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IMPACT OF POLLUTION ON YAMUNA RIVER: A REVIEW

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ABSTRACT

River Yamuna is one of the most polluted rivers of the India. It originates from Yamunotri glaciers in the lower Himalayas at an elevation of approximately 6387 meters. The barrages formed on the river are playing a major role in escalating the river pollution. River can be divided into five segments on the bases of hydrological and ecological conditions. Water quality of only one segment (Himalayan segment) meets the river water quality standards. Normally no water is allowed to flow downstream of the Himalayan segment (Tajewala barrage) especially in the summer and winter seasons to fulfill the demand of water of the surrounding area. Whatever water flows in the downstream of the Tajewala barrage is the untreated or partially treated domestic and Industrial wastewater contributed through various drains. The discharge of untreated domestic and industrial effluents have severely affected the quality of Yamuna River and now it falls under the category E, which makes it fit only for recreation and industrial cooling, completely ruling out the possibility for underwater life and domestic supply. Almost every year mass death of fishes is reported. Pollution levels in the Yamuna River have risen. The Yamuna has been reduced to a small stream, draining industrial effluents, sewage, dirt and other toxic substances. There is an urgent need to take stringent measures to alleviate these pollution loads and save an ailing river.

KEYWORDS: Yamuna River, Himalayan Segment, Delhi Segment, Organic Matter, River Water Quality, India.

INTRODUCTION

River Yamuna is the largest tributary of the Ganga River in North India. Its total length is around 1370 kilometers. Yamuna originates from the Yamunotri Glacier of Uttar Kashi in

Uttar Pradesh. River Tons and Giri are the important tributaries of Yamuna and principle source of water in mountainous ranges. Yamuna flows through the states of Delhi, Haryana and Uttar Pradesh, before merging with the Ganges at Allahabad. World famous cities like Delhi, Mathura and Agra lie on its banks. On the basis of hydrological and ecological conditions Yamuna has been classified into five segments that are Himalayan Segment, Upper Segment, Delhi Segment, Eutriphicated Segment and Diluted Segment.[1] Table 1 and Figure 1 show the area covered under these segments. After origin Yamuna river flows through several valleys for about 200 km in lower Himalayas and emerges into Indo-Gangetic Plains. In the Himalayan Segment (from Yamunotri Glacier to Tajewala Barrage) the river water quality is good and it meets all the standards also. Within this segment in Hathnikund/Tajewala in Yamuna Nagar district of Haryana state, river water is diverted into Eastern Yamuna Canal (EYC) and Western Yamuna Canal (WYC). Generally no water is allowed to flow in the down-stream of the Tajewala Barrage especially during summers and winters to fulfill the water demand of Delhi.

Yamuna River passing through 22 km in Delhi was once described as the lifeline of the city, but today it has become one of the dirtiest rivers in the country. According to the Central Pollution Control Board (CPCB) the water quality of Yamuna River falls under the category "E" which makes it fit only for recreation and industrial cooling, completely ruling out the possibility for under- water life.[2] The pollution of the Yamuna River from domestic discharges from Delhi, Ghaziabad, Noida, Faridabad, Mathura and Agra has rendered the river unfit for any use. Yamuna's water quality in the Himalayan segment and in the segment after confluence with the Chambal river is relatively good.[3-5] In Delhi around 3296 MLD (million liters per day) of sewage by virtue of drains out falling in Yamuna and approximately 3.5 lakh people live in the 62000 Jhuggis that have come up on the Yamuna river bed and its embankment.[6]

The Yamuna has five segments

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

River Segments	Segment Are	Approx. Segment Length
Himalayan Segment	From origin to Tajewala Barrage	172 km
Upper Segment	Tajewala Barrage to Wazirabad 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

