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Yamuna river water analysis and case study

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Abstract
Yamuna, the second name of Yamuna is Jamuna and is called the longest and one of the largest river of Ganga in Northen India. Yamuna originates from 6387 meters on the south- western slope of Banderpunch peaks in the top most region of lower Himalayas in Uttarakhand, it passes through a length of 1387 kilometers and has a drainage system of 366,223 squaremeters that is about 40.2% of entire Ganga basin, before met at Triveni Sangam.
The water of river Yamuna is used for both abstractive and in stream uses like irrigation, domestic water supply, industrial purpose etc. It has been subjected to over exploitation both in quality and quantity. The river is polluted by both point and non- point sources, NCT- National Capital Territory, Delhi is the major contributor, followed by Agra and Mathura. Near about 85% of the total pollution is caused by Domestic source. This destruction of natural resoures like Yamuna is the issue used to be taken as major concern as it also destroy the aquatic life too.

Keywords: yamuna, irrigation, domestic water supply, industrial purpose, NCT

Introduction
River Yamuna is the largest tributary of the river Ganga. The main stream of the river Yamuna originates from the Yamunotri Glacier near Banderpunch (38059'N 78027'E) in the musoorie range of the lower Himalayas at an elevation of about 6320 meter above mean sea level in the district Uttarkashi (Uttranchal). The catchment of the Yamuna river system cover parts of the states of Uttaranchal, Uttar Pradesh, HP, Haryana, Rajasthan, Madhya Pradesh and the entire state of Delhi**.** The river Yamuna transverses a distance of about 1370 kilometers in the plain from Saharanpur district of Uttar Pradesh to the confluence with river Ganga at Allahabad. The major tributaries of the river are Tons, Betwa, Chambal, Ken and Sindh and these together contribute 70.9% of the catchment area and balance 29.1% is the direct drainage of main river and smaller tributaries. On the basis of area, the catchment basin of Yamuna amounts to 40.2% of the Ganga Basin and 10.7% of the country. Table 1 and table 2 shows the state wise land use pattern of the catchment area of river Yamuna.

Table 1: Different segments of the river Yamuna [1]. River Segments

	Segment Area	Approx. Segment Length
Himalayan Segment	From origin to Tajewala Barrage	172 km
Upper Segment	Tajewala Barrage to Wa-zirabad Barrage	224 km
Delhi Segment	Wazirabad Barrage to Okhla Barrage	22 km
Eutriphicated Segment	Okhla Barrage to Chambal Confluence	490 km
Diluted Segment	Chambal Confluence to Ganga Confluence	468 km

At the origin point (from Yamunotri Glacier to Tejawala Barrage) the river water is good and fulfil all the standards also. Within this Tejawala segment in Yamuna nagar district of Haryana state, river water is divided into Eastern Yamuna Canal (EYC) and Western Yamuna Canal (WYC), no water is allowed to flow at the down stream of Tejawala Barrage during summers and winters to fulfil the water demand of Delhi. It is said that 57 million of the population is directly depends on Yamuna waters with an annual flow of about 10,000 cpm and 4400 cpm of which is directly going for irrigation that is 96% is contributed for irrigation. Okhla barrage is another barrage 22 kilometers down stream of Wazirabad barrage and is known as Delhi segment. It accept water from 17 sewage drains of Delhi, Najafgarh drain, this segment known as the most polluted segment of Yamuna. Further on okhla barrage remaining water flow is the waste water generated from domestic and industrial waste from Delhi, Noida is a and joins the river through shahdara drain. At the Mathura up stream, the Gokul barrage polluting the river by decreasing the flow. About 21 sewer lines of Mathura is directly discharge into Yamuna passing through is clear temple.
Yamuna river once designated as the safeguard of Delhi city, but Delhi, urban contributes 70% of the total pollution load due to inadequate official underground drainage system. Almost 60% of the waste disposal dumped in the river. Treated effluents from Yamuna Vihar treatment plant discharged into the drain, and then drain carries effluents of

the un-sewered colonies, treated and untreated effluents then picked up at kondi treatment plant and treated, discharge into drains which carry effluents of unsewered colonies in Delhi and Noida and the results the river remains polluted. The sewage generation has been estimated by the CPCB at 3964 million liter per day CMLD, out of which only some percent of MLD is being treated. Therefore, about 80-85% of water we daily used is untreated. According to CPCB, yamuna river stand at E category which makes it fit for recreation and industrial cooling, completely destroying the probability of under water life too.

