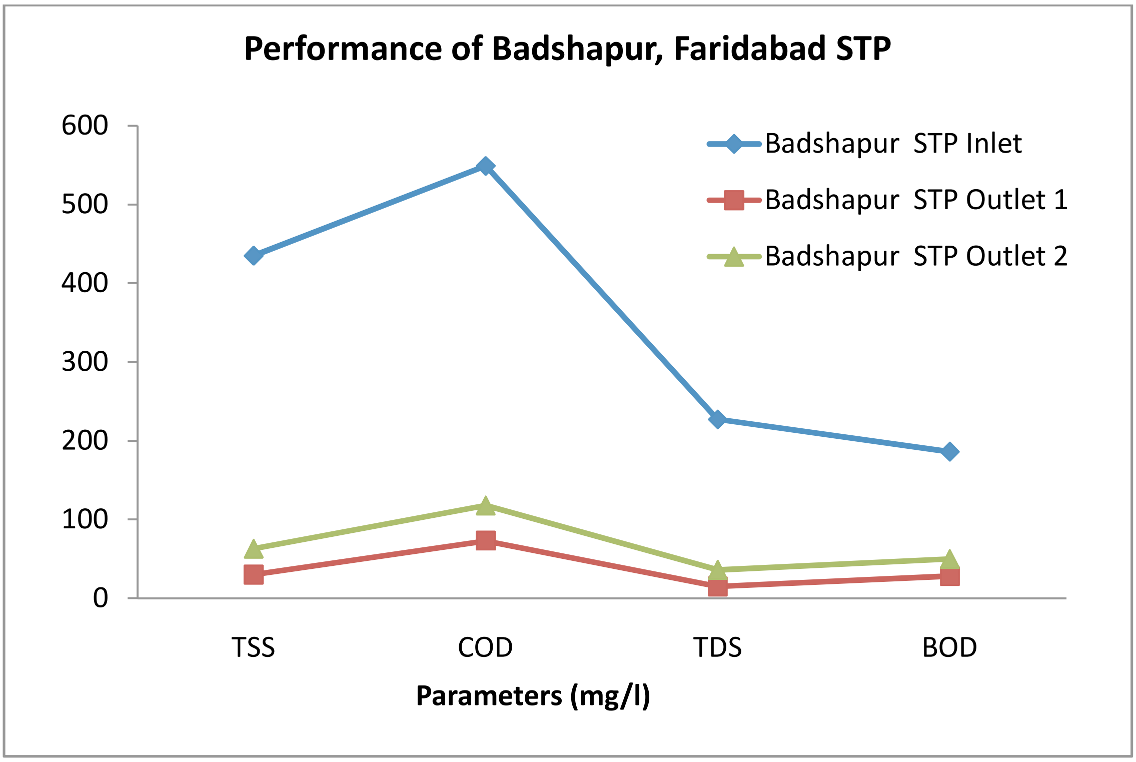


Fig 6.7: Performance of Badshapur STP.

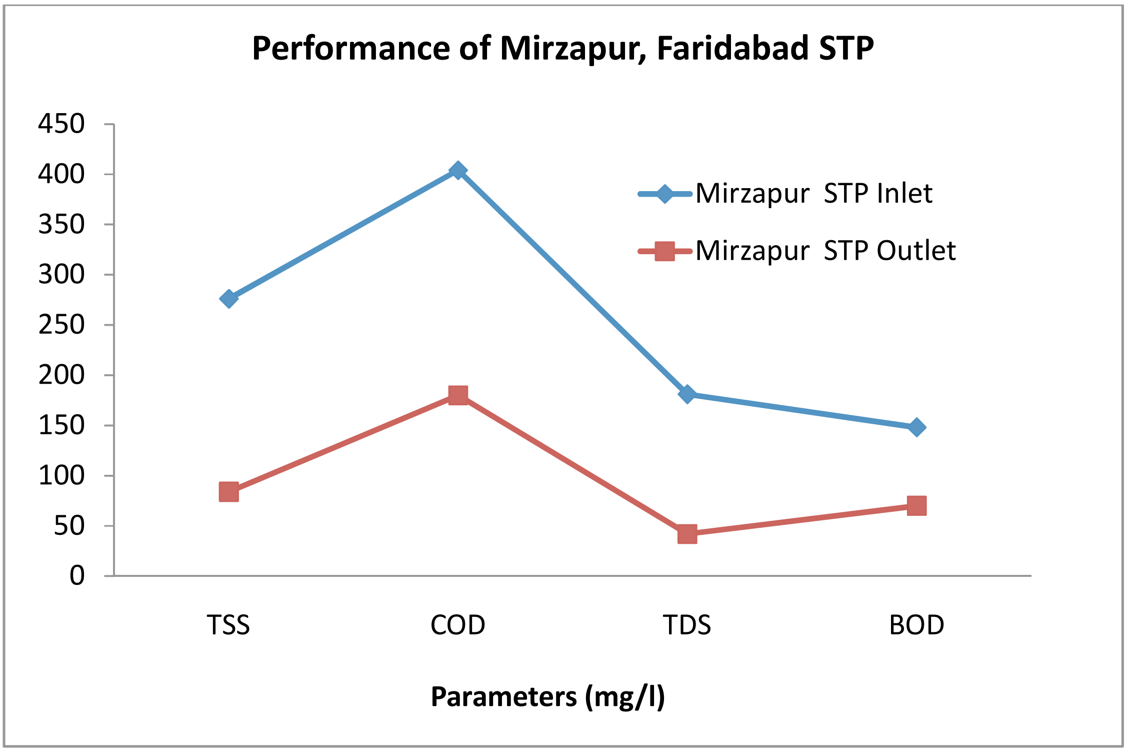


Fig 6.8: Performance of Mirzapur STP.

Values of Manganese were also found in all the tested samples higher than the desirable limits. Values of the Manganese were found 0.89 and 0.92 mg/l at the Gauchi drain and Ballabgarh STP outlet respectively against the desirable limit of 0.05 mg/l. Values of Nickel, Lead and Zinc was found under the prescribed standards of BIS.

But iron was found in varying concentration in almost all the tested samples. Maximum value of iron found in Gauchi drain and Ballabgarh STP was 31.4 and 32.4 mg/l respectively against the desirable limit of 0.3 mg/l. Even the minimum concentration of iron found was higher than the prescribed limit. Details of the concentration of heavy metals tested at different STPs of 1st segment are shown in Fig 6.9, Fig 6.10 and Fig 6.11. And the details of the concentration of heavy metals tested at different drains and river locations of 1st segment are shown in Fig 6.12, Fig 6.13and Fig 6.14. Result of heavy metals of different river and drain locations are shown in Table 6.3 and results of heavy metals of different STPs of segment 1 are shown in Table 6.4.

Table 6.3: Heavy Metal results of river & drains in Segment 1

Sampling Location	Cd (mg/l)	Cr (mg/l)	Cu (mg/l)	Fe (mg/l)	Mn (mg/l)	Ni (mg/l)	Pb (mg/l)	Zn (mg/l)
Asgar Pur Village	BDL	0.08	0.15	16.8	BDL	BDL	BDL	0.53
Noida Drain	BDL	BDL	0.12	6.43	BDL	0.13	BDL	0.44
Hindon River	BDL	BDL	BDL	4.29	BDL	BDL	BDL	0.12
Indirapuram Drain	0.02	BDL	BDL	2.99	0.27	BDL	0.2	0.28
Pratap vihar Drain	BDL	BDL	0.06	6.9	0.35	BDL	BDL	0.32
Budhiya Nallah	BDL	0.08	BDL	BDL	0.03	BDL	BDL	0.01
Hasan Pur	BDL	BDL	BDL	1.42	0.41	BDL	BDL	0.03

Table 6.4: Heavy Metal results of STPs in Segment 1

Sampling Location	Cd (mg/l)	Cr (mg/l)	Cu (mg/l)	Fe (mg/l)	Mn (mg/l)	Ni (mg/l)	Pb (mg/l)	Zn (mg/l)
Noida STP Sec 54 Inlet	BDL	BDL	0.11	9.83	BDL	0.1	BDL	0.44
Noida STP Sec 54 Outlet	BDL	BDL	0.14	2.21	BDL	BDL	BDL	0.11
Noida STP Sec 50 Inlet	BDL	BDL	BDL	1.31	BDL	BDL	BDL	0.19
Noida STP Sec 50 Outlet	BDL	BDL	0.06	3.47	BDL	BDL	BDL	0.16
Indirapuram STP Inlet	BDL	BDL	BDL	1.93	0.15	BDL	BDL	0.27
Indirapuram STP Outlet	BDL	BDL	BDL	0.33	0.12	BDL	BDL	0.07
Vijay Nagar STP Inlet	BDL	BDL	0.03	2.7	0.3	BDL	BDL	0.27
Vijay Nagar STP Outlet	BDL	BDL	BDL	1.92	0.38	BDL	0.44	1
Badshapur Faridabad STP Inlet	BDL	0.11	0.35	15.2	0.26	BDL	BDL	0.79
Badshapur Faridabad STP Outlet 1	BDL	BDL	BDL	1.99	0.26	BDL	BDL	0.04
Badshapur Faridabad STP Outlet 2	BDL	BDL	BDL	1.59	0.25	BDL	BDL	0.34
Mirzapur Faridabad STP Inlet	0.02	0.29	0.03	20.2	0.31	0.25	BDL	1.3

Mirzapur Faridabad STP Outlet	BDL	BDL	BDL	BDL	0.16	BDL	BDL	BDL
Ballabgarh STP Outlet	BDL	0.85	0.14	32.4	0.92	0.33	BDL	3

6.2 ANALYSIS OF 2ND SEGMENT OF STUDY AREA OF RIVER SYSTEM

Second segment of study area is selected between the Vrindavan and Mathura. First wastewater sample in this stretch were collected from the Kalidhey Drain. Location of sampling was 2 km away from the river system. BOD, COD and TSS of the Kalidhey drain were 82, 275 and 182 mg/l. Waste water from the Kalidhey drain is meant to be treated from Kalidhey STP having the capacity of 0.5 MLD. But during the sampling STP was found non-operational, whereas flow of the drain was found 9.5 MLD. Water sample was not collected from the above said STP as it was not working state from last 4-5 months.