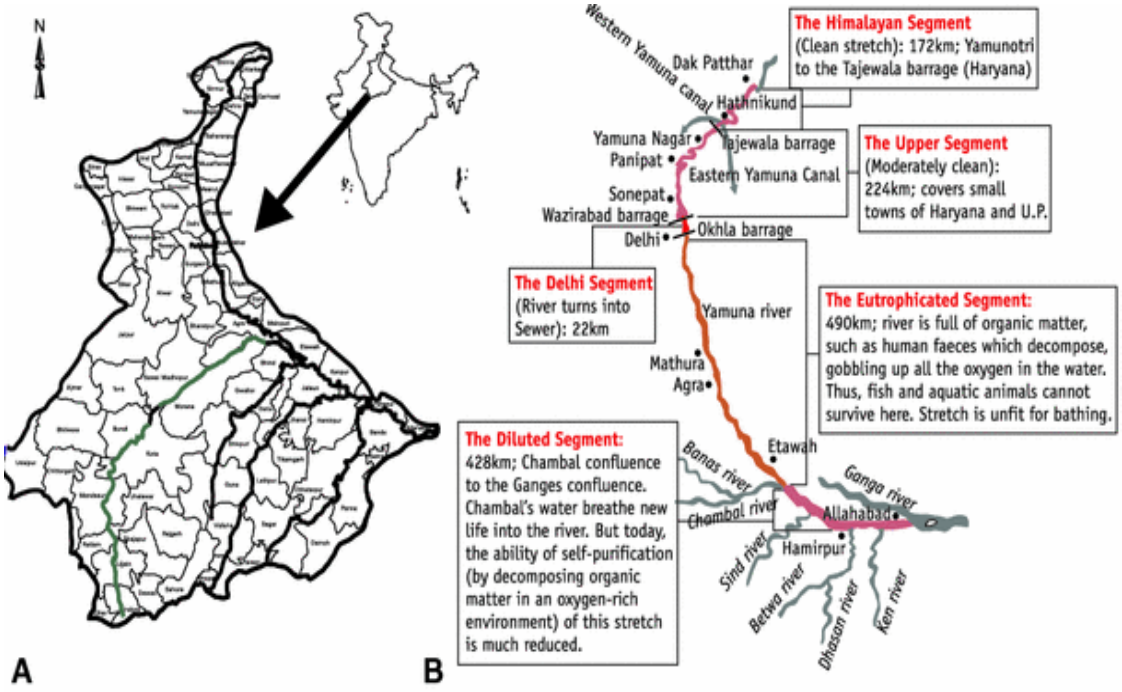

Figure 1: Shows the different segments of River Yamuna.

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 in 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 is called abstractive uses or uses involving collection and transportation. The other is just opposite of the first, in which withdrawal and transportation of water are not required but the water is utilized. It is known as non-abstractive or in-situ water uses.

Abstractive Uses

The river water is abstracted at different locations for varied uses. At two places i.e. Hathnikund /Tajewala & Okhla, the water abstraction is significant. The annual abstraction at various locations is presented and percent use of abstracted water for whereas; the sharing of Yamuna river water by various states is depicted.

The various abstractive uses of river water are as below

Domestic Water Supplies

The large urban centers 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 like Delhi, Mathura, Agra, and Allahabad use the Yamuna water significantly for domestic water supplies. The water abstracted for domestic water supply at various locations is 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 plants at various locations to withdraw more and more water from the river drinking purposes.

Table 2: Water Abstraction from Yamuna River.

S. No.	Location	River Water Abstraction Approx. MLD	Abstraction Use
1	Hathnikund	20000	Irrigation, Drinking water supply and others
2	Wazirabad	1100	Drinking water supply
3	Wazirabad to Okhla stretch	5000	Irrigation and others
4	Okhla to Etawah Stretch	400	Irrigation, Drinking water supply and others
5	Etawah to Allahabad Stretch	475	Irrigation, Drinking

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.

Western Yamuna Canal (WJC)

This canal originates from the right bank of Yamuna River at Hathnikund / Tajewala bar//894rage. The capacity of the main canal is 163m3/sec and irrigates an area of about 486,000 hectares annually in Haryana State. This irrigation system is more than 100 years.

Eastern Yamuna Canal (EJC)

This canal takes off from the left bank of the River Yamuna at Hathnikund / Tajewala barrage. The canal is about 206 km long and has a capacity of 85m3/sec. It irrigates an area of about 191,000 hectares annually in Uttar Pradesh.

Agra Canal

Agra canal originates from the right bank of Yamuna River at Okhla barrage. The canal is 163 km long and carries a discharge of about 63.5m3/sec. It irrigates about 138,000 hectares of land mainly in two districts of Mathura and Agra in Uttar Pradesh.