Aquatic pollution occurs when harmful or potentially harmful, effects results from the entry into the ocean of chemicals, particles, industrial, agricultural, and residential waste. 80% of aquatic life pollution comes from land. Upstream from Wazirabad before river enters Delhi, it is the home to turtles, different species of fish, crocodile and an abundance of aquatic plants and phgtoplankton. But when it enters in Delhi, the river starts to die. Downstream from Wazirabad, the river is ecologically dead and have no aquatic life. Every year mass death rate of fishes is increasing because of low level of DO and a very high degree of pollution. Sewage from 21 drains flow, polluting it to a level that is enough to kill component essential for maintaining aquatic life. Agents like phytopeaukton are responsible for sustaining the aquatic food web by creating organic compounds from carbon dioxide dissolve in the water. Factors like river basin degradation, ecological pollution, contaminant effect on ecosystem and ecology, solid and liquid waste and on river bed have all combined to kill Yamuna aquatic life. The 21 drains discharge around 850 MGD (Million gallons per day) of sewage into Yamuna. The. According to recent report, 33 sewage treatment plants has been established, at present treat only 390 MGD of this, remaining 640 MGD is inadequate to treat, thus all the sewage emptied into the river. Approximately 75% of the precipitation in Yamuna basin occurs in 4 monsoon month from June-September. This effects the river and water quality upto a greater percent.

The need of the fresh water is increasing day by day, by growing population and increase in the agricultural and industrial activites. Yamuna fulfilled the demand of water of Uttar Pradesh, Madhya Pradesh and Delhi.

Water quality status of river Yamuna

According to CPCB, the quality criteria for healthy water is 5 mg/l DO for marine life and 3mg/l BOD, pathogen counting should not more than 500 per 100 ml. The scenario of India in river water quality having 5 different classes for rivers based on their quality status that is class A, B,C,D,E which says- class A belongs to the river water is fit for drinking after suitable disinfection. Class B belongs to the river water is fit only for bathing.

Class C belongs to the river water is fit for drinking after proper treatment. Class D belongs to the river water is fit only for marine life and wildlife. Class E belongs to the river water is fit for industrial cooling, irrigation etc. Yamuna belongs to class E. The factors involved in the analysis of water quality are as follows-

Biochemical oxygen demand (BOD)-

The amount of dissolve oxygen that must be present in water in order for micro-organisms to decompose the organic matter in the water, used as a measure of the degree of pollution. The BOD value is most commonly expressed in milligrams/litre. The water quality of river was good before met at Najafgarh drain. BOD at palla generally meets prescribed standards of 3mg/l and was found in the range of 1-8mg/l. At okhla drain, BOD values were found well above the limit at 3mg/l and was in the range of 9-97mg/l.

At Nizamuddin bridge and okhla BOD values were found in the range of 4-40mg/l and 5-37mg/l respectively. Figure shows the Yamuna BOD level at different locations-

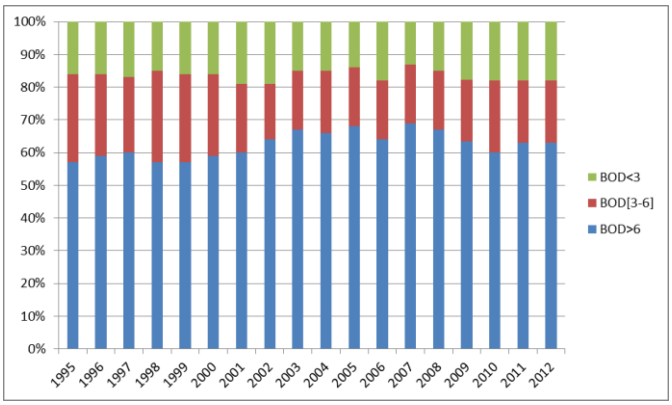

Fig 1: Water Quality Trend of BOD [mg/l]