Two STPs of Vrindavan are located at Kalidhey, Pagalbaba and two STPs of Mathura located at Masani and Trans Yamuna. Capacity of Pagalbaba STP was 4.5 MLD. Water samples collected from the inlet and outlet of the STP. Values of BOD and COD measured at the inlet of the STP were 162 and 374 mg/l and at the outlet were 50 and 160 mg/l. Values of the TSS at the inlet and outlet was found 214 and 70 mg/l. Even at the outlet of the STP waste water after the treatment were found exceeding the standards except pH. Another STP located in Mathura was also found non-operational. Total capacity of the STP at Masani was 13.5 MLD, whereas total flow measured at the Masani drain was 30 MLD. Bypass of the sewage was observed at the Masani pumping station. Wastewater samples collected from the Masani drain and values of the BOD, COD and TSS were found 30, 125 and 275 mg/l.

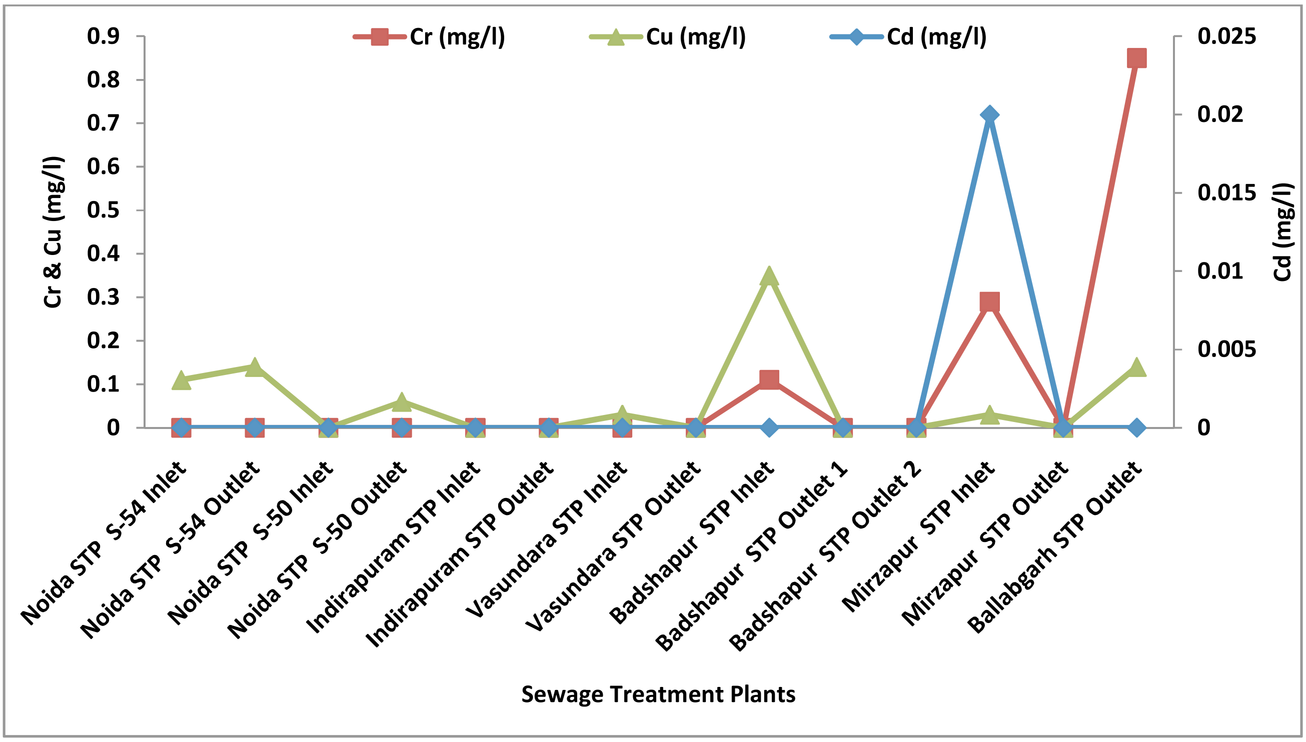


Fig 6.9: Results of heavy metals at different STPs

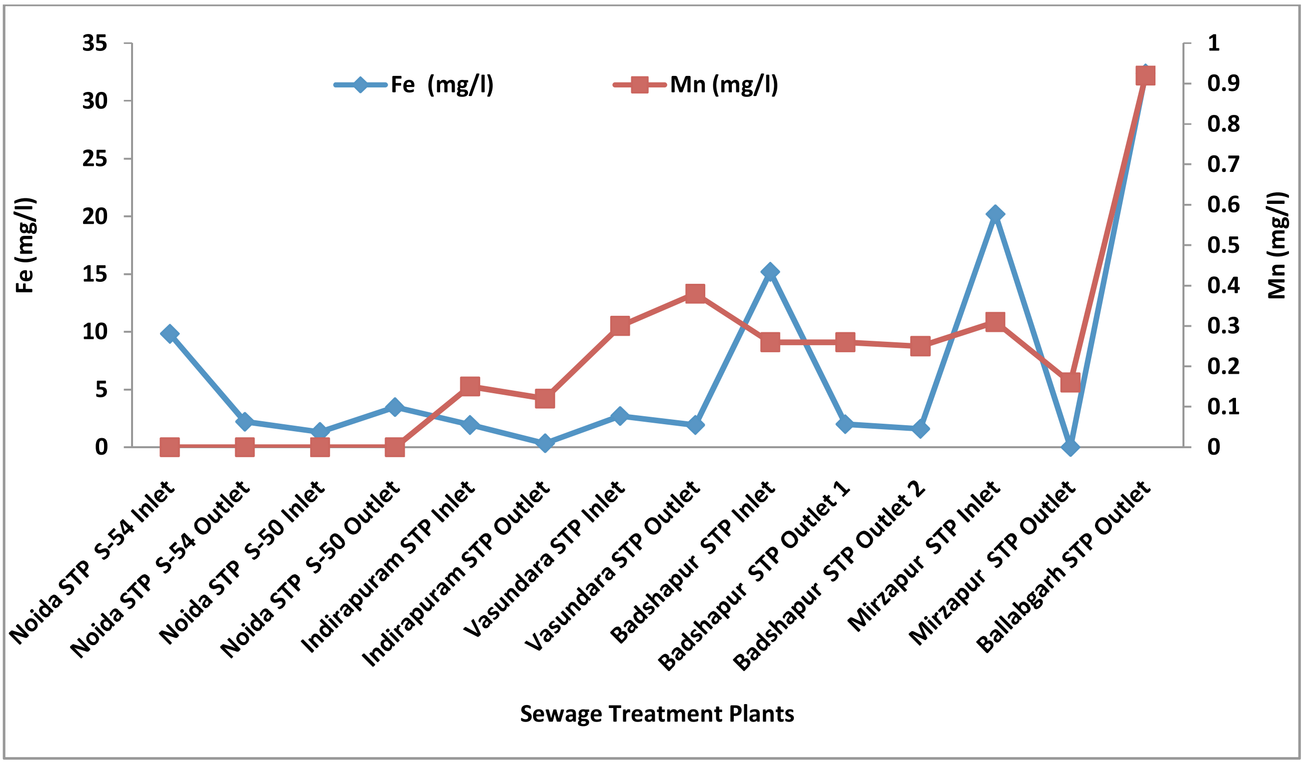


Fig 6.10: Results of heavy metals at different STPs

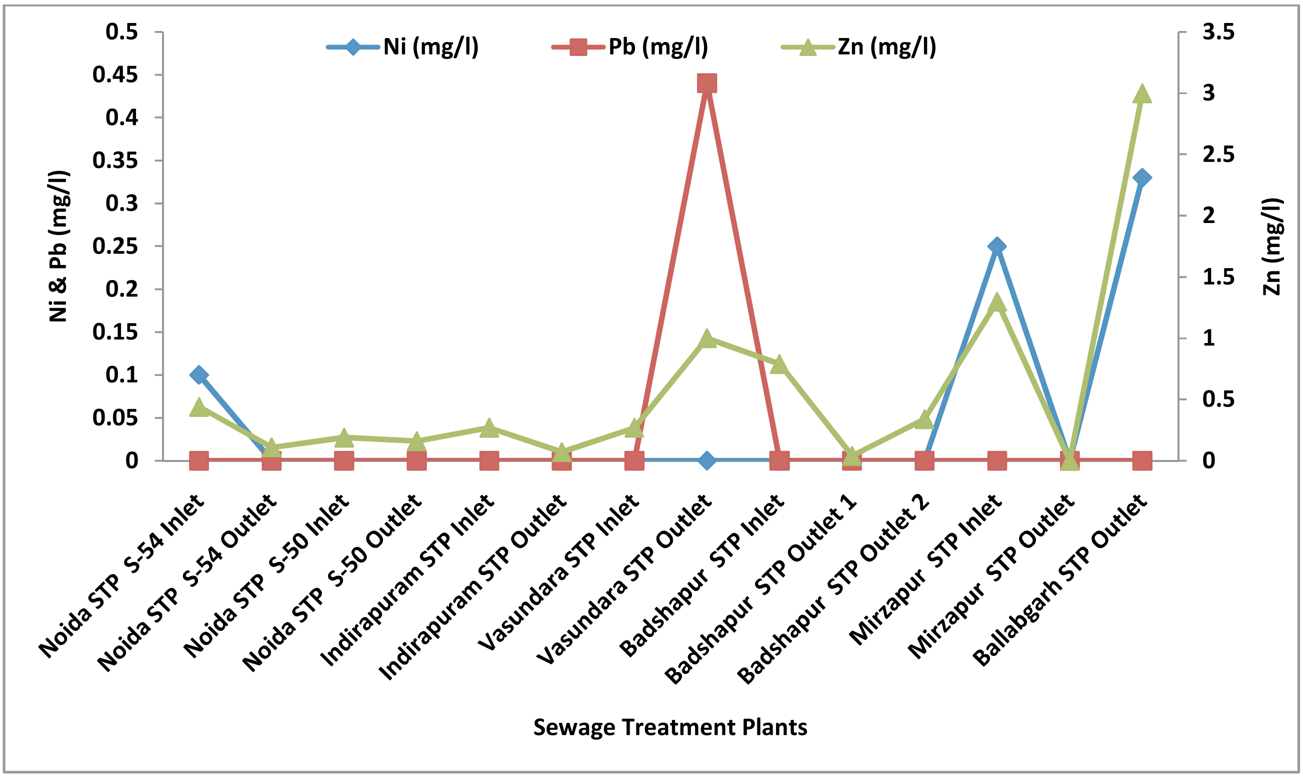


Fig 6.11: Results of heavy metals at different STPs

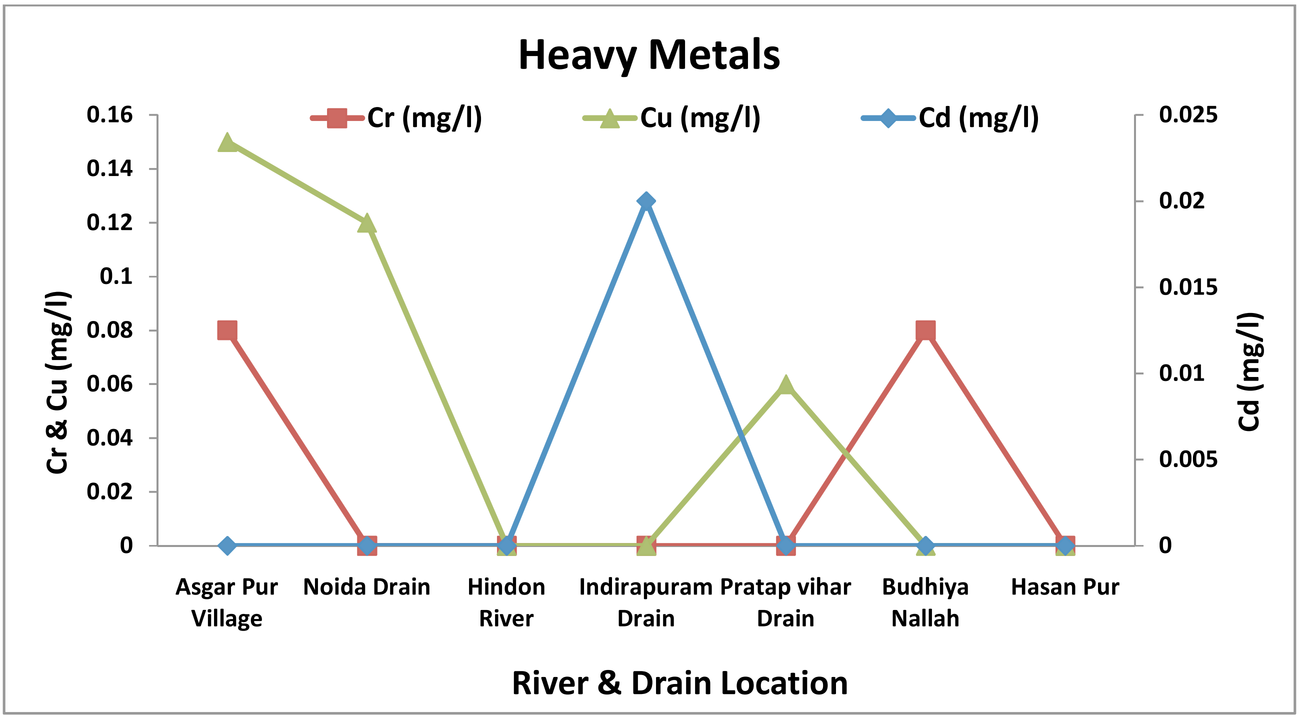


Fig 6.12: Results of heavy metals at different River and Drain locations

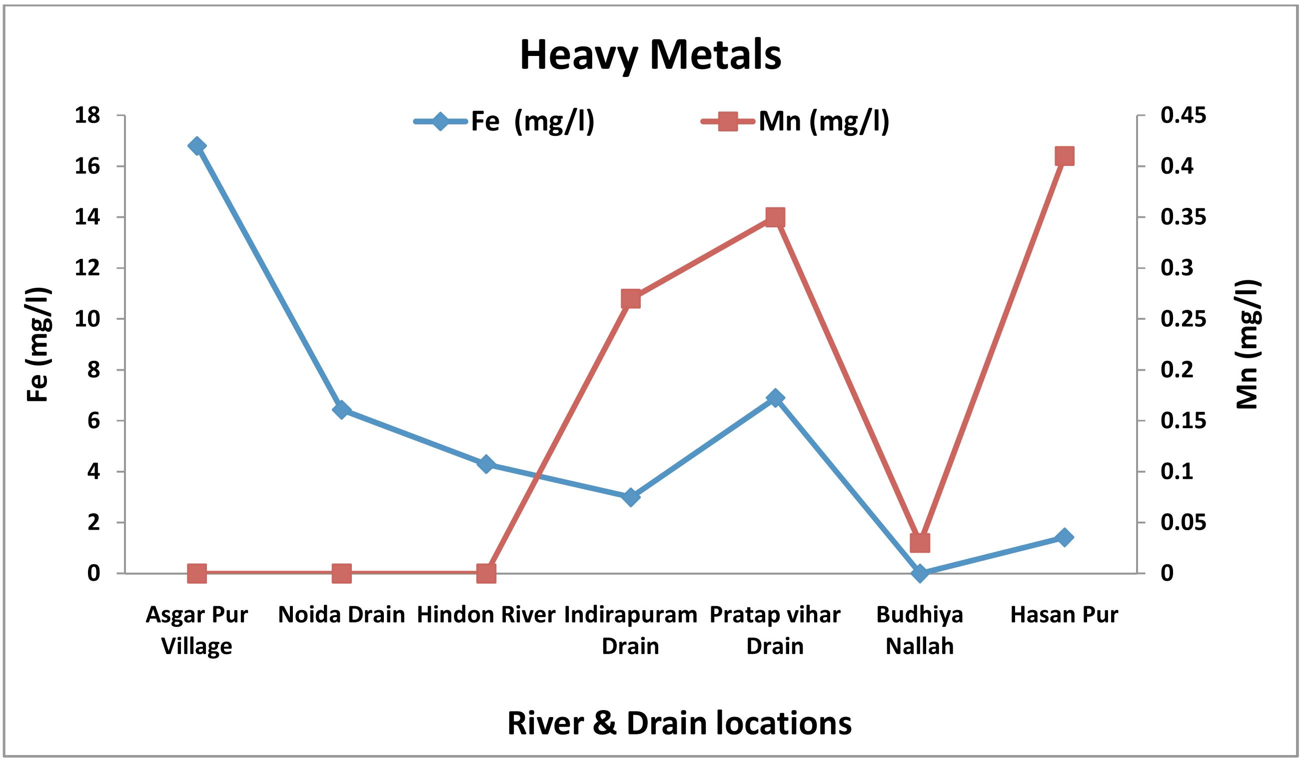


