

# Assessment of Pollution Load and Its Impact on Aquatic Biodiversity of River Ganga: A Review



D. S. Malik, Aditi Bisht, and Ruchika Chauhan

**Abstract** This review paper presents experimental results of some researchers who have observed Ganga River Water from Gangotri to West Bengal in the past 21 years. An attempt has been made to understand the gradual degradation of Gangajal and its present pollution level in relation to various uses. To assess water of Ganga, numerous measurements have been taken from time to time to study the physico-chemical condition of this sacred river by various researchers. These studies show that all is not well and the quality of Ganga is getting worse day by day. The reason could be the nostalgic mood of the industry and common man who continue to follow bad practices causing severe pollution of the Ganga. Though there are government laws to control river pollution, the implementation is not adequate as the laws in India are too volatile, too stringent and too inexpedient.

**Keywords** Pollution types · Water pollution · Aquatic biodiversity · Ganga river

## 1 Introduction

The Ganges River, also called in hindi as Ganga, is a prodigious river of the plains of the north Indian subcontinent. Since time immemorial it has been the holy river of Hindus. For maximum of its course it is a widespread and sluggish stream, flowing through the greatest fertile and thickly populated areas in the world [1]. In spite of its importance, its has an extent of 1560 miles (2510 km) which is moderately short compared to the other rivers of Asia or the world. The Ganges is a sacred river of India and Bangladesh. The Bhagirathi River flows from the base of Gangotri Glacier, which is known as Gaumukh. The river Bhagirathi is said to be the actual basis in Hindu culture [2]. It has over-all length 2525 km, it rises in the western Himalayas in Uttarakhand, and flows south and east through the Plain of Northern India and reaches Bay of Bengal through Bangladesh. It is India's longest river and second

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largest river in the world by water discharge. The basin of Ganga River is the most densely inhabited basin in the world, with over 400 million. In 2007 the river Ganga was graded amongst the five greatest polluted rivers of the world.

The mainstream of Ganga is formed when Alaknanda and Bhagirathi streams unite at Devprayag, which penetrates southwestward through the Shivalik range at the north border of the Indo-Gangetic Plain to appear from the foothills at Rishikesh [3]. It then moves to the plain at Haridwar which is a sacred place for Hindus. The magnitude of Ganga water rises evidently as it procures more streams and arrives a area of heavier precipitation. Since, April to June the melting snow of Himalayas feed the river, and in the monsoon period i.e., from July to September the monsoon feed the river sometime causing flood situations also. During winter season the flow of river declines.

In Uttar Pradesh the river Ganga receives right bank tributaries i.e., Yamuna and Tons which intersects the Ganges just below Prayagraj. There are also three main left-bank tributaries, which are the Ramganga, the Gomati, and the Ghaghara.

The next state in which the river enters is the state of Bihar. Its chief tributaries are the Ghugri, Gandak, the Burhi Gandak, and the Kosi river. The important tributary is Son River. The river then borders the Rajmahal Hills and flows southeast to Farakka in central West Bengal state. West Bengal is the last state that the Ganga arrives, and, afterward it flows into Bangladesh [4]. The Ganga is called a Padma in West Bengal. The western distributaries of the delta are the Bhagirathi and Hoogly river. As the Ganges entitles from West Bengal into Bangladesh, many distributaries branch off to the south. The Ganges is merged to Brahmaputra in Bangladesh near Goalundo ghat.

The Ganges area was said to be densely forested. Ancient literatures specify that in the sixteenth and seventeenth centuries hunting of wild elephants, buffalo, bison, rhinoceroses, lions, and tigers was common in this area. The unique natural vegetation has vanished from the basin of Ganga, and the land is now cultivated to meet the requirements of food of the population. Few wild animals are now commonly cited like for deer, boars, and wildcats, wolves, jackals, and foxes. Bengal tigers, crocodiles, and marsh deer are seen in Sundarbans.

Fish flourish in all the rivers, specifically in the delta area, where they form an important share of the residents diet. In West Bengal common fishes comprise feather backs, walking catfish, milk fish, gourami, and barbs [5]. The Ganga Dolphin or *Platanista gangetica*, which is unsighted cetaceous can be seen all over the Ganga–Brahmaputra basin, but now it comes under endangered category due to its illegal poaching. Numerous diversities of birds are found, such as parrots, myna, crows, partridges, kites, ducks, snipes and fowls.