Gurgaon Canal

This canal is an interstate project between Rajasthan & Haryana and takes off from Agra canal at a distance of around 8 km from its off-take at Okhla barrage. The water flow capacity of this canal is 14.15m3/sec and land irrigated by this canal is about 40,000 hectares.

In-Stream Uses

Hydropower

The total potential for hydropower development in the entire Yamuna basin is about 1300 MW. The present utilization is only one- third of total potential. There are few new schemes, which are at various stages of construction

Fisheries

Fish is not popular traditional food for the people residing in Yamuna basin area except in some tribes and castes and collectively called fishing community. This is the reason that the pisciculture is neither practiced on a large scale nor undertaken in an organized manner in the area. However, the entire river stretch and tributaries are being utilized for fishing in an unorganized manner.

There is a large scope of farming for fish and other aquatic animals in stretches of River Yamuna.

Growing Aquatic Plants

The most prevalent aquatic plants in River Yamuna is the water hyacinth. In West Bengal, this plant is used as cattle fodder and composted an aerobically on large scale. In Kerala too there are various schemes to generate biogas from water hyacinth. Unfortunately, these practices are yet to be undertaken in Yamuna basin.

Navigation

The most of the river channel of river Yamuna and its tributaries are not suitable for Navigation. Low flow of river further restricts this activity. A few locations, the boats are playing on the need-based basis, mainly for crossing the river. Earlier, the timber logs and

sleepers were floated down from the Upper Himalayan areas but now this practices is also replaced by road transportation. There is a scope to use the Yamuna River stretch between Agra and Allahabad for navigation.

River Bathing & Washing

River bathing and washing are one of the most important uses 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, Godavari etc. is considered more superior than bathing in the 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. Some of the prominent bathing centers at River Yamuna are Yamunotri, Kalpi, Paonta Sahib, Delhi, Mathura-Vrindavan, Agra, Bateshwar, Etawah and Allahabad on Yamuna River, Kota on Chambal, Orchard on Betwa and Ujjain on Shipra River.

Recreational Uses

In Yamuna basin is the river is used very little for recreational value due to unsuitable conditions like a rocky riverbed, low water depth etc. water sports like boating have a vast potential in future especially at urban centers and at various barrage sites in the reservoir formed by the barrages.

Cattle bathing and Washing

The cattle 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 churned up because of cattle wading.

Pollution Sources of River Yamuna

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. Yamuna water is being transported from Western Yamuna Canal to

Gurgaon canal via Najafgarh drain, Yamuna River, and Agra canal. Similarly, River Ganga water from upper Ganga canal is transported to Agra canal for irrigation in the district of Mathura and Agra via Hindon River, Hindon Cut Canal, and Yamuna River. The dilution that the rivers received through this means of water transportation affects significantly the water quality of drain, canal, and river.

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 into two groups.

Point Source of Pollution

When the source of pollution is single, well-specified and generate a significant amount of pollutants such source is known as a 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

Domestic Pollution

The domestic pollution is the major source of pollution in Yamuna River. About 75% 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 centers dumping domestic waste into Yamuna River are Panipat, Sonepat, Delhi, Ghaziabad, Mathura-Vrindavan, Agra, Etawah and Allahabad. The intensity of the 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 microorganisms 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 centers. Due to not-availability of sewerage system in these colonies, the night soil is collected, transported and dumped either in drains, tributaries or directly into the river without any treatment. During last few years because of the proliferation of Jhuggi Jhonpri settlement, this activity increased significantly and now become a major non-point source of river water pollution.

Industrial Pollution

After independence, rapid industrialization occurred in the Yamuna river basin. There are large clusters of industries established at Kota, Gwalior, Indore, Nagda, Khetri, Yamuna Nagar, Panipat, Sonepat, Delhi, Baghpat, Ghaziabad, Gautam Budha Nagar, Faridabad, Mathura & other places. 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. In order to comply with the environmental laws, it is compulsory for these industries to treat the effluent to achieve prescribed standards before discharging effluent into the environment.