Chemical oxygen demand (COD)

COD is the amount of oxygen needed to oxidize the organic matter present in water. Similar to BOD, it provides an index to the effect discharged waste water will have on the receiving environment. Higher COD level means a great amount of oxidizable organic material present in the sample, which reduced the DO. A reduction in DO lead to deleterious to higher aquatic life form. According to general standards for discharge of environmental pollutants, the total and maximum COD level of inland surface water is 250mg/l and 250mg/l for marine coastal areas.

Dissolved oxygen (DO) -

Dissolve oxygen is the amount of oxygen dissolved in water such as a lake, river, or stream. Dissolve oxygen refers to microscopic bubbles of gaseous oxygen O_2 that are mixed in water and avail to aquatic organisms for respiration. DO is the most important indicator of the health of a balanced aquatic ecosystem of plants and animals. DO parameter from to okhla barrage in the range of 0.0-3.0mg/l which reflects that DO is always voilating the prescribed standard of 5.0mg/l at okhla and 40mg/l at other two locations.

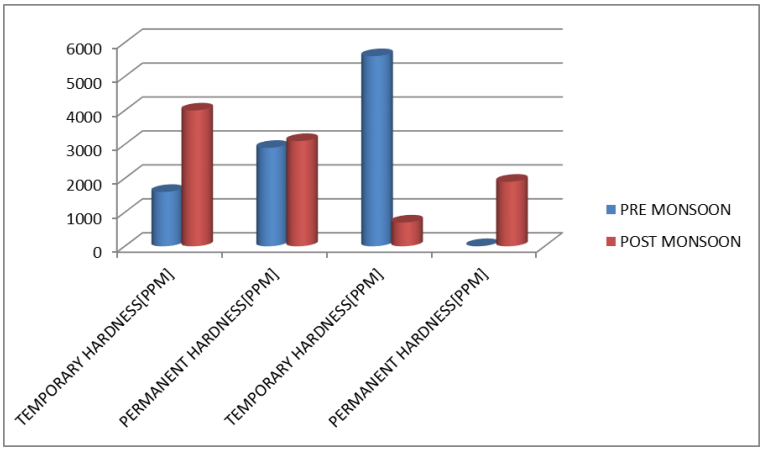

Fig 2: Water Quality of WYC during Pre and Post Monso

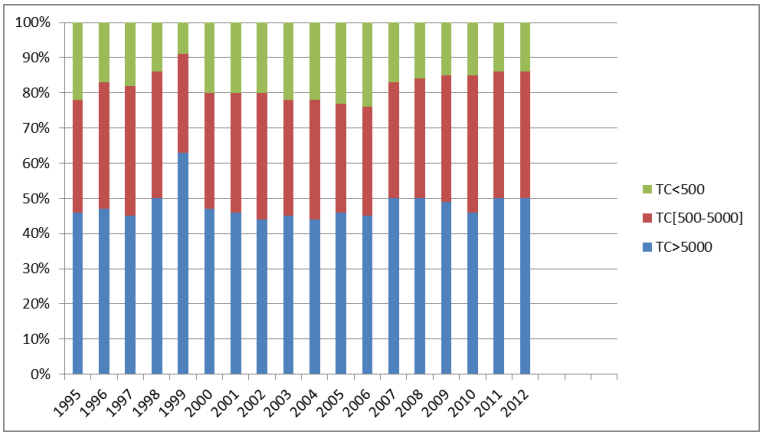

Fig 3: Water Quality Trend of Total Coliform [MPN/100ml]

Coliform

Total coliform was found meeting the standard of 5000MPN/100ml at palla on 14 out of 22 rounds of analysis and its values were ranged between 450-43000 MPN/100ml. At okhla with significantly high counts that is 330000-160000000MPN/100ml was found voilating prescribed standard of 500 MPN/100ml.