Fig 6.13: Results of heavy metals at different River and Drain locations

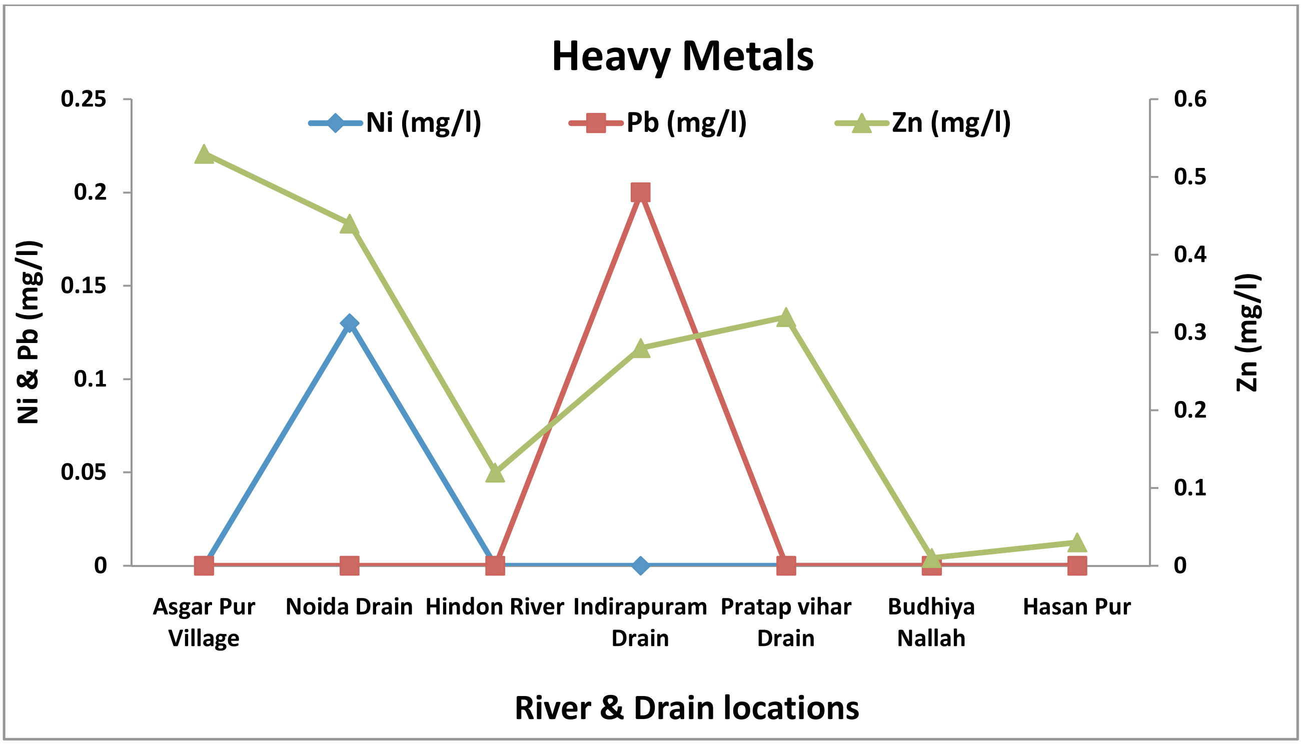


Fig 6.14: Results of heavy metals at different River and Drain locations

Mathura refinery drain was flowing adjacent to the Mathura refinery carrying the waste water from the oil refinery. Water sample collected from the drain and values of BOD, COD and TSS were measured 17, 86 and 105 mg/l respectively. All the measured parameters were found under the prescribed limit. But the oil and grease were found in the drain sample. Water sample were also collected from the STP located in Mathura known as Trans Yamuna STP. Only sample were collected from the inlet of the plant, as the outlet of the plant were found dry as shown in Fig 5.21. Very higher values of BOD, COD and TSS were found during the testing as 922, 2280 and 928 mg/l respectively. Another drain known as Amba kher drain flows in Mathura having load of 42.35 MLD. Sample was also collected from this drain and values of BOD, COD and TSS were found to be 52, 419 and 271 mg/l respectively. Physio-chemical results of the samples collected from the different drains of Vrindavan, Mathura and Agra in the 2nd segment of the Yamuna River are shown in Fig 6.15 and Fig 6.16 shows the performance of the Pagalbaba STP.

