Identification of issues and priority actions for Restoration of freshwater ecosystem: River Ganga (Kanpur to Bihar)

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ABSTRACT

In order to reduce Pollution of river Ganga and its Ecosystem which has been disturbed by human interventions and anthropogenic activities, had led to the degradation of the water quality of freshwater ecosystem. GOI launched Ganga Action Plan in 1985 were at-tempts had been made to control, improve and maintain ecological integrity of the ecosystem by physical, chemical and biological methods. Rapid urbanization, industrialization besides agriculture using chemical fertilizers and pesticides, which is directly released in the basin, have degraded the water quality. The paper deals with the impact of technical interventions in the form of liquid and solid wastes, carried by the river are the issues and challenges for the ecosystem. Besides these, there are some suggestions and recommendations to minimize the ecological degradation of the river to restore its ecology. The measures include active as well as passive restoration techniques to bring back the sustainable ecosystem of River Ganga

KEYWORDS

Species-diversity | Various Pollutants | Threats | Disturbances in Ecology | Conservation tools

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Introduction

Ganga river basin-is the freshwater ecosystem and is the largest of these. It originates from the ice caves at Gaumukh (N30°55', E 79°7') and traverses a distance of ≈ 2510 km from its source to its mouth (Ganga Sagar), draining eleven states of India. The river Ganga is home to a vast variety

theology but are different in terms of issues that need to be addressed:

- A. Upper Ganga ≈ 294 km Gaumukh to Haridwar
- B. Middle Ganga ≈ 1082 km Haridwar to Varanasi (Kanpur to Bihar) stretch
- C. Lower Ganga ≈ 1134 km Varanasi to Ganga Sagar.

Fig-1: Represents critically polluted stretch, Source: Status paper on river Ganga

of living organisms from simple microscopic flora and fauna to a large assemblage of higher invertebrates and vertebrates. River quality is day by day decreased due to domestic and industrial effluents pollution threatens not only humans, but also more than 130 fish species, 83 amphibian species and the endangered Ganga river dolphin. Due to industrialization, the number of factories and population has increased rapidly. The riverine systems has be greatly infected with pollutants released from industrial, domestic, mining and agricultural effluents.

Common carp and Tilapia are are commercially exploited species in Ganga which are used to evaluate the health of aquatic ecosystems because pollutants are building up in the food chain and are responsible for adverse effects and death in the freshwater ecosystems. The entire stretch of river Ganga (main stream) can be viewed into three segments where each segment is further divided into 5 stretches. These three segments not only differ in their geomorphology, ecology and

Originally the ecological setup of river Ganga

Ganga is a prime example of lotic ecosystem. It is referred as running water ecosystem, which has current were in, water is in motion. Before 30 years, the values of dissolved oxygen (DO) - exhibited a more or less stable pattern in Ganga. The average values ranged between 6.8-7.2 mg/l. The values were generally above 4.0 mg/l. Higher values were recorded in winters at Haridwar, Allahabad, Varanasi and Patna. There were only minor fluctuations. Biochemical oxygen demand (BOD) - depicts the pollution status of a stream and is measured as oxygen equivalent of organic matter. The values exhibited higher pollution level higher which was recorded at Kanpur downstream 15.5 mg/l, 14.15 mg/l, 16.39 mg/l and Coliform- the variation in total coliforms was 48333, 916667 and 835333 mpn/100 ml. The stretch from Kanpur – Varanasi- Bihar remains critical and needs focused attention.

Further, Ganga passes along 29 class-I cities and about 48 towns. Most of the cities had no Sewage

Treatment Plants or even if the plants existed, they were not functional or needed augmentation. There were several polluted stretches along its course where Ganga was critically polluted at Middle Ganga stretch {Kanpur-Bihar} as shown in (Fig-1)

Among the pollutants, toxic metals are of serious concern because they accumulate through the food chain and create environmental problems. Higher concentrations of heavy metals such as Mercury, Cadmium, Nickel, Lead, Arsenic, Zinc, Copper, Chromium. From industries forms