PH-: pH was the only parameter that meets the prescribed standards of 6.0-9.0 for palla and 6.5-8.5 for the remaining Nizamuddin bridge, okhla, okhla.

The reason of deteriation of Yamuna river water quality in delhi stretch especially after Wazirabad barrage is due to unabated discharges of waste water predominantly from domestic sources into the river. The other reason is the non-availability of fresh water in the river after Wazirabad barrage especially during non-monsoon period, which is essential to maintain self-purification capacity of the river.

Sources of river pollution

Unwanted effluent from factories

The number one cause is the discharge of untreated effluent from the factories that is in towns and cities along the Yamuna river.

Domestic waste

The major cause is the charge of untreated sewage from the houses and spaces in the large cities as well as small towns that lies close to Yamuna river.

Superstitious believes

People believes in dump their puja or hawan material directly into the Yamuna and also the clothes or things of a dead person as they believe Yamuna as mother called 'Yamuna Ji'.

Discharge by major drains

- There are twenty-one major waste water drains in NCT-Delhi out of which eighteen drains directly joins Yamuna river and rest joins Agra/Gurgaon canal.
- All the darins join Yamuna river downstream of Wazirabad barrage.
- The range of total BOD load of 18 drains join Yamuna river was 105 TPD (March, 2015).
- Total discharge of these drains was varied from 301 m^3/s (March, 2015) to 42 m^3/s (Feb, 2014)
- The collective average of these drains for the year 2014-15 in terms of discharge was about 36.3 m^3/s and 34.8 m^3/s respectively whereas, BOD load average for these 2 years was 163 tonnes/day (TPD) and 164 tonnes/day respectively.

River Water treatment processes

As of high volume of waste water from industries, commercial

sectors, agricultural sectors and from domestic drainage system, it is to be very important to treat this waste water. Even if there are many water treatment plants but only a small quantity of waste water is treated in them and rest is disposed off to river. So, it is highly recommended to treat waste water fully.

Contaminants in wastewater are removed by basic three methods-

- Physical unit operations
- Chemical unit processes
- Biological unit processes

Physical unit operations

These are the physical methods used to improve or treat wastewater by removing big solid impurities. The operations includes screening, sedimentation, aeration, flotation and skimming: Screening is typically used as a pretreatment method to remove larger suspended material. Sedimentation is carried out to settle solids by gravity, allowing heavier particles to settle down at bottom of the tank and treated water is removed out.

Physically adding air to waste water in aeration helps in increasing the dissolved oxygen of waste water.

Fat and grease are removed by passing sewage into small tanks where skimmers collect the fat floating on surface in flotation and skimming operation.

Chemical unit processes

Chemical treatment consist of using some chemical reaction or reactions to improve quality of water. Mostly chlorination, coagulation and flocculation, neutralization and adsorption are employed.

Chlorination is used to kill bacteria and to slow down rate of decomposition of waste water. Another oxidizing agent ozone is also used for disinfection. Coagulation destabilizes the non-settleable particles by neutralizing them and after employing flocculent like organic polymers, coagulated particles can form large masses which called as floc and then separate out quickly. Chemical coagulants like alum and ferric chloride are generally added to wastewater.

Neutralization is commonly used by industries to treat wastewater by adding acid or base to adjust pH level back to neutrality. For acid waste neutralization, lime is generally used.

Organic material can be removed by adsorbtion which is the physical adhesion of chemicals on to the suface of solid. Porous matrix of granular activated carbon is used as adsorbent.

Biological unit processes

The aim of the biological processes is to remove organic pollutants and biodegradable substances including plant nutrients. Biological processes can be characterized into two types based on the availability of oxygen to micro-organisms.

Aerobic decomposition is very effective in removing biodegradable organic material in waste water. Media bed material include plastic balls or other type of synthetic media on which bacteria, fungi and other micro-organisms grow and multiply, uses oxygen and consume organic material as food. Anaerobic processes are used in the treatment of heavily organically polluted wastewater by treating wastewater in a sealed reactor (in the absence of air) where micro-organisms decompose organic matter and methane and biomass are produced as final products.