Table 6.5: Physio-chemical results of drains joining Yamuna River in 2nd segment

Locations	PH	COD (mg/l)	BOD (mg/l)	TSS (mg/l)
Kalidhey drain	8	275	82	182
Masani Drain	7.75	125	30	275
Mathura Refinery Drain	7.51	86	17	105
Amba Kher Drain	7.67	419	52	271
Anurag Drain	8.16	238	99	219
Manohar Drain	7.69	252	66	98
Narva Drain	7.51	193	74	175
Redfort Drain	7.61	369	140	324

In Agra waste water samples were also collected from the STPs. Waste water samples were not collected from one of the STP located in Agra known as Budiya ka Nagla STP having the capacity of 2.25 MLD as the plant were found non-operational. Waste water sample collected from the inlet and outlet of the Jaganpura STP of Agra and the values of the BOD, COD and TSS of the sample from the inlet of the STP were found 620, 1935 and 358 mg/l respectively. Though, after the treatment, values of BOD, COD & TSS of the sample from the outlet of the STP were reduced to 86, 195 and 83 mg/l respectively. Fig 6.17 shows the performance of the Jaganpura STP.

Waste water samples also collected from the inlet and outlet of the Pilakher STP having the capacity of 10 MLD. Values of BOD, COD and TSS of the sample from the inlet were found 144, 429 and 521 mg/l respectively and the values of the above said parameters of the sample from the outlet were found 33, 132 and 91 mg/l respectively. Fig 6.18 shows the performance of the Pilakher STP. Water samples also collected from the Dhandupura STP having the capacity of 78 MLD but only 41 MLD of the STP were found under utilization. Samples from the inlet of the plant were tested and values of BOD, COD and TSS read out 123, 581 and 315 mg/l respectively. Values of BOD, COD and TSS of the sample from the outlet of the plant were found 27, 150 and 78 mg/l respectively. Fig 6.19 shows the performance of Dhandupura STP, Agra.

There are several drain flowing in Agra and discharging its waste in Yamuna River directly or indirectly. Rajwa drain having the flow of 7 MLD discharging its waste into Dhandupura STP. Wastewater sample were collected from the drain and values of COD, BOD and TSS were found 276, 123 and 153 mg/l respectively. Anurag drain was found discharging about 6.7 MLD of waste water into Jaganpura STP through Manohar nagar pumping station. Values of COD, BOD and TSS of the sample collected from the Anurag drain were found 238, 99 and 219 mg/l respectively. Results of physio-chemical parameters of STPs in 2^{nd} segment are shown in table 6.6.

Manohar drain was also found discharging about 9.85 MLD of waste water into Jaganpura STP. Water sample collected from the Mahohar drain and the values of COD, BOD and TSS were found to be 252, 66 and 98 mg/l respectively. Water sample was also collected from the Narwa nallah. Narwa nallah was found discharging its 55.5 MLD of waste water into Dhandupura STP. Values of COD, BOD and TSS were fund 193, 74 and 175 mg/l respectively.

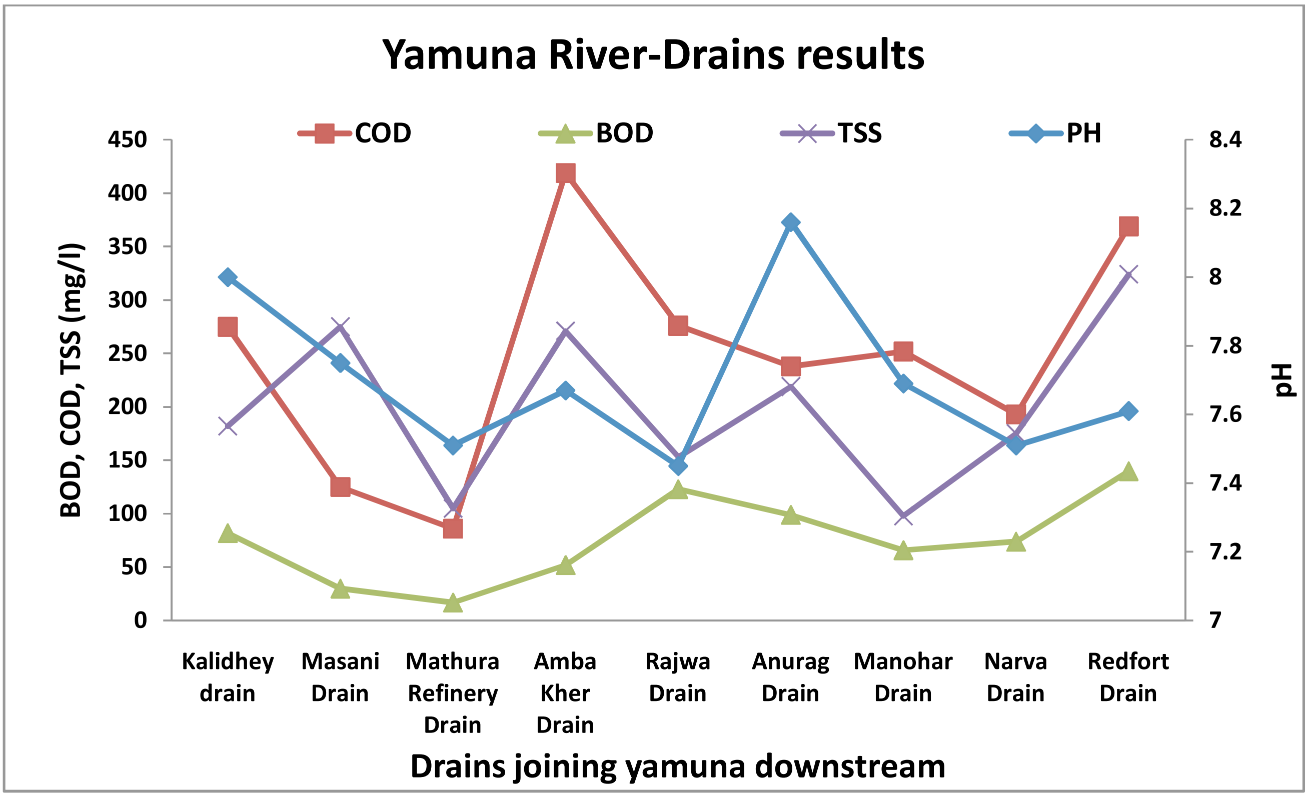


Fig 6.15: Physio-chemical results of different drains joining Yamuna River in 2nd segment.

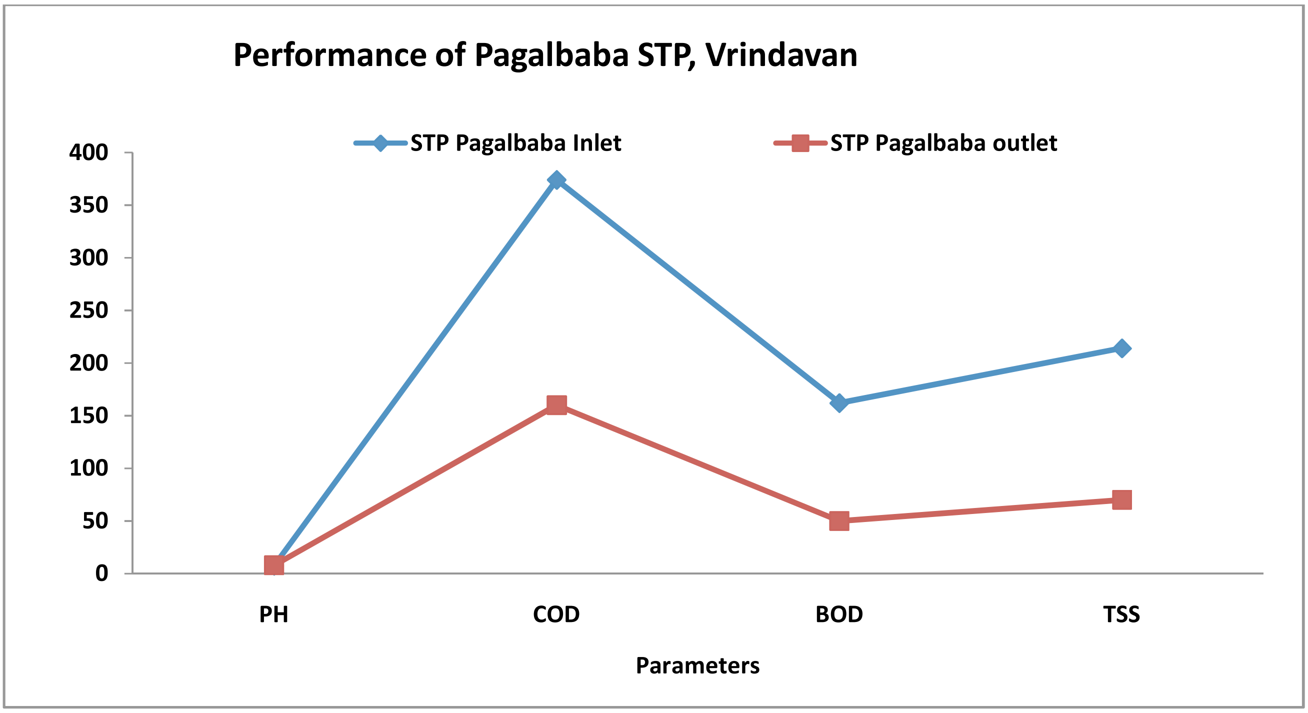


Fig6.16: Performance of Pagalbaba STP, Vrindavan

Water sample were also collected from the most polluted drain of Agra i.e. Red fort drain. Waste water discharge from this drain in to Yamuna River is maximum as compared to other drain of Agra as around 8 smaller drains also joins this drain and total load accounts up to 40 MLD. Values of COD, BOD and TSS were found 369, 140 and 324 mg/l respectively. Results of the samples of different drains of Mathura and Agra are shown in Fig 6.15 and table 6.5.

Heavy metals were also tested for the each drains and river water location in the 2ns segment. Cadmium and chromium was absent in all the tested samples. Whereas, copper was present in most of the tested samples of STPs and drains. Value of copper was found maximum in Red fort drain i.e 0.98 mg/l followed by Jaganpura STP sample having 0.35 mg/l. Values of Lead and Zinc was found under the prescribed standards of BIS. But iron was found in very concentration in almost all the tested samples.