The use of the Ganga water for drinking and irrigation is common since the ancient times. The use of water in irrigation is defined in sacred scripture and mythological books inscribed more than 2000 years ago. The Irrigation facility and canal system was developed in the period of Muslim rule in the twelfth century onward. The channel system was further extended by the British [6]. The cash crop production of U.P. and Bihar in Ganges valley is benefited from the of irrigation canals. In olden times the Ganges and some of its tributaries, particularly in the east, remained

significant transport routes. By the nineteenth century, irrigation-cum-navigation channels designed the chief routes of the transport system through water. The arrival of paddle steamships transformed internal transportation, motivating the evolution of indigo manufacture in Bengal and Bihar. Regular steamer facilities contended from Kolkata to Prayagraj and far beyond, along with to Agra on the Yamuna and up the Brahmaputra water transportation decline in mid-nineteenth century with the emergence of Railway transportation. Bangladesh and Bengal remain to depend on the waterways to transport jute, tea, grain, and other agricultural products. The Ganga's hydroelectric potential is massive, which is estimated to have fluctuated from some 51,700 to 128,700 MW. Some of that potential has been exploited in India, like in Uttarakhand, on Yamuna River and its tributaries in Himachal Pradesh, and in downstream, in Chambal and Rihand rivers.

The river Ganga faces so much stress due to various human activities and development. Pollution in the Ganga River, possess noteworthy threats to health of human and the environment. Extremely contaminated with human waste and industrial pollutants, the river delivers water to approximately 40% of the population of the country in 11 states. Nowadays, the Ganga is well-thought-out to be the fifth-most polluted river in the world [7]. Many initiatives have been taken to clean the river, but all of them were unsuccessful to bring anticipated results.

## 2 Causes of Pollution in Ganga

All through festival periods, over 70 million individuals take dip in the Ganga to clean themselves from their previous sins. Few used and unused materials like food, plastic waste, flowers, leaves, dead bodies, clothes, human and animal waste are left in the Ganges and its shores by the tourists and pilgrims which are also accountable for its contamination [8]. As per available data 12,000 MLD (million litres a day) of sewage from from municipal and industrial areas is drained into Ganga basin daily. Not only the sewage, nearly all human activities produce some type of environmental disorder that pollute the surrounding water [9]. For, convenience the large majority of sources of water pollution are divided in broad categories of waste:

(A) Industrial, (B) Agricultural, (C) Domestic waste, (D) Religious waste.

**Industrial waste:** Wastes from industry serve as main cause of contaminants because of (i) Manufacturing and drugs industry (ii) Power generation (iii) Mining and construction (iv) Food processing industries.

The Manufacturing industries includes the industries dealing with chemical, oil refining, organic chemicals and heavy metals. The example of such industry includes textile, leather tanning, plastics, pharmaceutical and paper pulp industries. The by product from such industry are extremely poisonous to many creatures, including humans. Many pharmaceuticals involved in making drugs like antibiotics and various other medicine [7]. The endproduct or the waste from such industries get mixed with water as the industries dispose them in the river and it increases the BOD and COD.

Power producing industries are chief contributors of heat and radioactivity. Radioactivity from nuclear power plants can contaminate surface as well as ground water in a variety of ways. The water gets contaminated by minning of uranium and enrichment plants. Minning industry contribute in sediments and acid drainage. As, main segment comprises vegetables, fruits, dairy, alcoholic and non alcoholic drinks and packed food [10]. The common worry in the industries are consumption and discharge of water, chemicals and compounds used in processing and cleaning, packing, removal and food leftovers.

**Agricultural waste:** These are produced by the agriculture and animal rearing. Agriculture is a chief source of organic chemicals, specially pesticides. The pesticides penetrate in surface and under ground water bodies. The usage of nitrogen manures upsurge the concentration of nitrates in ground water, leading to high nitrate levels in ground water sources [11]. The water may penetrate deep or run off may occur which may harm the flora and fauna of the marine biodiversity [10].

**Domestic waste:** These are the waste produced by households. Domestic waste Also include septic tank waste which ends up of in natural waters. These days numerous individuals dump their garbage into rivers, ponds, lakes and streams, thus creating the water body as the ultimate resting place of cans, bottles, plastics and other products from households [12]. Maximum of nowadays washing products are detergents and cleaners which comes from the petro chemicals industries. The chemicals substance contained in washing powders and other cleaners effect the well-being of all forms of life in the water.

