International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Pollution Study of River Yamuna: The Delhi Story

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Abstract: ***Water pollution may be defined as the presence of one or more contaminants or combinations thereof in such quantities and of such durations in the water tend to be injurious to human, animal or plant life,(aquatic life) or property, or which unreasonably interferes with the comfortable enjoyment of life or property. In easier words, it is the contamination of water bodies like lakes, rivers, ponds, seas, oceans and even groundwater. This is due to discharge of environmental pollutants or effluents into water bodies without treatment. Water pollution affects the entire biosphere, including not only the individual species but also their natural biological communities. It results in the death of much of the aquatic life residing inside the contaminated water body. It also leads to various diseases like cholera, dysentery, diarrhea, malaria, dengue, chickingunia, etc. and even fatal in some cases if that water is consumed without treatment.***

Keywords: Water pollution, Delhi Segment, Yamuna, Treatment, Aquatic life, Tajewala Barrage, Confluence, Tributary, BOD, COD, DO

1. Introduction

River Yamuna or Jamuna is the longest and second largest tributary of river Ganga in northern India. It originates from Yamunotri glacier at a height of 6,387 metres (20,955 feet) on the south western slopes of Banderpooch peaks in the uppermost region of the lower Himalayas in the state of Uttarakhand. Having a total length of 1,376 kilometres (855 miles) and drainage area/system of 3,66,223 square kilometers (1,41,399 square miles), it is the longest river of India that doesn't meets the sea. It merges with the River Ganga at the TriveniSangam in Allahabad (Uttar Pradesh) , making it a huge confluence.

The river Yamuna crosses the following states-Uttarakhand, Himachal Pradesh, Haryana, NCT of Delhi, Uttar Pradesh with its banks situated in cities like Yamunotri, Paonta Sahib, Yamunanagar, New Delhi, Mathura, Agra, Auraiya, Ettawah and Allahabd. The river affects the lives of around 5.7 crores(57 million) Indians on a daily basis as it provides its water not only for drinking but for other consumption needs(including washing, irrigation, livestock,etc.), energy needs(providing surface water for thermal power plants, water for industrial processes & also money needs(tourism activities).

The annual flow rate of the river is 10,000 m^3 out of which 4,500 m^3 is daily consumed. The river suffices the demanding needs of water for not only the states it passes through but also for the states of Rajasthan and Madhya Pradesh. With the continuous rise in water pollution and increasing demands, will this river will be able to survive in the next 2-3 decades. This research paper explores the reasons for this pollution and tries to find technical and basic methods of treatment to bring it back from being a sewer. The main pollution segment i.e., Delhi segment is the thing majorly focused on.

2. Segments

Yamuna is divided into five segments depending on several hydrological and ecological parameters. The Himalayan Segment, the Upper Segment, the Delhi Segment, the Eutrophicated Segmentand the Diluted Segment are the respective five segments

A. The Himalayan Segment

The Himalayan Segment, covering 172 kilometres(107 miles), lies between the YamunotriGlacier (Uttarakhand) and Tajewala/Hathnikund Barrage (Haryana). The water quality is best in this region with optimum levels of BOD (0-3 mg/L), COD, TDS and DO (6-10 mg/L)& more or less no pollutants. This segment is highly enriched with its scenic beauty, exotic flora and fauna species. Four of its tributaries, Rishi Ganga Kunta, Hanuman Ganga, Tons (largest) and Giri have already join the main river in this region.

B. The Upper Segment

From the upper segment, at Tajewala Barrage, the downfall of the river starts. The upper segment covers a region of 224 kilometers (139.2 miles) between the Tajewala Barrage and Wazirabad Barrage(Delhi). At Tajewala barrage, the river gets diverted into 2 halves- The Eastern Yamuna Canal(EYC) and the Western Yamuna Canal(WYC). Generally no river water is allowed to pass between this downstream region of the barrage in order to fulfill the water demands of the Yamunanagar district and its surrounding districts (mainly during summer). Whatever the water that flows between Tajewala Barrage and Wazirabad barrage comprise of industrial, domestic and agricultural effluents (not or partially treated). The BOD (1-3 mg/L) , COD and DO(10-7 mg/L) fall under their respective permissible limits.