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
- Pollution due to in-stream uses of water
- Agricultural Pollution

There are three major sources that contribute agricultural pollution in the river

- Agricultural residues
- Fertilizer and Pesticides
- Animal husbandry
- Excess Salts from applied irrigation water

The various types of agricultural residues generated in the river basin are degraded naturally as it is a part of saprophytic food chain and thus not contributing much to the river pollution. In the Yamuna basin the application rate of fertilizer is still low, moreover, due to marginal irrigation in the basin, there is little chance of leftover nutrients from fertilizer application to

reach, drain or wash away except during monsoon. The nutrients and pesticides are generally adsorbed by the sediment particles and reach to the river along with runoff sediments, particularly during early floods. These chemicals geo accumulate in riverbeds, which is not stable due to sandy nature of river bottom. Hence, with the flushing of the riverbed by water current, these chemicals mixed slowly with the supernatant river water. The solid waste generated from animal husbandry is generally collected dry and rarely washed. A major part of this solid waste is used as organic manure. In rural areas, the animal husbandry solid waste particularly animal dung is formed into cakes and dried for burning as dung cakes. Because of this, there is no significant water pollution caused from animal husbandry. However, with the change in cooking style with more and more use of cooking gas, urbanization of rural areas, modernized cattle farming, illegal and unorganized dairy farming in urban centers etc. is increasing the organic pollution from these sources. The plants consume water only through transpiration and the salts present in the applied irrigation water accumulated in the soil and ultimately leached or washed off to adjoining water bodies. The buildup of salinity is frequently observed in parts of Haryana. In an almost entire stretch of Yamuna River that lies in the plain area, the riverbed is extensively used for farming during the lean period when the river stream shrinks to a minimum. The riverbed farming, which mainly includes vegetables, melons, cucumbers starts after monsoon season and continued until the end of summer season. During farming, there is frequent use of pesticide, washing of vegetables, disposal of farming residues etc., which provides a direct impact on river water quality applied irrigation water accumulated in the soil and ultimately leached or washed off to adjoining water bodies. The buildup of salinity is frequently observed in parts of Haryana. In an almost entire stretch of Yamuna River that lies in the plain area, the riverbed is extensively used for farming during the lean period when the river stream shrinks to a minimum. The riverbed farming, which mainly includes vegetables, melons, cucumbers starts after monsoon season and continued until the end of summer season. During farming, there is frequent use of pesticide, washing of vegetables, disposal of farming residues etc., which provides a direct impact on river water quality.

Dumping of Garbage and Dead bodies

A large portion of the solid waste generated by the unauthorized inhabitants all along the bank of Yamuna River or its tributaries finds its way into the river. The waste includes domestic waste, waste from dairies, unauthorized slaughtering, flowers and other material used during worships carcass of animals etc. The dumping of human and animal dead bodies

are also sometimes observed in the Yamuna river. Disposal of infants dead bodies in the river water is practiced in the entire Yamuna stretch. Floating of human dead bodies was partially eaten by animals and in the rotten state are generally observed in the lower part of the river. Such disposal of dead bodies increases the risk of pathogenic contamination besides another negative impact.

Immersion of Idols

Immersion of idols, especially during Durga Puja, Ganesh Puja takes place all along the bank of the river. Flowers, Straw, Bamboo, Clay / Plaster of Paris, harmful chemicals used for paints, plastic bags are finds its way into the river. As the Durga Puja festival is also getting popularity in Northern India the rate of idols immersion is also increasing every year.

Pollution Due to In-stream use of Water

The various sources of pollution caused by the stream use of water are

Bathing and clothes washing

Cattle wading

Open defecation

Because of spiritual faith, the bathing in River Yamuna is very common. Bathing, especially mass bathing, significantly contributes disease-causing pathogens in the river water and enhance the bacterial load. The religious activities e.g. offering flowers, milk, sweets etc. into the river water further increase organic loading in the river. Since the food items are not consumed by aquatic animals due to their limited availability. The other activities associated with bathing are clothes washing. This activity contributes inorganic, organic and biological contaminants in the river water beside detergents. Excessive presence of detergent caused significant foaming at the site of turbulence. Foaming not only hampers the oxygen diffusion rate in the river water, essential for self-purification but also affect various biological activities. The Yamuna basin is one of the densely populated river basins in the country. In the basin, due to the non-existence of sanitary facilities in rural areas and urban areas, especially in slum clusters, a large section of the population use either catchment area or directly to the river for open defecation. The activity contributes organic pollution and pathogens in the river water.