**Religious waste:** All through the festive periods, more than 70 million individuals take holy dip in the Ganga to wash themselves of their former sins. Some materials like flowers, clothes, and wastes are left in the Ganga and its banks which are also accountable for its contamination [13]. Traditional beliefs of people say that being burnt on its banks and ashes floating down the Ganga will rinse the sins of those individuals who expire and this bring them straight to salvation. In Varanasi alone, an approximately forty thousand bodies are burned every year and are put into the Ganga [14]. As numerous families do not have enough money for cremation wood, countless bodies are placed into the Ganges are only half-burnt.

### 3 Pollution in the Major Cities from Which River Ganga Flows

#### 3.1 Rishikesh

The town of Rishikesh is situated in the foothills of the Himalayas. It is recognized as the Gateway to the Garhwal Himalayas and is also famous as “Yoga Capital of the World”. It is identified as the pilgrimage town and observed as one of the holiest places for Hindus. Sages and saints have stayed as well as visited Rishikesh since early periods to meditate in search of higher knowledge [15]. Ganga river

subsequently flowing 249 km through its slender Himalayan valley, it arises from the foothills at Rishikesh, then move out onto the Gangetic Plain at the pilgrimage town of Haridwar [16]. The river Ganga is admired by millions of people in India but still unprocessed sewage is directly dumped into its water in Rishikesh. The untreated waste of hotels, ashrams, temples and shops is discharged in the river daily. The river Song flows through Dehradun meet Ganga River near Lakshman Jhula which is close to town of Rishikesh. The quality water beyond this point is finest. The water quality is degraded after this point as untreated sewage flowing in Song go in the Ganga and causes contamination. The quality of water was tested in 15 locations between Gangotri and Haridwar water in 7 sites above Lakshman Jhula was found to be of finest quality and appropriate for drinking. Whereas water quality of other sites tested between Rishikesh to Haridwar was not found of good quality and was not suggested for consumption and other domestic purposes without subjecting it to purification [3]. According to researchers, the main source of water pollution in Ganga is due to mass bathing, urban waste and effluent from sewage treatment, domestic sewage, discharge from hotels and ashrams reaches the Ganga, causing additional contamination.

### **3.2 Haridwar**

In Sanskrit, the ceremonial meaning of Haridwar is Hari means “Lord Vishnu” and Dwar means “gateway”. So, Haridwar is said to be “The Gateway to Lord Vishnu”. Haridwar got this name because it is usually the place where devotees initiate their Char Dham Yatra for attainment of God. The city is positioned on the right bank of the river Ganga, at the bases of the Shivalik ranges. It is observed as a holy place for Hindus, holding chief spiritual events and serving as an entrance to numerous prominent places of worship [17]. One of the significant of the events is the Kumbh Mela, which is in every 12 years. Millions of tourists, devotees, and pilgrims assemble here to perform ceremonial bathing on the banks of the river to wash away their sins to attain moksha. The water quality in this area is degrading year by year even after lots of efforts of government to clean it. The degrading quality if water is due to the pilgrims and visitors who come to the city to wash their sins and leave the city with the garbage disposed in the river. Also, the untreated sewage, chemicals from industries and waste water is major cause of polluted water in Haridwar [18]. Many institutes like Gurukul Kangri, IIT, Roorkee, PSI, Dehradun, Doon University checked the water quality on various parameters and found the water quality of this region is not good and is unfit for drinking and do not fulfil the criteria of CPCB for bathing during festive seasons also.

### 3.3 *Uttar Pradesh*

Uttar Pradesh is a state of northern India, having over 200 million inhabitants, it is the most heavily settled state in India furthermore the densely populated province subdivision on the globe. The two important rivers of the state are Ganges and Yamuna which joins at the confluence of Triveni in Prayagraj (Allahabad) [19]. These two foremost tributaries, the Yamuna, which proceed by the Delhi (capital region) and afterwards abruptly aligned the south eastward flow of the river Ganges prior joining it near Prayagraj [20], including Tons, which go along north from the Vindhya range in Madhya Pradesh and unite the river Ganges just beneath Prayagraj. The major left bank tributaries in UP are the Ramganga, Ghagra and the Gomti river. The Ganga river arrives Uttar Pradesh at Bijnor and it flows through Bulandshahr, Hapur, Meerut, Muzaffarnagar, Aligarh, Kasganj, Sambhal, Amroha, Badaun, Shahjahanpur, Hardoi and Raebareli. It flows through 27 districts in U.P. [21]. The reports shows when river reaches Bijnor, water quality was B standard, which is suitable for outdoor bathing as the biological oxygen demand (BOD) or dissolved oxygen level was 1.4 mg per litre at the place. Quality of water kept on decreasing as it moves forward. The quality of water is C, but when the Ganga arrives at the territorial area of Kannauj, the quality of water changed from C to D, as it moves forwards. The quality of water remained in category D from Bithoor in Kanpur to Prayagraj [22]. In Noida, the Yamuna river water quality was testified to be E, which can be used for irrigation, industrial cooling and waste disposal in controlled way. The BOD level at Vrindavan and Mathura was testified to be of D water quality. Kanpur has the maximum pollution load i.e., 75% amongst all of the towns of Uttar Pradesh. The pollution load is due to the drains, sewage treatment plants, tanneries, industries, etc. [14]. Approximately, all classes of wastes are impending out of Varanasi, viz. all kind of biodegradable as well as non-biodegradable wastes, sewage, industrial waste, animal corpses, unclaimed human dead bodies. Water quality in Varanasi is intolerable for drinkable or for farming and it is getting worse [20].