C. The Delhi Segment

After crossing the Wazirabad Barrage, finally the Yamuna River enters Delhi. It travels for 22 kilometres(13.7 miles) through the northwest, north, northeast, east and south Delhi regions. It finally leaves Delhi at the Okhla Barrage. 70 percent of Delhi's water needs are sufficed because of Yamuna (only after treatment) which is claimed as polluted by several agencies as the BOD(3-25 mg/L), COD and DO(7-1 mg/L) values of the riverwater are seriously bad. This is as a result of the discharge of seventeen sewage drains into the river, The NAJAFGARH DRAIN being the biggest one. This segment is declared as the most polluted

segment and due to this region the United Nations has declared the river "dead"

D. The Eutrophicated Segment

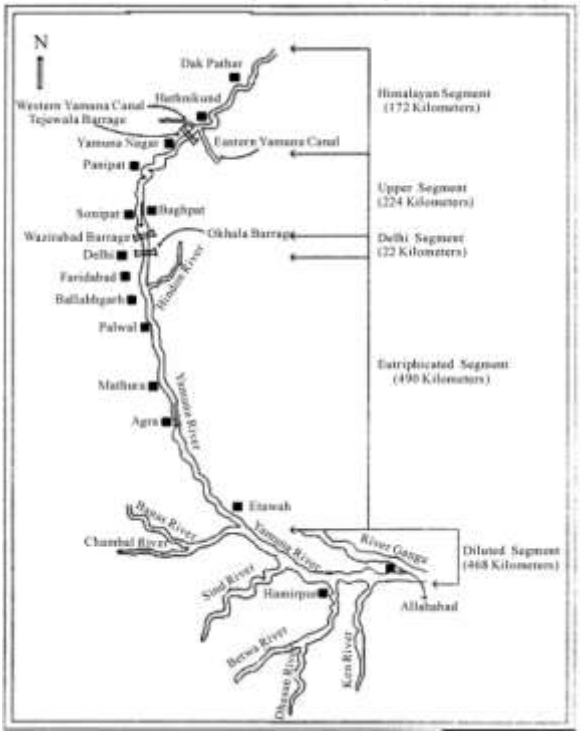
This segment lies between the Okhla Barrage and the Chambal Confluence covering a spectacular are of 490 kilometres(304.5 miles), the largest of all. Soon after leaving Delhi, Yamuna meets its tributary Hindon (a whole rain fed river, originating in the ShivalikHimalaya of length 400 kilometres) at Faridabad-Ballabhgarh border. The river then is sidetracked to the Agra Canalfor irrigation purposes. The quality of water in this segment continues to remain bad(as flow is decreased due to Mathura Gokul Barrage) but less when compared to Delhi segment due to treatment plants set up in this segment.

BOD: 18-6 mg/L , DO: 1-12 mg/L

E. The Diluted Segment

Yamuna River after receiving water through other important tributaries(Chambal, Banas, Sind, Betwa, Dhasan& Ken) joins the river Ganga and the underground Saraswati at Prayag (Allahabad) after traversing about 950 kilometres. This segments' total length is 468 kilometers(291 miles). The pollution level is under permissible limits as shown below

BOD: 13-1 mg/L, DO: 11-7 mg/L



3. The Delhi Yamuna Water Statement

The Delhi Segment is the poorest segment of all in the entire journey of Yamuna which contributes in making the river "the second most polluted river of India". This can be seen from the following table prepared by the Yamuna Action Plan:

Sewage Generated	*Total Sewage(L)*	*Sewage Treated(L)*
Daily	2871 million	1478
TDS	Quantity (mg/L)	Permissible Limit(mg/L)
	1000-10,000	100
BOD	Quantity (mg/L)	Permissible LIMIT(mg/L)
	15-30	3
COD	Quantity (mg/L)	Permissible Limit(mg/L)
	3-155	1-50
Coliform Level	Quantity (mg/L)	Permissible Limit(mg/L)
	11.8 Crore per 100 ml of water	5000 per 100 ml of water
DO	Quantity (mg/L)	Permissible Limit(mg/L)
	0	4
Required Drinking Water	Total Required (curses)	Available Quantity (curses)
	1480	1221
Forest Cover	Existing (%)	Required (%)
	24.2	33

The technical terms as mentioned in the table are explained in detail as:

a) Total Dissolved Salts

Total Dissolved Solids (TDS) are the total amount of mobile charged ions, including minerals, salts or metals dissolved in a given volume of water, expressed in units of mg per unit volume of water (mg/L), also referred to as parts per million (ppm). TDS is a measure of the combined content of all inorganicand organicsubstances contained in a liquid in molecular, ionized or micro-granular (colloidal sol) suspended form.