Water Quality Issues in Yamuna River

Most of the rivers including River Yamuna are spiritually regarded as a mother. People from all over the country visit various stretches of this river especially at Yamunotri, Paonta Sahib, Mathura-Vrindavan and Bateshwar to take a 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 hurt the sentiments of Indian masses besides having several adverse impacts on life process in the river.

The issues related to water quality of Yamuna River are described as follows

High Organic Contents River Yamuna receives the 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 the biotic community of the river but also affects its self-purification capacity. This problem is critical in the river stretch between Delhi and confluences of the river with Chambal. In Delhi stretch, the load of organic matter is so high that it consumes the entire dissolved oxygen available in river water.

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.

Excessive Presence of Pathogens

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

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.

Aesthetic Value

Yamuna river losing its aesthetic value, glory due to the severe odor 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.

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 term increases the turbidity. The turbidity of river water is also increased due to the direct influx of domestic and industrial wastewater. Increased turbidity has an impact on the productivity of water body besides affecting the biotic life of the aquatic system.

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 the 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 No. 2. 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 an increase in the concentration of pollutants in the river 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 the river.

Use of River Stream for Transportation of Water

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 the long & slow transportation system After installation of

STP along with 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 a 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 e.g. Mathura-Vrindavan and Agra. The discharges from these STP's located upstream from water abstraction point have an impact on the water quality making it unsuitable for various human activities occurring downstream of these STPs.

Role of Barrages

Presently there are six barrages in the Yamuna River and some other are in planning stage. The barrages have an impact on characteristics of Yamuna River

- Blocking the continuity of the river, which is a prominent characteristic of the lotic (flowing) environment.
- Less demand for irrigation water or rainfall in the catchment area leads to the intermittent release of water from the barrages and thus affecting the river water quality.
- Sludge containing inorganic, organic, toxic matters are generally get deposited at upstream of the barrage. This settled material flushes to downstream along with the sudden release of water from the barrages. Thus, pollutants mixed further with the river water at downstream, deteriorating its quality.
- The water generally releases from barrages during monsoon after a gap of 6-9 months. The water releases from the barrage after a considerable gap period, significant amount of deposited sludge in downstream reaches, which is dominantly organic in nature also flushes with it and flow in the river downstream.
- This sludge after mixing with the water at downstream consumes the available dissolved oxygen rapidly resulting in fish mortality and killing of other fauna of the river.
- Besides the negative impact of barrages on river characteristics, barrages also have one positive impact. Barrage forms some sort of reservoir towards upstream. This reservoir acts as oxidation pond to treat the river water.

Policies and Strategies to Improve Yamuna Water Quality

The Majority of rivers of India are facing acute water pollution problems and river Yamuna is one of them. Due to excessive industrialization and urbanization of river Yamuna especially in Delhi, Mathura and Agra have now become a drain. The water pollution of the river has gained large heights. Now it is become imperative to, yield a plan identifying viable remedial options and strategies for the Yamuna River clean up. Efforts will be made to resort to a bottom-up approach rather than a top-down one to help this highly polluted river, which is the major life-supporting artery of Delhi, Mathura, Agra and Etawah and many other cities in India. To apply the strategies effectively, we need to develop awareness among masses, education, and improved watershed management that will improve the water quality of this holy river.

Some of the important measures that can be

Proper Management and Treatment of Wastewater

Waste water discharges in rivers destroy marine lives; degrade the environment, and causes water shortage and waterborne diseases. Their proper management and treatment are necessary because it reduces or removes the organic matter, solids, nutrients, disease-causing organisms and other pollutants from the wastewater before it is discharged to river water. Delhi alone contributes around 3,296 MLD of sewage water in Yamuna River. Therefore it is imperative to take necessary action and promotes the following strategies.

Conserve Water and Use It Effectively

Now day's both urban and rural areas, are facing the problems of water shortage and the majority of the urban areas are dependent upon the river water for the domestic supplies. Due to severe pollution river water requires high-grade treatment prior to use for domestic purposes, which is expensive and not easily feasible. Therefore the conservation of water is necessary. Usually, the construction of houses, footpaths, and roads has left little-exposed earth for water infiltration and recharge of groundwater aquifers. In the rural and urban areas, the floodwater quickly flows to the Nallas (drain) and rivers, which then dry up soon after the rains stop. If this water can be held back, it can seep into the ground and recharge the groundwater bodies.