Advanced wastewater treatment process

After all these treatments, there even exist a known amount of plant nutrients and dissolved solids which means that waste water still contains some amount of BOD and COD in it. And if the waste water is of industrial origin, it may also contain traces of organic chemicals, heavy metals and other contaminants.

Different advanced treatment methods are employed in such cases to satisfy the specific goals which include the removal of (1) suspended solids (2) BOD (3) plant nutrients (4) dissolved solids and (5) toxic substances. Three methods which are finding wide application in advanced waste treatment are ion-exchange, electrodialysis and reverse osmosis.

Ion exchange

This process reduces hardness and It has also been used selectively to remove specific impurities and to recover valuable trace metals like chromium, nickel, copper, lead and cadmium from industrial waste discharges. As there are cations and anions in the wastewater, we must use two different types of resins: a cation exchanger and an anion exchanger. The cation resin is used in the hydrogen form (H^+) and the anion resin in the hydroxyl form (OH^-), so that the cation resin must be regenerated with an acid and the anion resin with an alkali.

In the water softening process, the hardness producing elements such as calcium and magnesium are replaced by sodium ions. A cation exchange resin in sodium form is normally used. All anions are removed with the strong base resin. This combined arrangement produces pure water.

Riverse Osmosis (R.O.)

In the reverse osmosis process, demineralisation water is produced by forcing water through semipermeable membranes at high pressure. Vessel is divided by a semipermeable membrane (one that is permeable to water but not the dissolved material), and one compartment is filled with water and other with concentrated salt solution, water diffused through the membrane towards the concentrated solution and reversely by applying sufficient pressure to the concentrated solution to overcome the osmotic pressure force the net flow of water through the membrane becomes towards the dilute phase. Thus solute concentration retained on one side of membrane and pure water is separate out.

Electrodialysis

Electrodialysis uses ion-selective membranes and an electrical potential difference to separate anions and cations in solution. Inside an electrodialysis unit, the solutions are separated by alternately arranged anion exchange membranes, permeable only for anions and cation exchange membranes (permeable only for cations) between the two electrodes. When the voltage is applied across the cell containing mineralised water, the anions migrate to the positive electrode and the cations

migrate to the negative electrode.This causes solution in alternate compartments to become more concentrated while that in the remaining becomes more dilute that is demineralized water.

Legislation on water pollution:

Various laws and policies are being framed to control the pollution of water through numerous ways are as follows:-

1. Water prevention and control of pollution act, 1974

The prime objective of this act is to provide for the prevention of water pollution and cater to the maintainance of water bodies and carry out activities to promote restoration of water. Water contamination is monitored and prevention can be done in this direction to control quality of water.

To promote the proper implementation of the act, **Section 24** of the act imposes a duty upon a person to refrain from allowing any poisonous matter, as standards determind by central pollution control board, into any stream of water on the land. And any person, who violates with provision of the Section shall be made liable to be punished with imprisonment of one year and six months which may be extended to six years.

2. Water prevention and control of pollution cess act, 1997

Industrial waste is one of the main cause of water pollution. Waste water from industries pollute the river to a significant extent. This law levies a cess or tax on water consumed by persons carrying on certain industries and local authorities. A 25 percent rebate is given to any nperson or local authority that installs a sewage treatment plant or trade effluent treatment plant. Indusries like paper and pulp, fertilizer, power generation, cement etc. are come in this category. If industry does not pay cess, the owner will be punished with imprisonment of three months or with a fine of 500 Rupees or with both.

3. Environment protection act, 1986

This act deals with the prevention and control of environmental pollution, including water pollution, by specifying the restrictions allowed to discharge or emit any environmental pollutant in excess of standard. The act prohibits a person carrying on any industry, operation or process from discharging or emitting water pollutants in excess of prescribed standards.

Penalities for this act is punishable by imprisonment of seven years or a fine of one lakh or both.

Though many acts have been passed by the parliament to control the pollution of water still, there is an equal need for preventing oue streams, lakes, rivers, reservoirs from being polluted as right to clean water is our fundamental right to human's right to life.

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