Principal sources for TDS in receiving waters are agricultural and residential runoff, leaching of soil contamination and point source water pollution discharge from industrial or sewage treatment plants.

The most familiar chemical constituents are calcium, phosphates, nitrates, sodium, potassium and chloride.

The chemicals may be cations, anions, molecules or agglomerations on the order of one thousand or fewer molecules so long as a soluble micro-granuleis formed.

b) Biological Oxygen Demand

Biological oxygen demand(BOD) is the amount of dissolved oxygen needed by aerobic biological organisms in a waterbody to breakdown organic material present in a given water sample at certain temperature over a specific time period. It is expressed in milligrams of oxygen consumed per litre of sample for the biologically oxidizable impurities during 5 days of incubation at 20° C and is often used as a robust surrogate to determine the degree of biodegradable organic pollution in water.

c) Chemical Oxygen Demand

Chemical oxygen demand (COD) testis commonly used to inhonestly measure the amount of organic compounds in water. Itis expressed in mg/L. The basis for the COD test is that nearly all organic compounds can be completely oxidized to carbondioxide with a strong oxidizing agent under acidic conditions. The amount of O_2 requisite oxidizing an organic compound toCO_2,NH_3&H_2O.

The COD is determined by refluxing the sample in the attendance of excess $K_2Cr_2O_7$, (as an oxidizing agent). H_2SO_4 is used to acidify the solution, and Ag_2SO_4 is added as a catalyst to speed the oxidation of low-molecular-weight fatty acids.

Mercuricsul fate, (HgSO4), is added to complex any chloride that is present, thus prevent the precipitation of the Ag^+ catalyst as AgCl. After refluxing for 30min, the solution is cooled to room temperature, and the excess $Cr_2O_7^{2-}$ is determined by aback titration, by means of ferrous ammonium sulphate (titrant) & ferroin (indicator).

Since it is difficult to completely remove all traces of organic matter from the reagents, a blank titration must be performed. The difference in the amount of FAS needed to titrate the blank and the sample is proportional to COD

COD of water (mg/L) = $((A - B) * M * 8 * 1000)$/Volume of Sample

Where:
A = FAS used for Blank (mL)
B = FAS used for sample (mL) (content of unreacted dichromate)
M = Molarity of FAS(M)

d) Coliform Level
It is used to determine the level of coliform bacteria present in the water bodywhich indicatesof fecal contamination, which isn't directly dangerous but displays the presence of pathogens. A fecal coliform is a facultative anaerobic, rod-shaped, gram-negative, non-sporulating bacterium. Coliform bacteria generally initiate in the intestines of warm-blooded animals. Fecal coliforms growin the presence of bile salts or analogous surface agents, are oxidize negative, and produce acid and gas from lactosewithin 48 hours at 44 ± 0.5°C.
It gravely pollutes the quality of the surface water (here river water) as there is anelevated risk of injurious diseases like dysentery, cholera, typhoid, ear infections, hepatitis A and waterborne gastroenteritis. Tests for the bacteria are cheap, reliable and rapid (1-day incubation) for people. In addition it reduces DO, increases BOD, cost of treatment shoots up & affects the aquatic life

e) Dissolved Oxygen
Number of molecules of O_2 dissolved in one Liter of water – Expressed as mg/L (ppm).It is one of the best indicators to understand the health of the water body and life sustaining ability. Most life supporting water systems –4-6 mg/L of DO. Factors affecting DO levels are:
1) Water temperature
2) Organic waste
3) Aquatic plant populations
4) Water flow
5) Altitude (atm. Pressure)
6) Human activities

4. The Pollutants

The pollution is on a high scale and increasing day by day as per the table above. Some of the common pollutants in the Delhi segment are:

a) Industrial Effluent
The river is called "mailee" (dirty in hindi) as the colour of the river is black. The river is stagnant for over 9 months. It is more of an industrial drain as most of the effluents untreated are dumped in the river by the industrial units..

Central Pollution Control Board (CPCB) had estimated that there were approximately 359 industrial units, which directly or indirectly discharge their effluents in Yamuna. A report of CPCB indicates that there were about 42 industrial units in Delhi directly polluting the Yamuna.

b) Domestic Waste Water
According to a CPCB survey, Delhi contributes 23 percent of the total wastewater generated by Class I cities (cities with more than 100,000 people). More shockingly, this is 47 per cent of the waste generated by 101 Class I cities and 122 Class II cities (Population: 50,000-99,999) in the Ganga basin.