Promote Wastewater Treatment & Technologies

Works on the development of effective and easily feasible and economically feasible wastewater treatment techniques should be supported by the government. Encourage people

in a social gathering to reduce wastewater generation and use low cost and low maintenance wastewater treatment techniques at the common collection points.

Drainage Water Management and Treatment

The drainage water management relies on the natural rainfall. It can be done by forming water control structure in the main, sub main or lateral drain such as different kinds of check dams. These structures control the surface runoff and ensure the maximum infiltration of drainage water and recharge the water table. Apart from that within the drainage canal or drain route artificial filters based on grain size sedimentation can be formed they are very effective in water treatment.

Recycling and Reuse of Wastewater

Now day's wastewater can be recycled through effective technologies and it can be reused for different purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing, and recharge a ground water basin. Wastewater can be recycled and reused onsite; for example, an industrial can recycles water it used for cooling processes. Likewise, the municipal wastewater and sewage water can also be recycled and can be used for industrial purposes.

Financing Wastewater Management Schemes

There is a number of Governments, semi-government, NGO's, private companies and environmental agencies are available which are working in the field of wastewater management.

These organizations should be encouraged to work on the waste management techniques and can be financed through projects, schemes.

Improving the Sewerage System

The status of sewerage systems especially in the cities, towns, and blocks all along the Yamuna River course is an extremely bad, due to this large quantity of untreated or partially treated sewage water mixed with river water. Further many cities, small towns, and blocks do not have the sewer system facilities. The existing sewer system improvement and formation are needed to reduce the risk of seepage of sewerage water and material into the groundwater and river, especially during rainy seasons.

Upgrading of Sewage Treatment Plant

The old, inadequate sewer systems are one of the major causes of water pollution in the Yamuna. Now it's become imperative to upgrade all the existing sewerage treatment plants and increase their capacity. The areas without sewer system need immediate action as most of the wastewater and waste is directly dumped in river water or ground.

Proper Disposal of Sewage

Disposal of sewage effluents is big problems almost in every big city. It cannot be simply disposed of due to their microbiological and chemical characteristics. Only after full treatment, they can be discharged into the river, but alone in Delhi, approximately 1393 a million liters of untreated sewage is disposed of in the Yamuna. Even the partially treated sewage effluents are not fully suitable for the discharge in the river. More sewerage treatment plants should be formed immediately to prevent the water pollution in Yamuna River and discharge of untreated sewage should be banned.

Agricultural Practices Improvement

Farmers are using large quantities of chemical fertilizer, insecticides, pesticides, to increase short-term crop yields or keeping the soil productive, without knowing the exact quantities are required. It is estimated that about one-half of every metric ton of fertilizer or pesticides applied to fields never even makes it into plant tissue, but instead, ends up evaporating or being washed into local waterways. The excess amount of fertilizer use entered the soil, ground and surface water bodies and pollutes them and during the rainy season by runoff, it pollutes the lakes, ponds, and rivers and causes eutrophication, which decreases the dissolved oxygen level and threatens animal and plant health. To prevent such situation emphasis should be given on the use of bio-fertilizers having least chemical constituents and accelerate the efforts to prevent the soil erosion through vegetation cover especially along the either side areas of the river.

Environmental Management

River environmental management depends on interactions between river, environment and human infrastructure, including the interactions between ecology, hydrology, water quality, climate, flooding, public sanitary facilities, wastewater inputs and waste water treatment facilities. Thus a river directly as well as indirectly reflects the environmental management system facilities of any town, city, state, and country. To protect Yamuna River from the pollutants some of the important steps should be taken immediately such as.