### 3.4 *Bihar*

Bihar is a state in the eastern part of India. It is the 12th wide—ranging by the territory (94,163 km<sup>2</sup>) and is ranked 3rd largest state by population. The river Ganges splits the Bihar plain, which flows west to east. Magadh, Mithila, and Bhojpur are the three main cultural provinces of the Bihar state. In Bihar quality of water is alkaline in nature with more total solids and also above saturated with dissolved oxygen. The chlorides are well in the permitted limits of drinking water quality standards. Whereas, some of the selected parameters are to some extent higher than the prescribed limit by WHO which makes it unfit for household and commercial purposes. The hardness of water is Slightly high in some sites which makes it unfit

**Table 1** Physicochemical characteristics of ganga at various location

Parameters	Unit	Rishikesh	Haridwar	UP	Bihar	West Bengal
pH		7.5	7.5	7.40	7.75	6.06
EC	dSm <sup>-1</sup>	140.4	0.29	0.44	0.007	
DO	mg L <sup>-1</sup>	9.67	9.8	6.40	7.425	3.4
BOD	mg L <sup>-1</sup>	2.25	1.3	3.3	2.475	4.51
COD	mg L <sup>-1</sup>	5.32	4.00	19.20	15.125	26.15
TDS	mg L <sup>-1</sup>	55.68	109	166.92	250.25	254.1
Turbidity	NTU	7.79	46.72	166	–	147.83
Chloride	mg L <sup>-1</sup>	5.11	7.90	2.80	35.05	119.83
References		[25, 26]	[27]	[28]	[29]	[30, 31]

for drinking purpose also. Though high pH, TDS, Hardness, DO, BOD and MPN standards recommends cleansing is essential for domestic consumption [23, 24].

### 3.5 West Bengal

West Bengal is a province in the eastern part of India, in between the Himalayas and the Bay of Bengal. And its capital, Calcutta hold on architectural and cultural remnants of its formerly like an East India Company, the trading post and the capital of British Raj. Afterwards Bihar, the river evades the hills of Rajmahal to the south and proceed southeast to the Farakka in the West Bengal, at the crest of the delta [24]. The West Bengal is the last Indian state in which the Ganges enters, and then it flows to the Bangladesh, the Mahananda river and gets joined to the north. In India, West Bengal as well as in Bangladesh, the river Ganges is pronounced as the ‘Padma’ 0.1779 MLD wastewater is discharged into the River Ganga through 54 canals in West Bengal. The results show that the capacity utilization of West Bengal requires immediate attention. Grossly Polluting Industries West Bengal generates maximum effluent of 75.5% in terms of water consumed [14] (Table 1).

## 4 Impact of Pollution on Aquatic Biodiversity

Enormous quantity of river Ganges water is also used for irrigation purpose due to which the Ganga downstream of Narora (UP) is being assassinating. The establishment of non-coastal waterways leads to expand in pollution and homicide the aquatic life [3]. In West Bengal, the Farakka barrage access the saline water and cause flood in Bihar. The experts found that river Ganges is getting highly polluted as people are dumping a lot of wastes, toxic elements which causes the depletion of dissolved

oxygen in the water and stimulates the circumstances of hypoxia, which is quite harmful for aquatic life. The most polluted part of the river Ganges is at Kanpur, it is the most populated city in Uttar Pradesh where the people in the locality washes their dirty clothes, bath their animals, urinate and discharge sewage in the water which makes the water impure [32].