The untreated domestic wastewater is dumped in the Yamuna, which has ammonia in it, increases its concentration. The water becomes untreatable when the ammonia concentration reaches to 0.4 mg/L or more. In Delhi often during summer(March to June), the ammonia content in Yamuna River goes above the permissible limit

c) Pollution From Agriculture
A lot of agricultural activities are done along the banks of the river in Delhi. Crops that are grown along the banks of the river are radish, cauliflower, cabbage, spinach, tomato, etc. Agriculture, directly or indirectly, pollutes the river through ground and surface water runoff of agricultural land through monsoon & non-monsoon rains & seepage of irrigation water,which consists of artificial fertilizer residues, insecticides, herbicides, pesticides and farmyard waste(livestock excreta)

d) Solid Waste
Dumping of solid waste and garbage is one of the major problems in Yamuna River. As per the above table, TDS in Yamuna is 1000-10,000 mg/L while the permissible limit is 100 mg/L. The main reason behind this is the high density of the population living in the city and the dumping of untreated water and solid waste into the river. Solid waste are generally composed of human fecal matter, cow dung, generated from various authorized and unauthorized dairy colonies located in Delhi NCR are being discharged untreated into river Yamuna and are considered as one of the major non-point source of pollution. . In other words, every flush a Delhite does directly gets discharged in the Yamuna without any treatment.

e) Other Sources
There are many other reasons of pollution of Yamuna river water. In India, rivers are believed to be Goddesses but the Indian folk only pollute their goddesssuch as on holy and religious occasions every year,(including Ganpati Visarjan, Chhatth Puja, Diwali, Kojaagar,etc.) thousands of peoples take a dip in the Yamuna and leave behind worship materials, polythene bags, clay idols, human excreta, account books and floral offerings in the river water, which increases the suspended materials in the water. The

superstitious mindset of the peoples has contributed and still contributing and escalating the Yamuna River Pollution.

Due to non-availability of proper sanitation facilities to all, some people uses river catchment areas for defecation, which causes pathogenic and organic contamination in the river. This increase the coliform level in the river and lead to not only pollution but increase in water-borne diseases.

Peoples have the habit of dumping unburnt bodies of human beings and animals into the river. According to superstition (mostly Hindu religion and other religions), bodies of those who die from certain diseases (asthma, tuberculosis, leprosy, snake bite, poisoning etc.) and those of newborn babies, unmarried persons and holy men are consigned to the river. But poor people were also dumping bodies into the rivers to save on costly wood cremation.

5. Strategies and Policies to Reduce Pollution

a) Proper Management and Treatment Procedures
Delhi has 17 drains discharging all the sewage directly into the river. Delhi has 6 Water treatment plants around its territory with different capacities as:

Water Treatment Plant	Capacity(MGD)
Chandrawal(Northeast Delhi)	103
Wazirabad(North Delhi)	132
Haiderpur I & II(Northwest & South Delhi)	225
Nangloi I & II(South & West Delhi)	40
Bhagirathi(East Delhi)	105
Sonia Vihar(East Delhi)	140

As per the report of Delhi Jal Board(DJB) in 2010, the treatment plants aren't fully used up to their capacities. Also, some machines used are very old. DJB should make plans making the system more efficient by using the plants to their optimum capacity, build new plants, develop or import new treatment technology. Along with that, smaller units can be set up along the 17 drains to reduce the discharge near the spot only specially the Najafgarh Drain, which passes from North-west to North delhi.

b) Checking on Agricultural and Industrial Waste
Different bodies like the Ministry of Water and Sanitation, Government of Delhi should adopt some measures to check on the increasing pollution by industries and agriculture fields. Proper disposal techniques should be thought of and implemented

c) Laws and Legislation
As per the new law policy of the Government of Delhi, headed under Chief Minister Mr. ArvindhKejriwal, barriers and embankments have been placed or imposed on bridges and banks along Yamuna to reduce the dumping of waste directly into the river. Special fines and penalties have been decided and implemented for such activities. Along with that on auspicious occasions like Ganesh Visarjan, Chatth Puja, Diwali, etc special provisions are made to prevent the river from pollution as now only biodegradable effigies can be dumped in the river. Policemen and guards are kept on duty to check this and other unwanted activites.