Table 6.6: Physio-chemical results of STPs in 2nd segment

Locations	PH	COD (mg/l)	BOD (mg/l)	TSS (mg/l)
STP Pagalbaba Inlet	7.45	374	162	214
STP Pagalbaba outlet	7.93	160	50	70
Trans Yamuna Inlet	7.05	2280	922	928
STP Jaganpura Inlet	8.23	1935	620	358
STP Jaganpura Outlet	8.21	195	86	83
STP Pilakher Inlet	7.74	429	144	521
STP Pilakher Outlet	8.44	132	33	91
STP Dhandupura Inlet	8.87	581	123	315
STP Dhandupura Outlet	8.29	150	67	78

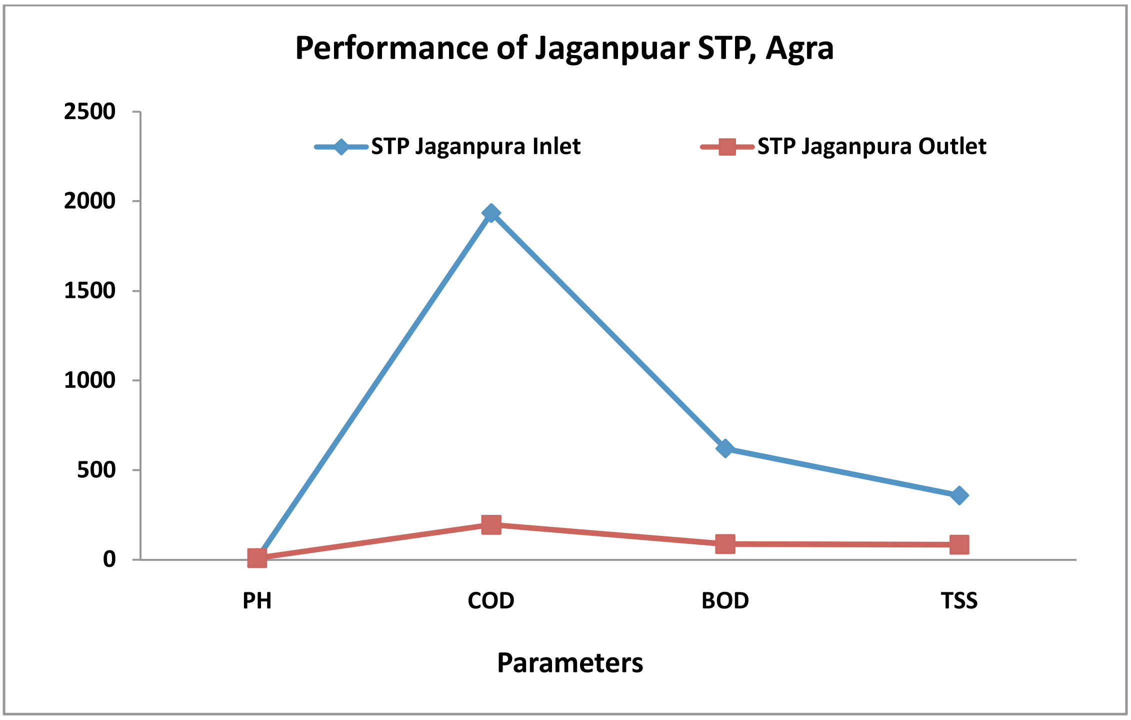


Fig6.17: Performance of Jaganpura STP, Agra

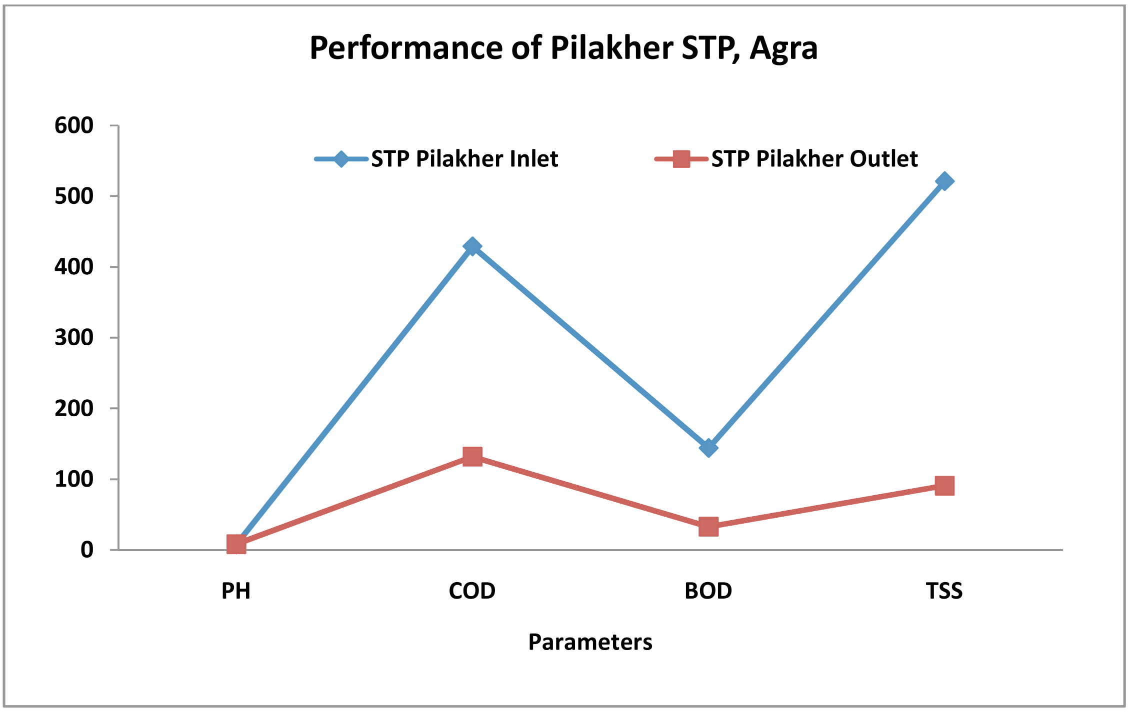


Fig6.18: Performance of Pilakher STP, Agra

Maximum value of iron found in the sample of Jaganpura STP and Amba Khar Drain was 13.6 and 8.32 mg/l respectively followed by Red fort drain having iron concentration up to 5.58 mg/l against the desirable limit of 0.3 mg/l. Concentration of iron in the sample of Sikandara water works was found 0.26 mg/l. Details of the concentration of heavy metals tested at different STPs of 2nd segment are shown in Fig 6.20.

6.3 TOTAL POLLUTION LOAD IN YAMUNA

The river has extremes of dry as well as flood conditions during a year. Due to high population density of the catchment, the river remains almost in dry state during January to June in many parts of its stretch and under flooded conditions during July-September. The water is contributed into the Yamuna River, not only through its tributaries but also by the canals and drains from various urban centers. There are several drains that are discharging it is partially/untreated waste water in to Yamuna River. Waste water contributed by all these drains is also essential as it prevent the river to become monsoon river from the perennial river. Due to the abstraction of large amount of water from the barrage, river water characteristics change dramatically at the downstream of the barrage. Increase in the pollution load due to lesser discharge is most common at the downstream of Okhla barrage. From the barrage only 101 cusec of water is allowed to flow at the downstream as most of the water either diverted to the Gurgaon canal or to the Agra canal for the irrigation purposes. Total wastewater contributed by different dains into Yamuna River is shown in Fig 6.21 and Fig 6.22.

Maintenance of minimum flow is the responsibility of Upper Yamuna River Board for which an MOU was signed between the Governments of Uttar Pradesh, Haryana, Rajasthan, Himachal Pradesh and NCT of Delhi on 12.05.1994 regarding allocation of surface flow of Yamuna upto Okhla which provides that ‘a minimum flow in proportion of completion of upstream storages going up to 10 cumec shall be maintained downstream of Tajewala and downstream of Okhla head works throughout the year from ecological considerations, as upstream storages are built up progressively in phased manner.' It is to mention here that this provision is regarding releases of water in the downstream from Tajewala & Okhla barrages and not for any particular section.

Table 6.7: Results of heavy metals of drains and river locations in 2nd segment of Yamuna River

Sampling Locations	Cu (mg/l)	Fe (mg/l)	Ni (mg/l)	Pb (mg/l)	Zn (mg/l)	Cd (mg/l)	Cr (mg/l)
Mathura Refinery Drain	0.03	3.27	BDL	BDL	0.18	BDL	BDL
Amba Kher Drain	0.16	8.32	0.13	BDL	0.58	BDL	BDL
Sikandara Water works	BDL	0.26	BDL	BDL	0	BDL	BDL
Jaganpura STP	0.35	13.6	BDL	BDL	4.16	BDL	BDL
Rajwa Drain	0.08	1.33	BDL	BDL	0.19	BDL	BDL
Jeewni Water works	BDL	0.79	BDL	BDL	0.02	BDL	BDL
Narva Nallah	0.32	3.52	0.65	BDL	1.18	BDL	BDL
Red fort Drain	0.98	5.58	0.18	0.1	2.36	BDL	BDL
CETP inlet	0.19	2.73	0.28	BDL	0.26	BDL	BDL
CETP outlet	0.5	3.2	0.32	BDL	0.63	BDL	BDL

The release of 10 cumec is the upper limit when the upstream storages are created. No lower limit has been prescribed in the MoU. It may be mentioned here that till date no storage capacity has been created, even when all the storages are created, the maximum prescribed release in the MoU for ecological purposes is only 10 cumec (or 352 cusec). Although the upstream storages are yet to be built up, 160 cusec of water is being released from Tajewala barrage into river Yamuna as per the statement of discharges ex-Tajewala supplied by Haryana.