The scientists have found a lot of quantity of mercury in the river Ganges, as they collected specimens contains the amount mercury, which results in the tenced muscles of the fishes which assembles in the body of the aquatic organisms [5]. Approximately 50–80% of mercury is organic and it causes a connection between the food habit, mercury levels in muscles and the length of the fish. The ‘Ganga River dolphin’ is one of the fresh water dolphins in the world is listed as endangered species [33]. Irrigation dams and hydroelectric powers prevent the dolphins from proceeding up and down along the river Ganges, which is the most important reason for their depleting population. Another fresh water species of the river Ganges that is ‘Ganges Softshell Turtle’ (*Nilssonina gangetica*) which can also be seen in the river Indus, Mahanadi River, systems of Pakistan, Bangladesh and Southern Nepal [34]. These turtles are basically found in the deep rivers, lakes of freshwater. And as these turtles consists of prolonged agedness and elevated trophic levels in the food web of the aquatic life. But they are at risk due to the various mode of pollution.

## 5 Challenges and Remedial Measures

The Prime Minister of India Narendra Modi made it his own plan and set a aim to clean Ganga by 2019, which was then extended to 2020. Namami Gange is being executed by the National Mission for Clean Ganga (NMCG), and its state counterparts to achieve the twin purpose of effective reduction of pollution, management and rejuvenation of Ganga [35] there are well proportioned 221 projects under the scheme, which comprise STP, ghat development, cleaning of surface, afforestation, cleanliness, and public awareness, out of which only 58 have been completed.

River ecosystem have agonized from human interference resulting in habitat loss and degradation and as a consequence numerous fish species of freshwater have become vigorously jeopardized specific in Ganges basin [27]. In India 2246 Indigenous finfishes have been portrayed of which 765 has a place with fresh water fish. 143 species have a placed with 11 orders, 72 genera and 32 families were recorded across the Ganges which is about 20% of fresh water fishes proclaimed in India. Out of 143 species, 133 species were local to waterway Ganges and its tributaries and rest 10 species were exotics. Cleaning waterway ganga is a monstrous project which has gained critical progress after 2014 yet at the same time has far to go [36].



## 6 Challenges for Failure of Namani Gange Project

There are few challenges which Namani Gange project face which may lead to its failure. First challenge 2000 million litres capacity STPs had to be transformed of which only 328 MLD have been completed claimed by Namani Gange project. The status of project brings a doubt that whether the government would even accomplish its aim. Second Challenge is that the river self purifies it when there is constant flow of water. The river fails this elementary test except during rainy season. Therefore, it's not just about contaminated Ganga. It is about the survival of Ganga. Third challenge is the contamination from the cities which flows through a network of small and increasingly larger open drains, which ultimately flows into the Ganga. None of the three metropolises has a system for administration of solid waste, most of which is discarded in the roads, clogging exposed drains and adding to the contamination. Fourth challenge is scrubbing up the huge stretch of 2525 km that the Ganga crosses is a programme where regulating the funds becomes as giant issue. The UP SAAP in 2016 said that the towns in Ganga basin would require Rs. 5794 crore just for the formation of sewer networks in the state. Last challenge is the cleaning of the Ganga needs continuous synchronization between the agencies accountable for carrying out various tasks. This demands a visualization and a clear-cut strategy. The water resources department engaged MOUS with 10 ministries for better application of Namani Gange.

The cleaning of Ganga is not only the responsibility of government but every individual in the community. Basic remedial measures which can be followed to help clean Ganga can be done by setting up an approachable local authority to manage the responsibility and budget for cleaning area near the ghats, records should be maintained of the tourist and devotees visiting the area and the traffic should be maintained and also local people as well as tourists should be made aware of the responsibility of keeping the river clean.

## 7 Conclusion

The Ganga river agonizes from countless problems, most significant ones being the pollution of water. Release of untreated and partly treated sewage and industrial wastewater into the river is a main issue. Change of water flow of river through Upper and Lower Ganga canals, leaving nearly very little flow in the main river making the dilution difficult after treatment.

In Uttar Pradesh, there is requirement of handling of sewage water and accessibility of suitable conveyance system for sewage. It also requires minimum flow for its subsistence in the stretch of Uttar Pradesh. Subsequently a river is an existing eco-system and consequently final goal should be to protect the operation of the river eco-system.

Main industries like Tannery, Sugar, Pulp and Paper mills contributes noteworthy contamination load to river and its tributaries. There is instant requirement of strong environment investigation in order to check their compliance with the standards. It is also essential that minimum flow through the year should be maintained to support eco-system of river and aquatic life. It would be advisable to generate additional water storage capability for river system and release water in the thin period to efficiently sustain minimum flow in the river.

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