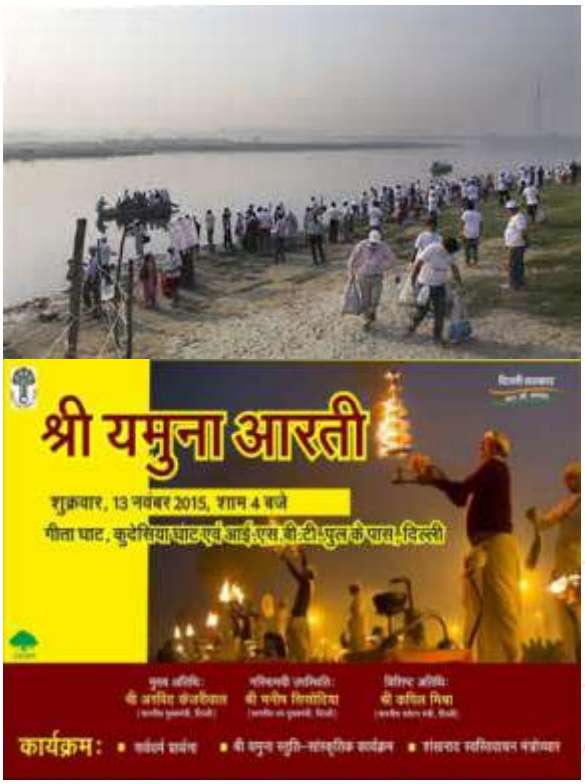
Along with this, the Central Government has set a special drive to clean Yamuna and other rivers. This is regarding the waterway policy introduced by Mr. Nitin Gadkari, Minister of roads and transportation, in the year 2016 with the first one being between Delhi and Agra.

d) Afforestation
As per the Delhi Master Plan 2021, to develop a world-class city, by Delhi Development Authority, the cleanliness of Yamuna is important. Funds are raised for new projects to be undertaken for the protection of the rivers such as afforestation, tourism and recreational activities.

e) Awareness Through Mass Media
Along with that a separate Mission 'Nirmal Yamuna' (NYM)has been initiated under which plans to make Yamuna clean and healthy by 2019. Under this, a program me named "YAMUNA AARTI" is organized every evening at QudsiaGhat to aware people about Yamuna's importance and lost treasures and making them realized about the river. No diyas, garlands are allowed to be dumped in the river at the time of AARTI which is not the case in GANGA AARTI in Varanasi, Haridwar and Rishikesh. This is done to reduce the floating waste in the river.

The government has also taken help from different NGOs for spreading awareness among people and raising funds. Fund are also provided under the Swatchch Bharat Mission(SWA, a Central Government initiative for a clean and healthy India)

Special toilets are decided to be built under SWA and NYM so as to prevent defection in the river.



6. Conclusion

The pollution study of Yamuna shows us the truth about how it has been neglected over the years. Delhi, the capital of the country, boasts to be a developed or a high-tech city but we have seen the horrible conditions of Yamuna there by the water analysis. The various reasons have been discussed above and the various measures and policies have also been mentioned. But nothing is going to change if we don't change. The blame game can no longer be played & individual steps need to be taken for the good future of Yamuna. If Yamuna has a good future, then our future generations will have a good& prosperous one or Yamuna will become a page in a history book forever.

References

[1] YAMUNA RIVER SYSTEM,http://india-wris.nrsc.gov.in/wrpinfo/index.php?title=Yamuna_River_System
[2] YAMUNARIVER,https://www.mapsofindia.com/maps/rivers/yamuna.html
[3] A RIVER ABOUT TO DIE by Anil Kumar Misra,http://file.scirp.org/Html/12-9401064_1806.htm
[4] TREATMENT PLANTS OF DELHI, Govt. of NCT Delhi,http://www.delhi.gov.in/wps/wcm/connect/056b83804a10d627b181fbe4899821f2/WTP+in+Delhi.pdf?MOD=AJPERES&lmod=1170192194&CACHEID=056b83804a10d627b181fbe4899821f2
[5] GOVT'S YAMUNA AARTI RAISES A STINK,http://timesofindia.indiatimes.com/city/delhi/Govts-Yamuna-aarti-raises-a-stink/articleshow/49249727.cms
[6] DELHI WATER SUPPLY, Govt. Of NCT Delhi,http://www.delhi.gov.in/wps/wcm/connect/9efb73804c2c48a08208869991226613/23+-+36+Water+Supply.pdf?MOD=AJPERES&lmod=-336094425&CACHEID=9efb73804c2c48a08208869991226613
[7] Wikipedia Engineering Chemistry, by Jain & Jain