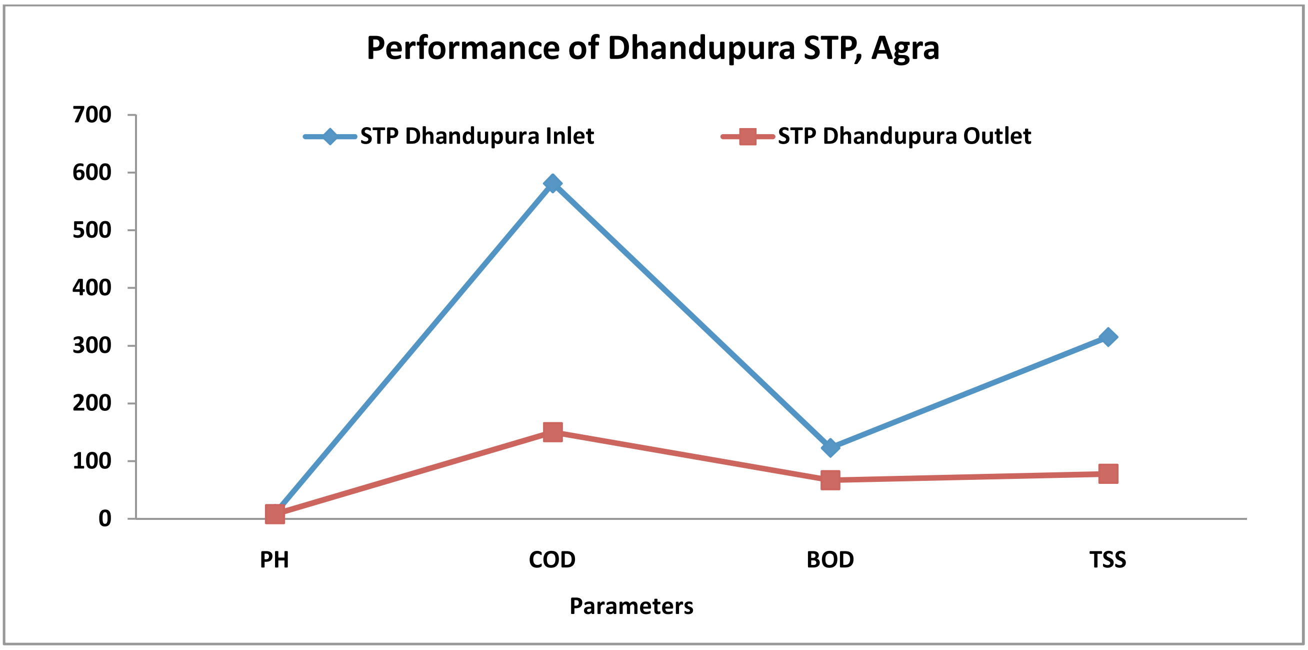


Fig6.19: Performance of Dhandupura STP, Agra

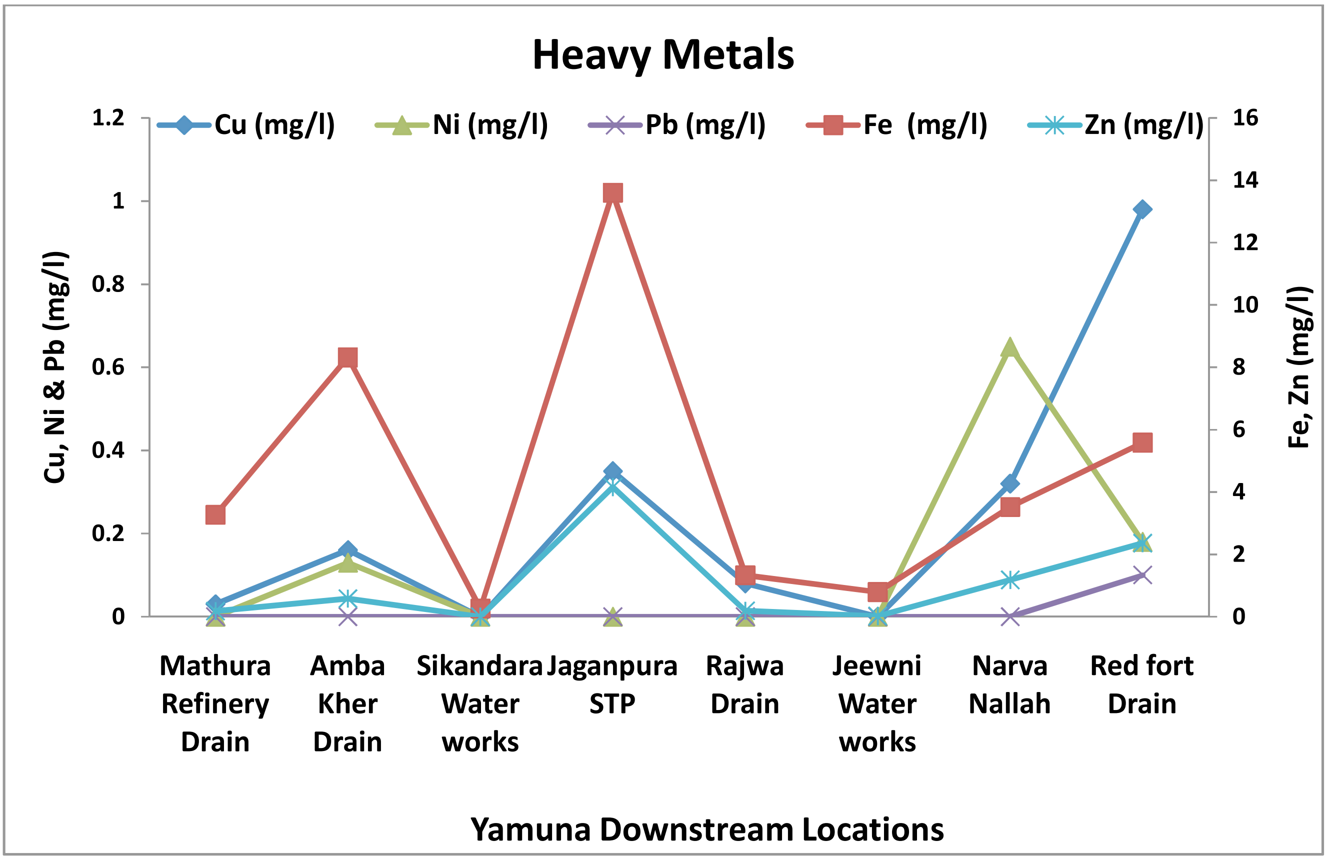


Fig 6.20: Results of heavy metals at different River and Drain locations

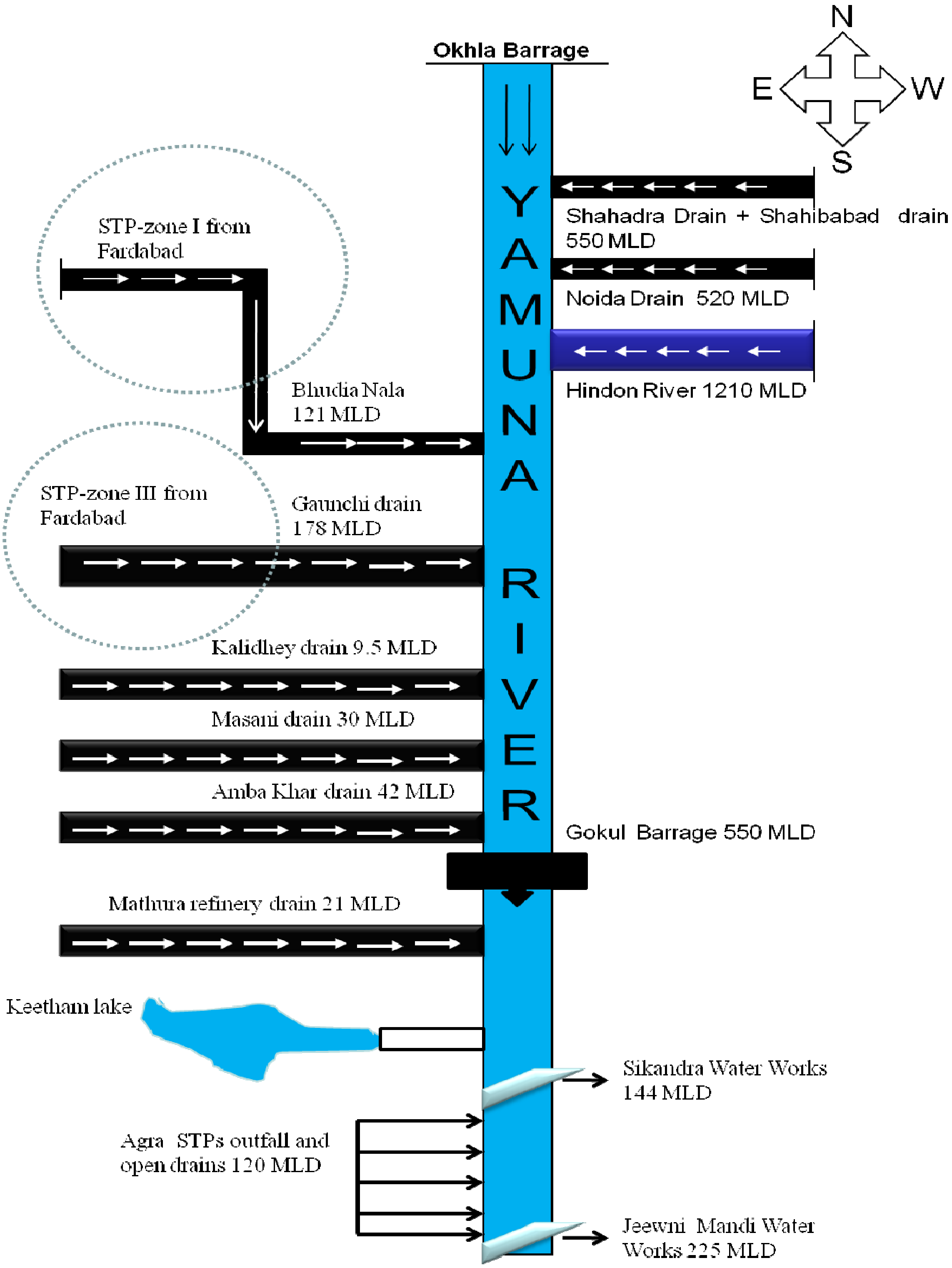


Fig 6.21: Drains joining river Yamuna and water abstraction from Okhla to Agra

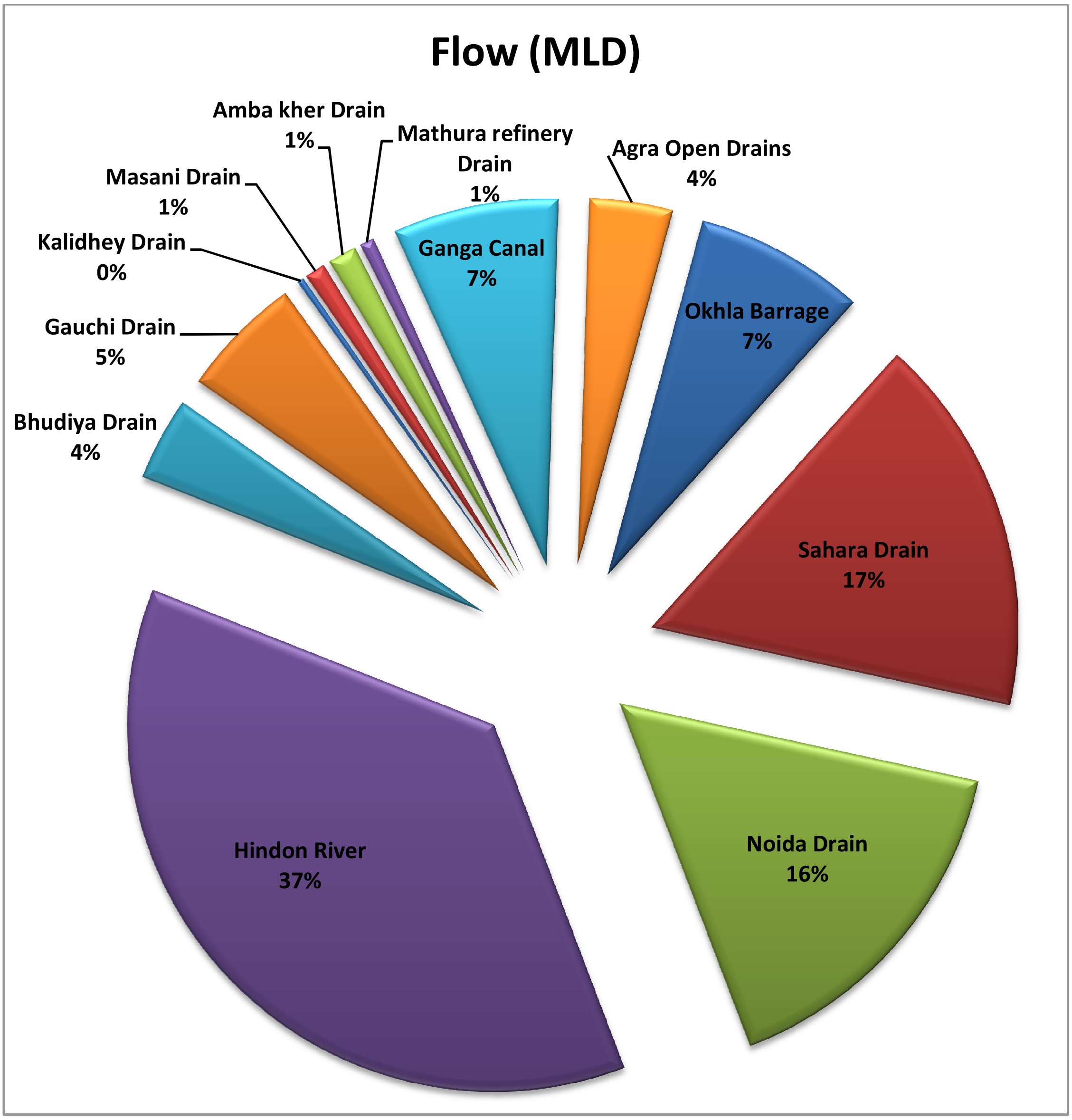


Fig 6.22: Contribution of different drains in flow of Yamuna River

Besides this, 140 cusec is also released by Haryana into river Yamuna through Najafgarh drain downstream of Wazirabad barrage, as stated by Haryana. As per distribution of water made by UYRB to basin states, 381 cusec of water at Tajewala and 369 cusec water at Wazirabad is provided to NCT of Delhi. This includes 51 cusec water for irrigation purposes. Only 101 cusec of water is allowed to flow in the downstream of the barrage. The DWF is comprised of wastewater from urban and rural settlements.

At the 5 km downstream of the barrage shahdara drain contributes about 550 MLD of waste water of east delhi and at the downstream of 17 km from the barrage noida drain joins the river containing waste water from the noida and greater noida and contributes 520 MLD of waste water. At the downstream of 38 km from the barrage hindon river joins the river containing waste water from the various drains of Uttar Pradesh and contributes about 1210 MLD of water/waste water. As the yamuna bed becomes dry after the barrage, Hindon river, Sahadara drain and Noida drain helps in maintaining the flow of the river as it contributes around 70% of total flow of yamuna upto Agra.

After that in Faridabad, Bhudiya nallah and Gauchi drain joins river yamuna containing wastewater from STP zone –I and STP zone –III and contributeas about 121 MLD and 178 MLD of waste water respectively. At Hasanpur village yamuna crosses from Haryana to Uttar Pradesh. In Vrindavan and Mathura kalidhey drain, masani drain and amba kher drain contributes 9.5 MLD, 30 MLD and 42 MLD of load in to yamuna River. Some of the water also contributed by the Ganga canal before the gokul barrage and accounted to around 100 cusec. At the gokula barrage water again abstracted to the water treatment plant having capacity of 550 MLD. At the downstream of the barrage 1300 cusec of water is allowed to flow. At a few distance from the barrage, mathura refinery drain joins the river and adds 21 MLD of waste water. After that fresh water again abstracted from the river at the sikandara water works having capacity of 144 MLD. In agra around 8 drains joins the yamuna river having total flow of around 120 MLD. Near the Taj, Jeewni water works extract about 225 MLD of water from the river for the domestic supply. Continuous abstraction of fresh water and load contributed by sewage drains are the major problem of Yamuna River.

Chapter 7

CONCLUSION & RECOMMENDATIONS

The schemes of pollution abatement under the Yamuna Action Plan were implemented in 15 towns. These are Yamunanagar & Jagadhari, Karnal, Panipat, Sonepat, Gurgaon & Faridabad in Haryana, Delhi and Ghaziabad, NOIDA, Mathura, Vrindavan, Agra and Etawah in Uttar Pradesh. Emphasis was laid on appropriate treatment technologies and resource recovery from sewage by using the treated sewage for irrigation and aquaculture, sludge as manure and bio-gas for power generation. It was agreed upon Central and State Govt. that the schemes under the Action Plan would be implemented by the State Governments through the identified nodal agencies with due emphasis on public participation and institutional development to make the programme sustainable. The Ministry of Environment & Forests was coordinated the overall implementation of the programme. Under the programme, it was proposed to set up sewage treatment plants. The following categories of work were taken up under the programme:

1) Interception & Diversion of Municipal Waste water
2) Sewage Treatment
3) Low Cost Sanitation
4) Improvement of ghats
5) Afforestation along the river banks
6) Community Participation

7.1 CONCLUSION

1) The pollution of the river is directly linked to the inefficient water planning and management in whole study area.

2) The growth in the sewage treatment plant and common effluent treatment plant capacity has not kept pace with the increase in population and number of industries in study area. Treatment capacity has almost increased 8 fold in last 40 years whereas; waste water generation has grown 12 fold in the same period.

3) STPs are being erected but continue to remain under utilised. Around 50 per cent waste water joins Yamuna untreated nullifying the effort and money, spent on treatment of the rest. The actual functioning of STPs and the treatment standards are such that even treated water remains grossly polluted in the context of micro-nutrients and pesticides.

4) Total load of waste water generated was not found diverting to sewage treatment plant from most of the sewage pumping stations in Mathura, Vrindavan and Agra as the pumping station were under operation only 3-4 hours/day and bypassing of sewage was observed.

5) Major amounts of pollutant wastes are dumped straight into the Yamuna River. Adding to this hefty problem is the fact that the economic boom further increased the population. The population was already in a poor situation, and the influx of those seeking work in the newly developed financial opportunities only added to this.

6) Okhla barrage in Delhi extract almost all the fresh water and sludge containing organic and toxic matters usually stored at upstream of barrage.

7) Of major note is the sewage situation; little has been done to cleanly accommodate these newcomers. As a result, the sewage is building up and not being dealt with properly. Sewage is dumped straight into the Yamuna River, which is where the majority of people in Uttar Pradesh bathes and washes their clothes.

8) Sudden release of the sludge in the downstream of the river water increases pollution level so high that led to mass death of marine life. Original status of Yamuna river is shown in Fig 7.1

9) According to the study, if we dispose waste water in to Yamuna River having flow 1/10th of flow of river and BOD 9.5-10 times the BOD of the river, characteristics of river will remain same even after mixing the drain. But the at most of the drains after the barrage, flow of the drains falling into the river was found approximately equals to the flow of the river.

10) One of the worst aspects of this method of dumping is that the majority of people don't realize how bad the situation with waste is. The handling of waste in general is simply terrible; a recent survey indicates that two in every five residents have pollution related health problems. Yet lack of government motivation and lack of knowledge allows this poor state to worsen.

7.2 RECOMMENDATIONS

The things that need to be done can fall into a basic three step process. First of all, the people need to understand exactly how preposterous the situation is. Once the masses of cities are aware, it will be much harder for them to simply ignore the problems they are faced with. With people behind causes, there can be motivation for change. With enough people, this movement can be taken to the next level; government action. Some of the steps/actions that need to be taken in to consideration are:

1) Pathogens reach the river through several drains bringing industrial effluents and city's sewage. It is thus urgent that steps are taken to deal with them either through efficient STPs and CETPs or diverting at least some of the most polluting of them away from the river.

2) It is important that water pollution monitoring on the river should be made on regular basis.