Water Quality Data of Ganga River During 1986-2008

Sl No	Station/ Location	Distance in km	1986		1993		2002		2005		2008		Standard values	
			DO (mg/l)	BOD (mg/l)	DO (mg/l)	BOD (mg/l)	DO (mg/l)	BOD (mg/l)	DO (mg/l)	BOD (mg/l)	DO (mg/l)	BOD (mg/l)	DO (mg/l)	BOD (mg/l)
1	Rishikesh (0 km)	0	8.1	1.7	9.0	1.3	8.2	1.2	8.5	1.0	8.1	1.2	5.0	3.0
2	Haridwar D/s (30 km)	30	8.1	1.8	7.2	1.4	7.8	1.7	8.1	1.4	7.9	1.4	5.0	3.0
3	Gaithmukteshwar (175 km)	175	7.8	2.2	8.5	1.6	7.5	2.1	7.8	2.0	7.8	1.9	5.0	3.0
4	Kannauj U/S (430 km)	430	7.2	5.5	7.2	2.3	7.7	1.2	8.5	1.7	6.5	2.9	5.0	3.0
5	Kannauj D/S (433 km)	433	6.5	5.1	8.4	2.5	6.5	4.2	7.6	4.5	6.2	3.1	5.0	3.0
6	Kanpur U/S (530 km)	530	7.2	7.2	7.5	1.9	6.3	3.8	6.2	4.3	4.9	3.4	5.0	3.0
7	Kanpur D/S (548 km)	548	6.7	8.6	5.2	24.5	6.7	4.9	4.7	5.4	6.0	4.1	5.0	3.0
8	Allahabad U/S (733 km)	733	6.4	11.4	6.9	1.8	13.0	8.0	8.5	5.5	8.4	4.8	5.0	3.0
9	Allahabad D/S (743 km)	743	6.6	15.5	7.2	1.9	8.2	3.8	8.4	3.1	7.7	3.2	5.0	3.0
10	Varanasi U/S (908 km)	908	5.6	10.1	8.2	0.8	10.8	3.0	8.6	2.0	7.5	2.2	5.0	3.0
11	Varanasi D/S (916 km)	916	5.9	10.6	7.6	1.0	7.5	2.5	8.3	2.3	7.3	3.0	5.0	3.0
12	Patna U/S (1188 km)	1188	8.4	2.0	8.2	1.2	7.1	1.9	7.4	2.0	6.0	1.7	5.0	3.0
13	Patna D/S (1198 km)	1198	8.1	2.2	8.0	1.5	7.1	2.0	8.0	2.2	5.9	2.4	5.0	3.0
14	Rajmahal (1508 km)	1508	7.8	1.8	8.5	0.7	7.9	1.5	7.4	1.8	6.2	2.0	5.0	3.0
15	Patna (2050 km)	2050	7.3	1.0	7.1	0.9	7.3	2.7	7.0	3.0	6.9	2.2	5.0	3.0
16	Ulberia (2500 km)	2500	5.8	1.1	6.1	0.9	5.4	1.9	5.4	2.6	5.3	3.6	5.0	3.0

Table 1: Represents water quality data of Ganga River during 1986- 2008

Source: Status paper on river Ganga

Present scenario

According to the latest update received by CPCB, the actual measured discharge of wastewater is 6087mld, which is much higher than the estimated discharge of wastewater in 2013. CPCB estimates shows that 64 industries in the mainstream of Ganga consume 1123mld of water and discharge 500mld of effluent. STPS are ineffective because of factors like lack of electricity, lack of connectivity with drain etc. that contributes 90% of Ganga water pollution. 3000mld of domestic wastewater is discharged into the river, which is roughly half of its total load. (14).

YEAR	2009	2013
SEWAGE GENERATION(MLD)	2638	2723
TREATMENT CAPACITY(MLD)	1174	1208
GAP (MLD)	1464	1514
% GAP	55	55

Table 2: CPCB estimates the domestic sewage load on river Ganga from 2009-2013.

Source: Status paper on River Ganga

Fig 2: Represents factors causing pollution

Source: Author

Harmful complex compounds, which critically effect different biological functions and are of potential risk to aquatic ecosystem, animal, and humans.

energy to fuel life processes and to replace energy loss as heat.

Fig 3: Represents summary of factors, which are threats for the sustainable functioning of River.
Source: Author

Food Chain in Fresh water Ecosystem (Kanpur-Bihar stretch)

Fish population predominates depending upon grazing and detritus food chain. The next portion has Turtles, Crocodiles, Ghariyals and Gangetic Dolphin along with active breeding sites. Thus, there is one-way flow of energy through the biotic community and recycling of nutrients between the biotic and abiotic components of the ecosystem. Thus any ecosystem requires a continuous flow of

Phytoplankton's (Algae, diatoms) → Zooplanktons → Small Fish → Carnivorous fish → Grass → Rabbit → Fox

The ultimate source of energy is Sun. The ultimate fate of energy in ecosystem is for it to be lost as heat, metabolism, reproduction, etc. energy and nutrients are passed from one organism to the another through the food chain as one eats another. Inorganic nutrients are cycled, Energy is not. Decomposers remove the last energy from the remains of organisms.

Fig 4: Represents the hierarchy of food chain in the eco-system

Source: Author

How Water Pollution affects the Fresh water Ecosystem?