Solid Waste Management

Almost all the cities situated on the either sides of Yamuna River have been experiencing very high population growth and urbanization. This has increased the urban environmental problems, such as solid waste management. Most of the cities do not have an adequate solid waste management system and it causes heavy pollution to Yamuna River. Further, the quantity of solid waste generated has increased significantly and its characteristics have changed as a result of the change in peoples' lifestyles due to swift urbanization. Every day the river is polluted by solid waste disposal, animal bathing, disposal of dead bodies, slums along the river and cattle wallowing. Solid waste disposal of normally solid or semi-solid materials, resulting from human and animal activities, that are useless, unwanted, or hazardous can be recycled and reused in daily lives. Once cleaned and separated, the recyclables solid wastes can be converted into products from total or partial recycled materials. Common household items, such as newspapers, paper towels, aluminum, plastic, and glass soft drink containers; steel cans; and plastic laundry detergent bottles can be formed from totally or partially recycled solid wastes. Further recycled materials can also be used in innovative applications such as recovered glass in roadway asphalt (glassphalt) or recovered plastic in carpeting, park benches, and pedestrian bridges The cities like Sonepat, Panipat, Delhi, Noida Mathura, Agra, and Etawah produce a large amount of solid waste and plays a major role in polluting the Yamuna. If more and more recycled plants are formed in these cities then problem-related with solid waste disposal can be effectively controlled.

Formation of Public Toilets

Approximately 30 to 40% of urban population in major cities like Delhi, Agra, Mathura, and Etawah stays in slums without sanitation facilities. People in these areas generally have the practice of open defecation and discharge of sewage in the Yamuna river catchment area due to this the water quality of the river is continuously deteriorating. Water contaminated with fecal matter causes diarrhea (with proper sanitation, the risk level can drop by 40 percent); malnutrition, anemia or retarded growth, blindness schistosomiasis, and cholera and are a very common disease of the slum areas in Delhi, Mathura, and Agra. The formation of public sanitation facilities especially in the slum areas situated near either side of the river is the best solution to prevent further deterioration.

Formation of Electric Crematorium and Create Awareness

Cremation in Yamuna River and on its banks is also one of the reasons of river water pollution. Every day approximately 100 to 150 cremations are performed, most on wood pyres that do not completely consume the body. Along with the remains of these traditional funerals, there are thousand more who cannot afford cremation and whose bodies are simply thrown into the Yamuna. Further, the carcasses of thousands of dead cattle, which are sacred to Hindus, go into the river each year. The absence of adequate cremation facilities is contributing to a large number of partially unburnt corpses floating down the Yamuna.

Formation of electric cremation is the only solution of these problems. Muslims and Christians according to their rituals buried the body in the graveyard, whereas, Hindus and Sikhs burn up the cadaver and in the case of children's dead body is surged into the river. Both central and state government should accelerate it affords to guide, aware and convince people to use electric cremation for the anti-me sanskara (last rites) instead of wood. It's not only environment-friendly but also least expensive.

Formation of Holy Bathing Ponds

In India people (Hindus) bathe in rivers due to religious convictions and beliefs and dump holy materials and related materials along with domestic solid waste in rivers. River Yamuna is among one of the holiest rivers in India and people frequently take a mass bath in the river. Water quality is severely affected by mass bathing. Deterioration of river water quality may injure the health of the people taking the dip and also the population downstream which use the river as a source of water for drinking and bathing purposes. This problem can be solved by the formation of holy bathing ponds, near the ghats filled with river water along with artificial ground water recharge techniques. This will not only prevent river pollution but also recharge the groundwater resources.

Afforestation

Afforestation plays an important role in reducing the soil erosion and agricultural runoff. Afforestation along the either sides of Yamuna river banks would help in controlling the agricultural runoff, which is composed of fertilizers and pesticides. Further afforestation along the Yamuna River can also reduce the rise in river water temperature by preventing the direct exposure of river water with sunlight. This will also oxygenate the river water.

Canal Formation

The majority of the rural and some urban areas do not have the sewer systems in Delhi, Agra, Mathura and Etawah districts. Therefore the sewerage wastes and other domestic wastes flow directly to the Yamuna River through the open drains. Such wastes not only pollute the river but also pollute the surface and groundwater resources. This should be a ban at any cost and a barrier between the river and cities/towns should be formed. Canals should be formed parallel to the river for carrying all the towns domestic and sewerage waste to 7 to 10 km downstream of the town or city and dumped into the river after treatment. This will not only prevent the Yamuna pollution but also help in solving the drinking water problems in Delhi, Mathura, and Agra.