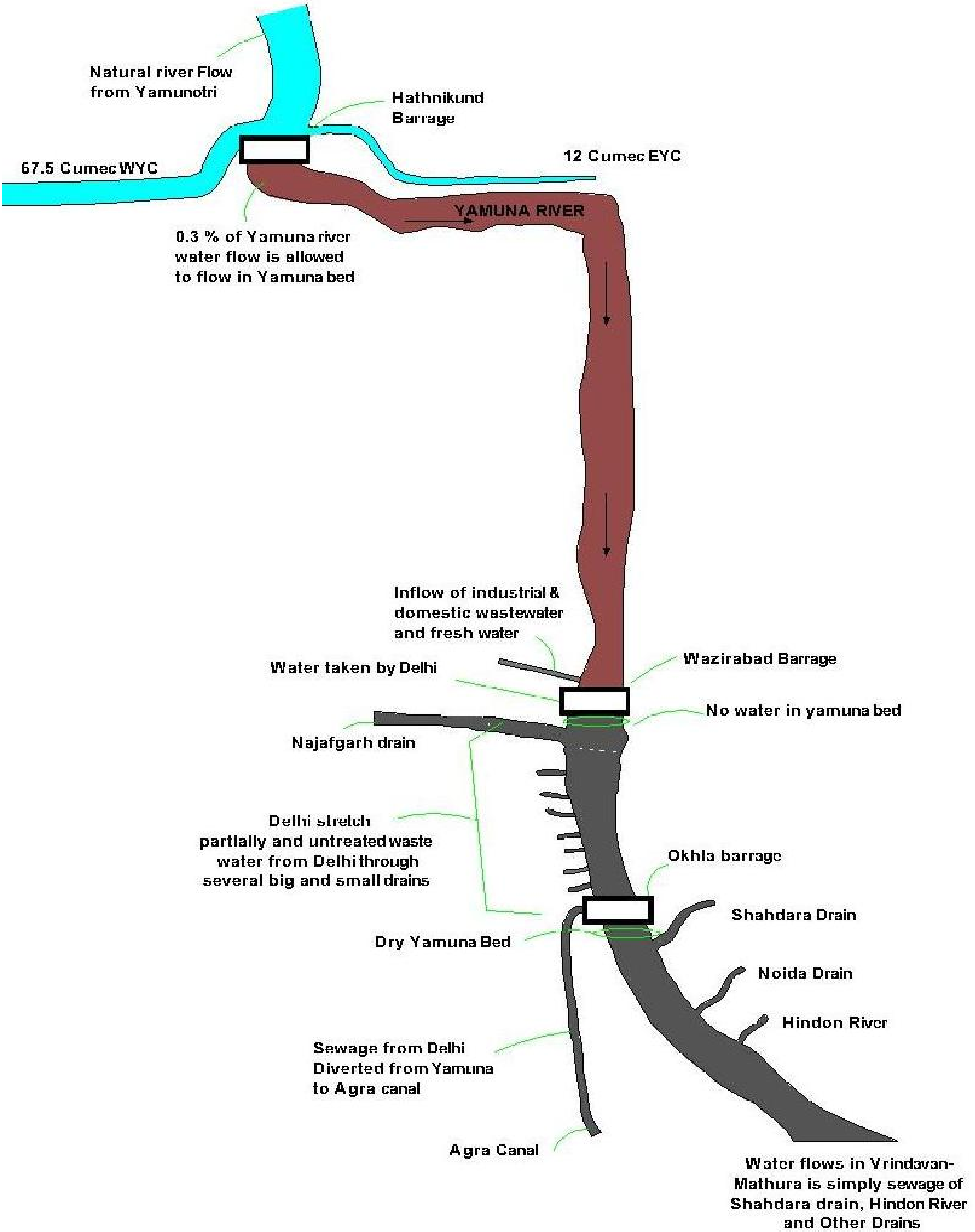


Fig 7.1: Original condition of Yamuna River

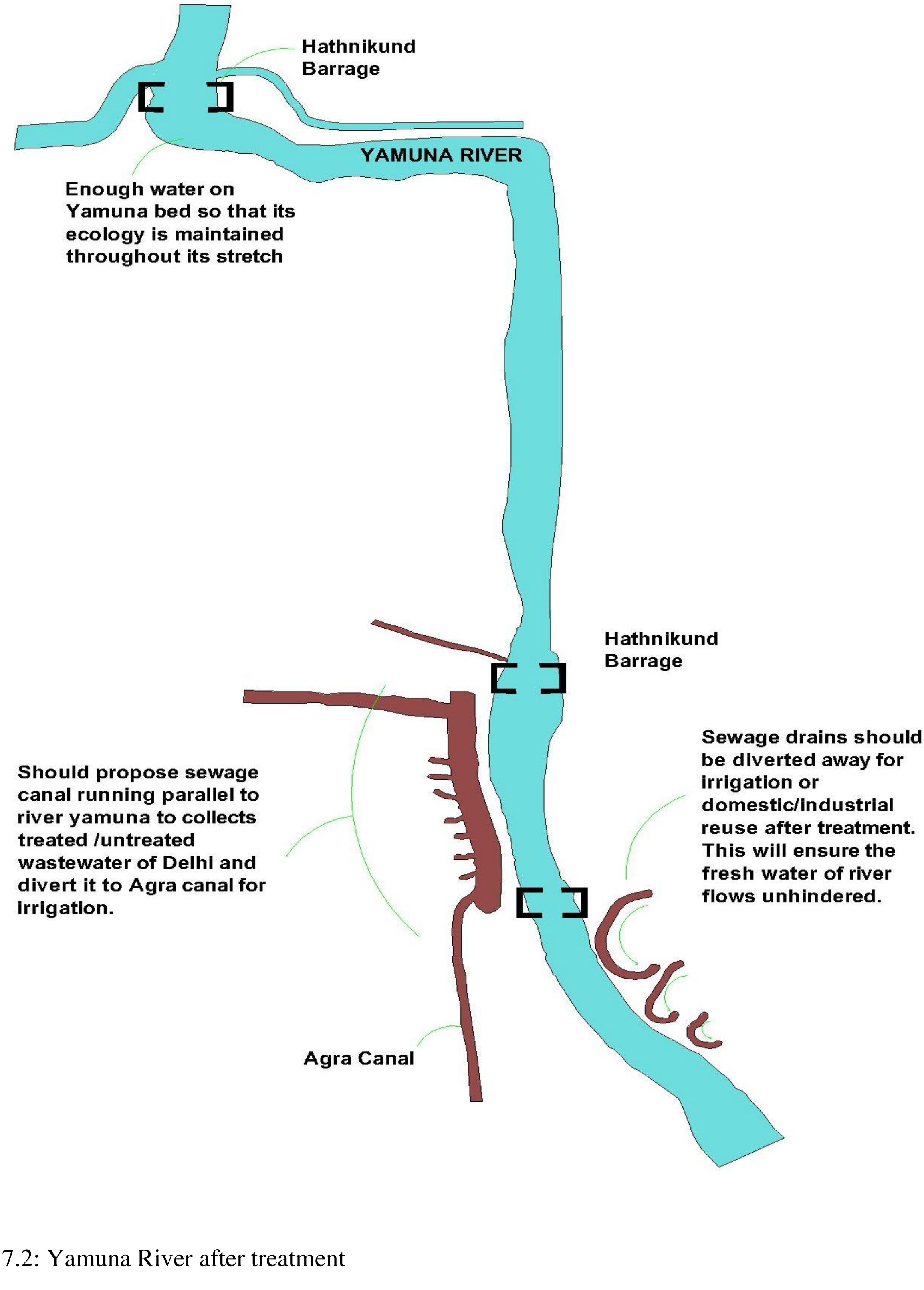


Fig 7.2: Yamuna River after treatment

3) It is well known that rivers with adequate flow in them have a self rejuvenation potential. It is thus urgent that in tune with recommendations already made by experts and the Courts, a minimum of 10 cumecs (cubic metre per second) flow in the river all along its length is ensured round the year.

4) In view of the fact that health burden monitoring and reporting leaves a lot to be desired, the concerned state department may review the situation and launch a special drive to improve the situation.

5) The critical role of flood plain in ground water recharge and in the city's water budget is all too evident. It is thus necessary that the remaining flood plains in the city are not compromised through constructions and concretisation in any manner.

6) A follow up study that may be able to track the flow of pathogens from the polluted river into food items (grains and vegetables grown in the flood plains) and further into humans is urgently called for to establish firm links (that on subjective grounds are otherwise indisputable) between the increasingly sick river and similarly rising trends of human health burden in the city.

7) Dilution of the river, mainly by reducing the city's demand of fresh water to keep the river alive by maintaining minimum flow in the river.

8) The most important element is to maximize the use of existing treatment facility and ensure the reuse of treated effluent.

9) All the waste water generated in Delhi, Haryana and Uttar Pradesh whether it is from authorized or unauthorized colonies, legal or illegal waste must be treated and not mixed with the untreated sewage.

10) For the control of Yamuna water degradation, there is need to put enough water into the river bed so that its ecology is maintained throughout its basin. For Yamuna river stretch in Delhi, there should be a canal running parallel to river containing all the treated/ untreated waste water from the 22 drains of Delhi and divert it to Agra canal for irrigation as shown in Fig 7.2. Drains joining the river on the right bank, should be reuse for irrigation after the treatment, this will ensure the water quality and flow of Yamuna remain unhindered.

REFERENCES

1) Anand, C., P. Akolkar and R. Chakrabarti : A comparative bioassessment of water quality on east and west banks of River Yamuna in Delhi. Published in Proceedings of International Conference organised by IWA, UK and IIT, New Delhi pp 433- 441 (Dec 11-13, 2002).

2) APHA : Standard Methods for the examination of water and waste water. 20th Ed. Washington D.C, USA, pp 9-56, 9.47 to 9.53 (1998).

3) CPCB (Central Pollution Control Board): Water Quality Criteria and Goals. MINARS/17/2001-2002.

4) CPCB (Central Pollution Control Board): Water Quality Status of Yamuna River. ADSORBS/32/1999-2000

5) WHO : Guidelines for Drinking Water Quality. Vol 3. pp 108-115 (1985)

6) DOE&F, State of Environment Report of Delhi, Department of Environment and Forest, Delhi, (2010)

7) Anand C., Akolkar P. and Chakrabarti R., Bacteriological water quality status of River Yamuna in Delhi, Journal of Environmental Biology, January 2006, 27(1) 97-101 (2006)

8) CPCB, Water Quality Status of Yamuna River, Central Pollution Control Board, Ministry of Environment and Forest, Delhi (2006)

9) Upadhaya Rahul, Hasan Aziz, Managing water quality of yamuna in Delhi, Physics and chemistry of Earth, (9-11), 372-378, (2011)

10) BIS, Indian Standards (IS: 2490), Domestic water specification, Bureau of indian Standard New Delhi (1991)

11) Bhargav Devendra Swaroop, Water quality variations and control technologies of Yamuna river, Journal of Environmental Pollution Series A, 37(4), 355-363, (1985)

12) Jain P., Sick Yamuna, Sick Delhi- Searching a correlation. Peace Institute Charitable Trust, (2009)

13) Claire Cummings, Francis Bezzina, Mitch Yunker, Water Pollution in the Yamuna River, New Delhi, India, Envs 160 Spring (2008)

14) Sharma D. and Kansal A., The status and effects of the Yamuna Action Plan (YAP), TERI University, Delhi