Wastewater and runoff carry micro plastics into waterways. → Plastic objects are broken down into smaller pieces by sunlight and surf/detergent actions. → Marine plastics are often mistaken for food. → Persistent bio accumulative and toxic

Compounds in freshwater ecosystem preferably sorbs to plastics. → Bioaccumulation may be amplified by plastics shuttling pollutants into marine organisms. → Potential plastic mediated-Bioaccumulation. → At the same time, constituents of the plastic processes accumulate themselves such as additives leach into the tissues of the organisms that consume particles. Similarly

compounds of heavy metals that are found in this stretch from industries and are toxic.

organism excretes waste or dies, the nitrogen in its tissues is in the form of organic nitrogen. Various

Fig 5: represents factors responsible for degradation of freshwater ecosystem
Source: Effects of Pollution in Freshwater ecosystem

Characteristics of Pollutants which leads to Disturbances of Natural Processes

Algae are microscopic plants that usually aquatic, unicellular, and lack stems, roots and leaves. Nitrates and Phosphates enter the system (such as sewage, fertilizers from agricultural run-offs) increased nutrients causes surface plant growth and algal blooms. It occurs in freshwater environment when an algal species out competes other species and reproduces rapidly. It kills fish and other aquatic life by decreasing available sunlight to water and by using all the available oxygen in the water, due to which water becomes cloudy and turns green, yellow brown or red, which lead eutrophication. It occurs when nitrite leaches into the water body and causes severe reduction in species diversity and water quality. Which results into the disturbance of Nitrogen cycle and Carbon cycle of the river. In aquatic environments (like freshwater- river), blue-green algae is an important free-living nitrogen fixer. Bacteria (called Nitrogen-fixing bacteria) form symbiotic relationships with host plants. The bacteria live in nodules found in the roots of the legume family of aquatic plants. When an

fungi and prokaryotes then decompose the tissue and release inorganic nitrogen back into the ecosystem as ammonia in the process known as ammonification (Fig-8). The ammonia then becomes available for uptake by plants and other microorganisms for growth.

Further, as result disturbed Nitrogen cycle in surface water, extra nitrogen can lead to nutrient over-enrichment. This leads to fish-kills, harmful algal blooms, and species shifts in aquatic and land ecosystems. Some forms of nitrogen (like NO_3^- and NH_4^+) also enter the atmosphere to become smog- nitric oxide (NO), Greenhouse gas- nitrous oxide (N_2O) and Acid Rain- (nitrogen oxides) thus degrades the climate.

Fig-6: Represents Process of Ammonification
Source: Nitrogen Cycle ppt.

In addition, Dissolved oxygen, also called DO, is vital to the health of aquatic ecosystem. Plants and animals need oxygen to survive. A low level of Dissolved oxygen in the rivers is affected by weather and temperature. It is important to monitor DO, since it can be used as an indicator of water quality. Algae produce oxygen during the day through photosynthesis but also quickly consume oxygen at night during respiration. Bacteria decompose the algae after the bloom dies, using a significant amount of oxygen in the process, which results in lack of available oxygen for other plants and animals. Carbon dioxide, also called CO₂, is found in water as a dissolved gas. It can dissolve in water 200 times more easily than oxygen. Aquatic plants depend on carbon dioxide for life and growth, just as fish depend on oxygen. Plants use carbon dioxide during the process of photosynthesis. Sometimes carbon dioxide levels in water become too high. Pollution causes too much carbon dioxide. Resulting into disturbance of CO₂ cycle, which leads to the unhealthy state of ecosystem. In these conditions, fish have a hard

time getting the oxygen they need from the water. Because of which they suffocate and die.

How pollution affects Abiotic component

Cold water holds more oxygen than warm water because Salmon needs a high level of oxygen to survive; they live in fast-moving, cold streams and rivers. Whereas warm-water fish such as bluegills, crappie, perch, walleye, catfish and carp can tolerate lower levels of dissolved oxygen in the water. Dissolved oxygen (DO) used as an indicator of water quality. Anoxia occurs when oxygen levels are low and often results when dry, hot weather causes water to warm and evaporation increases. If these conditions are severe, large “fish kills” (floating dead fish) may result due to lack of oxygen. Carbon dioxide, also called CO₂, is found in water as a dissolved gas. It can dissolve in water 200 times more easily than oxygen. Aquatic plants depend on carbon dioxide for life and growth, just as fish depend on oxygen. Thus for a healthy and sustainable ecosystem balance between Biotic and Abiotic has to be maintained.

1) Pollution sensitive species larvae vanished. This resulted into not only decline of fish population but other vertebrates as well. The use of organochlorine pesticides in agriculture posed new threats and resulted into accumulation in the tissues of fishes and higher vertebrates

2) The polluted river became unfit for both drinking and bathing, the entire river ecosystem was degraded. The commercially important freshwater fishes such as Indian major carps and Hilsa collapsed. The pollution tolerant—species heavily colonized near the city outfalls.

