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A STUDY OF WATER POLLUTION OF RIVER GANGA DURING LOCKDOWN PERIOD

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between both authors. Author NH designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author RP managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

In the present study, an effort was made to study the water quality of River Ganga and the effect of lockdown on the physicochemical characteristics of the river water in the state of Bihar. Exploratory research design has been used in which both primary and secondary data was collected. The data was further analysed using suitable tests. It has been found that there was no major change in the existing quality of the river during the lockdown period.

Keywords: The Ganges; lockdown; dissolved oxygen; total and faecal coliforms; biological oxygen demand.

1. INTRODUCTION

The insensitivity of man towards nature and environment has done quality damage the consequences of which is being suffered by all in the form of ozone depletion, global warming, glacier melting, smog, air pollution, cyclones, earthquakes, floods, hurricanes, water pollution, and what more [1]. It has been rightly said, "Disease is nature's revenge for our destructiveness." COVID-19 is a vengeful act of nature to heal itself while teaching a lesson to mankind.

The outbreak of COVID-19 pandemic around a year back engulfed the whole world slowly and by February 2020, India also fell prey to this life-threatening experience.

The worry was such that a worldwide lockdown was experienced and all activities had an impasse. Organizations faced deadlock, industries came to a halt, all economic pursuits paused and every human being got confined within the boundaries of his household. India too experienced a nationwide lockdown on 24th of March, 2020 which continued

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till 14th of April of the year 2020 [2]. This period was followed by relaxations in the lockdown from 15th of April, 2020 to 3rd of May, 2020 and subsequent unlock phases [3].

The pollution level in Ganga has been a topic of discussion since half a century and now it ranks at sixth most polluted river in the world after a span of fifty years [4]. The first step towards cleaning of Ganga was taken in 1985 [5] in the form of Ganga Action Plan I.

Trivedi [6] established that the 8,60,000 km^2 long Ganga basin is populated by approximately 43% of the inhabitants. The areas which are said to be a part of the basin stretch along the states of Uttarakhand, Uttar Pradesh, Bihar and West Bengal.

Bhutiani et al. [7] confirmed that more than twenty-nine cities, hundreds of towns and thousands of villages are situated along the banks of the Ganga river. The data shows that a large portion of the population is majorly dependent on the river water for both personal and commercial purposes.

Singh et al. [8] stated that the physicochemical properties of the Ganges have experienced a major change over the years as a result of multiple factors such as construction of dams, dump of domestic waste, discharge of industrial sewage, and emittance of fertilizers and insecticides due to intensive agricultural practices. The eight-week nationwide lockdown gave a chance to the Ganges to restore itself. The closure of all commercial enactments put a halt on unwanted matters in the river water.

2. OBJECTIVE

The present study was aimed to check the water quality of the Ganges during the lockdown period and to analyse the impact of the situation on the quality of the water of the Ganges with special reference to a few areas in Bihar, where domestic sewage, industrial wastes, agricultural wastes and air pollution affecting the river water are considered to be the major source adding to the river pollution.