Legislation and fines

Now it's become necessary to form strict rules and regulations and ensure their 100 percent implementation to control the escalating pollution in Yamuna River. Monitoring at the major pollution sites of the river should be started immediately. Dumping of domestic wastes and other polluting materials in the river should be banned and fine and imprisonment of 6 months to 1 year should be imposed based on the self-purifying abilities and waste assimilation capacities of a river, the effluent standards should be worked out separately for each of the various polluters.[7]

Awareness among the People

Prevention of Yamuna river pollution cannot be achieved without people's participation. Therefore it's important to create awareness among the people regarding the way river pollution is occurring and its related consequences. People should be taught various means to be adopted to reduce the increasing pollution levels in the river. In Delhi, the state government has formed 10 feet high wire barricades along all Yamuna bridge under the Yamuna Action Plan I with signboard messages to prevent people from tossing things into the Yamuna. Despite that almost everyday people throw flowers and religious materials in the river, which creates pollution. The help of different volunteer organizations and NGO's should be taken to launch campaign and create awareness. Print media and electronic media can play a major role in creating awareness and urging people not to throw garbage and other pollutants in rivers.

DISCUSSION AND CONCLUSIONS

Yamuna which acts as the life line for the majority of the cities like Yamuna Nagar (Haryana), Panipat, Sonepat, Delhi, Noida , Faridabad, Mathura and Agra plays a major role in polluting the river. Yamuna river flow is restricted through several barrages such as Tajewala Barrage.

Wazirabad Barrage, Okhla Barrage, Gokul barrage etc These barrages are directly or indirectly affecting the river water quality and aquatic ecosystem. Sludge's which contain inorganic, organic and other toxic matters usually get deposited at the upstream of the barrages and their sudden release in the downstream of the river water increases pollution level so high that led to the mass death of fishes especially Delhi and Eutriphicated segment frequently. Yamuna river enters Delhi near the Palla village 15 km upstream of Wazirabad barrage, which acts as a reservoir for Delhi. Delhi generates approximately 2871 MLD of sewage, against an installed sewage treatment capacity of 1,478 MLD. Thus, about 1,393 MLD of untreated and a significant amount of partially treated sewage enter the river every day.[8] The Delhi sewage system can be blamed for it and steps should be taken from not putting the industrial waste into the river as most of the industries are on the banks of Yamuna. In Delhi river water is black and it hardly flows. Now it's become imperative to maximize the use of the existing treatment facilities and ensure the reuse of treated effluents. All waste, legal and illegal, sewered and unsewered must be trapped and treated and not mixed with untreated sewage. Centralized sewage treatment plants cannot be considered as good because the cost of transporting waste to the treatment facility and transporting treated effluent back to the point of reuse makes them too expensive to run. Therefore, treatment facilities need to be constructed close to the source of sewage generation. Catchment area delineation is also an important component of water quality management. In order to reduce pollutant loadings at an outfall, it is necessary to examine and improve water use practices in the areas where pollutants originate. Further the raw sewage must be treated before it is discharged into the river stream. Large agricultural fields, of Uttaranchal, Haryana, Uttar Pradesh, and Madhya Pradesh significantly contribute to river pollution. If river catchment area is protected from the chemical contamination the river pollution related with irrigation can be minimized. This can only be done by switching to organic or biological farming methods and curtailing the use of pesticides and fertilizers. Several water treatment technologies prevailing in West are very expensive and country like India cannot afford it. Besides, that the conventional water treatment processes, based on chemical coagulation and

filtration or biological slow sand filtration, have little capacity to remove water-soluble pesticides. Therefore emphasis should be given to the easily feasible and economically feasible techniques capable of removing or minimizing the pesticides content from the water. The quality restoration of any river, especially of the Yamuna at different locations, is a very complex and interdisciplinary endeavor. Yamuna River pollution cannot be minimized merely by diverting the routes of different drains carrying wastewaters and/or establishing sewage treatment plants. The required strategy for pollution control should not only be a multi-line approach but also be fool proof. The various sources of pollution in the Yamuna river and possible strategies to restore this ailing river to its pristine status must be thoroughly examined and effective and enduring solutions established and implemented.

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