3) Rampant killing of soft shell turtles reduced the scavenging capacity of the river as the turtles feed mainly on the dead bodies and carcasses. However release of 40,000 soft shell turtles, in Ganga at Varanasi, had a positive effect on the dwindling population of these animals.

4) Anthropogenic activities have pushed Gangetic Dolphin on the verge of extinction. Gangetic Dolphin requires sufficient year round water flow to move, forage and carry out activities that ensure reproductive success and recruitment into breeding population.

5) (This includes Vikramshila Gangetic Dolphin Sanctuary 50 km of stretch) in Bihar 1st of its own kind in India. The Gangetic dolphin was declared a National aquatic animal by MoEF on May 10, 2010. (12, 14)

Fig7: represents observations made for the process of restoration
Source: Author

The BOD levels were higher and maximum values were recorded at Kanpur (Fig-2).

Observations

Among the five zones in the middle stretch of river Ganga, a total of 143 fish species belonging to 58 genera and 24 families were recorded. 29 species are threatened due to pollution in fresh water eco system. Schemes for Interception, diversion and Activated Sludge Process (ASP) and Oxidation Ponds were adopted for treatment of sewage, low cost sanitation, 28 electric crematoria and 5 Riverfront developments were successfully taken under Ganga Action Plan, phase I.

Parameter Specific Observations

Restoration Measures (Tools)

The following restoration measures seem inevitable in river ecosystem to bring river Ganga to sustainable, stable and healthy condition.

- a. To provide enough space for endemic(prevalent) species of both flora and fauna for growth and migration through Environmental Flows (E-Flows) by maintaining the lateral, vertical and longitudinal connectivity in the entire stretch of Ganga system.
- b. To provide connectivity with wetlands. Restoration of wetlands may be made point of

focus to ensure breeding sites of fish and other aquatic animals.

- c. From the above study, it is evident to identify all the species including zoo benthos, fishes and aquatic higher vertebrates, which come under rare, endangered and threatened category, should be conserved to maintain ecological integrity.
- d. Breeding sites for fish and other higher aquatic vertebrates should be identified and con-served. Soft and hard-shelled turtles lay eggs in the flood plains during the post monsoon period.
- e. To assess and monitor river health, primary data collection for all parameters including bio monitoring from selected stretches should be done by recognized and reputed research institutions

through empowering and involving local riverside communities.

- f. Use of chemical fertilizers and pesticides in agricultural in flood plains and riparian zone be regulated and restricted.

Conclusion

The study indicates that the River Basin has started showing signs of recovery and physio-chemical conditions of the river has improved discernibly. Fish diversity and biomass has started showing increasing trends in spite of many adverse factors, besides pollution invasion of exotic species is another big threat for the river biota.

The river basin is one of the most thickly populated areas of the world. It sustains thousands of aquatic species of flora and fauna including many endemic and charismatic mega-fauna like the Ganges dolphin, (12,14) Gavials etc. However, since 1950s the river is facing threats of erosion of its ecological integrity due to anthropogenic pressures in the form of construction of dams, barrages and embankments; loss of forest cover in its catchment area leading to heavy siltation, pollution from industrial effluents and domestic sewage degrading the water quality to the extent that the river water is not fit for even bathing purpose. Nevertheless, the river harbours rich and abundant aquatic biodiversity. The ecological changes cannot be attributed entirely to GAP but definitely it played an important role(14,16).The Eco-Restoration of big river like Ganga is subsequent of this recovery, and requires constant efforts, monitoring time and patience.

Recommendations and Suggestions

- a.** Large daily fluctuations in flow should be avoided. Equilibrium between sediment erosion and deposition is necessary to maintain essential habitat features.
- b.** Access to flood plains should be preserved to ensure natural spawning and rearing habitat for fishes, which are prey base of the dolphins. Enhancing the capacity and governance framework for Gangetic Dolphin conservation is needed.
- c.** Information on the pre development ecological conditions of a river is essential for evaluating migration efforts and to implement future development decisions. Post development empirical studies are needed to monitor the operational aspects as well as the effects on upstream and downstream populations of cetaceans and their habitat.
- d.** Effective construction of fish passage structure is necessary. Conventional fish ladders designed may not be successful because most fishes do not

jump. In the middle stretch of the river Ganges (Allahabad), which used to form a good share in catches below Allahabad, has almost disappeared after inception of Farakka barrage despite fish ladders were installed. Steps should be taken to improve fish pass way so that the fishes may negotiate upstream areas.

- e.** Cumulative and synergistic impacts of multi development should be considered in assessment of environmental impact.

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