3. METHODOLOGY

The paper is exploratory in nature. Both primary and secondary data have been used for the purpose of study. Secondary data has been collected from various published and unpublished sources which have been reviewed and perused thoroughly. The primary data has been collected from the sampling stations of Digha, Arrah and Aami sites of the Ganges in Bihar. The data collected has been tested, observed and validated for the results. Water was collected from the stations for physicochemical analyses thrice every month in March and April. The samples were collected in three separates sterile Biological Oxygen Demand (BOD) bottles from each station to test Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Total Coliform (TC) and Faecal Coliform (FC), while pH level was tested at the site itself with the help of pH meter (HANNA). Further, the samples collected to test Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD) were fixed on the spot using Winkler's method and then they were brought to the laboratory of P.G. Department of Jai Prakash University, Chapra, Saran, Bihar, for further analysis. Dissolved Oxygen (DO) was estimated in the first set of samples at the spot instantly after collection. The second set of samples was incubated at 27^oC for 5 days in the Biological Oxygen Demand (BOD) incubator in the laboratory. After completion of the test period, Dissolved Oxygen (DO) was estimated. The Biological Oxygen Demand (BOD) was computed from the difference between initial and final Dissolved Oxygen (DO) value as per APHA [9]. Further, as per APHA, Total Coliform (TC) and Faecal Coliform (FC) were tested too. Concentrations of total coliform bacteria and faecal coliform bacteria have been reported as Most Probable Number per 100 ml (MPN/100 ml). Two tests were done on the sample. The first test was presumptive coliform test. MacConkey Broth was used for multiple 5-tubes MPN dilution technique. A change in colour and gas formation showed positive result regarding the presence of bacteria. The second test was confirmation test of faecal coliform. The test was done using Brilliant green broth in which 1ml inoculum from positive tube extracted from presumptive test was inoculated and incubated for whole 24 hours at 45^oC. Production of gas was positive indication about the presence of bacteria. The collected data were further analysed by calculating mean, percentage increase and percentage decrease with the help of their respective formula.

Mean = Sum of the term/number of terms.

Percentage Increase = 100 X (Final Value-Initial value) / Initial Value.

Percentage Decrease = -100 X (Final Value-Initial value Initial Value.

4. OBSERVATIONS

4.1 Study of pH

While studying the pH of Ganga water at the three selected sites, it was observed that there was a decrease in the pH level from 8.83 to 8.06 at Digha,

8.45 to 8.01 at Aami and 8.47 to 8.16 at Arrah on both during pre-lockdown and lockdown periods, respectively (Table 1). All the three stations showed a decrease in pH level. The percentage decrease in pH level at following three stations were observed as follows Digha (8.72%), Aami (5.2%) and Arrah (3.65%).

4.2 Study of Dissolved Oxygen (DO)

While studying the dissolved oxygen of the three sites during the pre-lockdown and lockdown periods, it was found to be slightly decreased at Digha from 8.7 to 8.6 mg/L. On the other hand, the data showed an increase at Aami (from 8.2 to 8.9 mg/L) and Arrah (from 8.6 to 9.7 mg/L). The percentage decrease of DO at Digha was calculated at 1.14% while the percentage increase of the same was calculated at 8.53% and 12.79% for Aami and Arrah, respectively (Table 2).

4.3 Study of Biological Oxygen Demand (BOD)

While studying the BOD. of the three sites during the pre-lockdown and lockdown periods, an increase in BOD was found at Digha (from 1.6 to 1.7 mg/l), Aami (from 1.5 to 1.8 mg/l) and Arrah (from 1.6 to 2.0 mg/l). The percentage increase at all the three sites was calculated as 6.25%, 20% and 25% in the same order (Table 3).

4.4 Study of Total Coliform (TC) and Faecal Coliform (FC)

While studying the Total Coliform at the three selected sites, there was a decrease (from 54000 to 3900 MPN/100 ml) at Digha. However, it showed an increase at Aami (from 12000 to 35000 MPN/100 ml) and Arrah (from 7900 to 22000 MPN/100 ml). The percentage wise change at the three sites have been calculated as 92.77% decrease at Digha, 191.66% increase at Aami and 178.48% increase at Arrah (Table 4).

While studying the Faecal Coliform at the three sites (Table 5), it showed fall of FC at Digha from 11000 to 2200 MPN/100 ml (80% decrease) but increased at Aami from 4400 to 17300 MPN/100 ml with a percentage increase of 293.1% and from 2700 to 3067 MPN/100 ml with a percentage increase of 13.59% at Arrah. A large amount of increase in the TC and subsequently in FC was observed at Aami and Arrah.

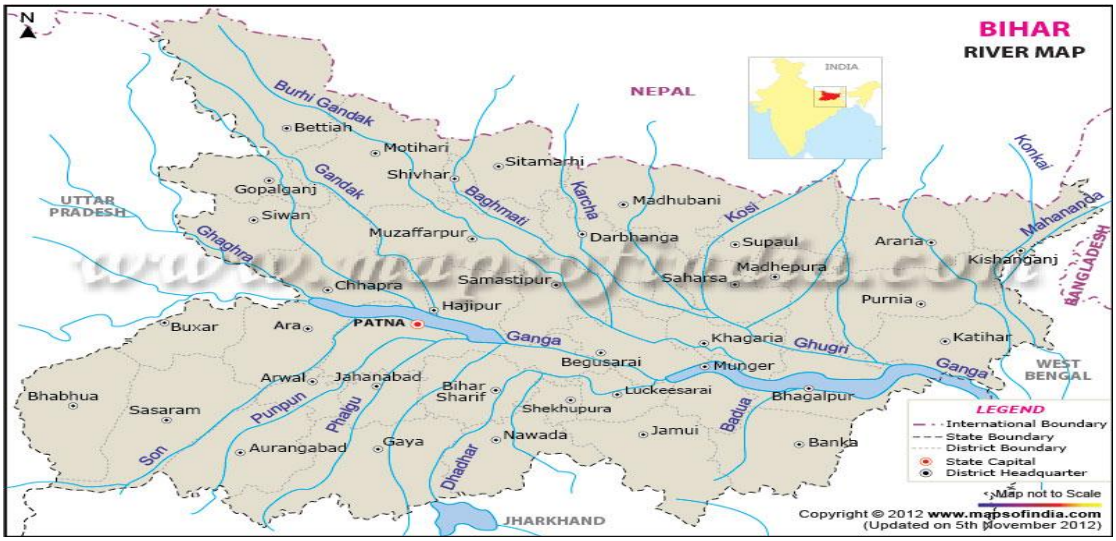

Fig. 1. The map showing the sampling site of study

Table 1. The pH of Ganga water during pre-lockdown and during lockdown

Period	Pre-lockdown				During lockdown				
Month	March, 2020				April, 2020				
Sampling station	I	II	III	Average	I	II	III	Average	
Digha	8.97	8.79	8.75	8.83	8.12	8.02	8.05	8.06	8.72% Decrease
Aami	8.61	8.4	8.35	8.45	8	8.05	8	8.01	5.2% Decrease
Arrah	8.62	8.6	8.2	8.47	8.2	8.15	8.13	8.16	3.65% Decrease

Table 2. The Dissolved Oxygen of Ganga water during pre-lockdown and lockdown

Period	Pre-lockdown				During lockdown				% Increase /
Month	March, 2020				April, 2020				Decrease
Sampling station	I	II	III	Average	I	II	III	Average	
Digha	9	8.5	8.7	8.7	8.7	8.5	8.5	8.6	1.14%Decrease
Aami	8	8	8.5	8.2	9.2	8.9	8.5	8.9	8.53%Increase
Arrah	8.4	8.6	8.8	8.6	9.8	9.7	9.5	9.7	12.79%Increase

Table 3. BOD of Ganga water during pre-lockdown and lockdown periods

Period	Pre-lockdown				During lockdown				% Increase /
Month	March, 2020				April, 2020				Decrease
Sampling Station	I	II	III	Average	I	II	III	Average	
Digha	1.8	1.6	1.4	1.6	1.6	1.8	1.6	1.7	6.25% Increase
Aami	1.6	1.4	1.4	1.5	1.4	1.8	2.2	1.8	20% Increase
Arrah	2.2	1.4	1.2	1.6	1.8	2	2.2	2	25% Increase

Table 4. Total Coliform (TC) of Ganga water during pre-lockdown and lockdown (in hundreds)

Period	Pre-lockdown				During lockdown				%
Month	March, 2020				April, 2020				Increase /
Sampling station	I	II	III	Average	I	II	III	Average	Decrease
Digha	60000	54000	48000	54000	3300	3600	4800	3900	92.77% Decrease
Aami	16000	12000	8000	12000	34000	35000	36000	35000	191.66% Increase
Arrah	7800	9800	6100	7900	11000	20000	35000	22000	178.48% Increase

Table 5. Faecal Coliform (FC) of Ganga water during pre-lockdown and lockdown (in hundreds)

Period	Pre-lockdown				During lockdown				%
Month	March, 2020				April,2020				Increase/
Sampling Station	I	II	III	Average	I	II	III	Average	Decrease
Digha	16000	9000	8000	11000	1200	1200	4200	2200	80% Decrease
Aami	5600	4400	3200	4400	9900	19000	23000	17300	293.1% Increase
Arrah	3600	3200	1300	2700	1600	3300	4300	3067	13.59% Increase

5. DISCUSSION

The environmental boon came in disguise of the pandemic which forced social animals to put a break on all the activities. Air quality improved and the rivers appeared to be cleaner than ever. Nature rejuvenated itself in a unique manner [10].

The Indo-Gangetic Plains witnessed a low level of aerosol for the first time in a score of years. The reduction in pollution level and a lesser number of pollutants resulted in a cleaner Ganga whose water once again started getting used by living creatures in various ways. This came true just solely because of the halt in the flow of industrial effluents due to shutdown of the industries, factories and plants.

But this is a broader picture. In the present study, the quality of the River Ganga water did not show any striking improvement. The changes were observed only with minor improvements. The present findings are significantly different from other recent studies. Most of the studies showed a vivid and obvious improvement in the water quality. A positive change in the water quality has been seen as a result of break in the discharge of effluents from various sources. Uttarakhand Pollution Control Board reports [11] have stated that the water quality of the Ganges in

Haridwar was considered fit for drinking after the stoppage of industrial dump. The improvement has been obvious enough to mention that the same areas, water was not even suitable for bathing earlier.

A lot of improvement was seen between Haridwar and Kanpur as the whole stretch was laden with industries which were closed during the lockdown. According to Uttar Pradesh Pollution Control Board [11], a level of dissolved oxygen of at least 7 mg/L is considered to be a number which shows that water has minimum impurities. The report of UPPCB [11] suggested that the DO level is found at 8.9 mg/L in upstream and 8.3 mg/L in downstream. The data shows a significant improvement in water quality in the state of Uttar Pradesh.

An assessment report shared by the Central Pollution Control Board [11] has revealed that improvements have been found in the quality of Ganga water. The water collected from most of the points stated that the water has improved in quality so much that it was considered suitable for bathing and aquatic life. According to the expert of IIT Roorke the water of River Gangs from Devprayag to Har ki Pairi become fit for drinking, this indicates that faecal coliform (FC) was not present in that area [12].

The Central Pollution Control Board [13] even mentioned that an improvement in water quality was seen in U.P. against lack of improvement in Bihar and West Bengal. Sewage concentration was high in most of the areas along the stretch.

The Central Pollution Control Board [13] has further revealed in its report that the water quality of the Ganges had gone down from 64.6% to 46.3% while the lockdown continued. The water was not suitable for human consumption in any form, not even bathing, leave alone drinking.

Bihar State Pollution Control Board [14] came up with a finding that the water at the banks of the river in Patna showed an improvement in quality with a decrease in TC and FC whereas an increase in DO, BOD and pH. The TC and FC count has shown a drop at Digha similar to the present study. The DO increased to 8.7 mg/L from the earlier figure of 7.7 mg/L which is quite above the normal level of ≥ 5 mg/L [15].

In comparison to the above data, the present study has shown minor improvements in few areas while showing an overall increase in water pollution even in the lockdown. The findings differ from the other studies on the ground, that the reports which showed an improvement were prepared on the basis of samples collected from the upstream and midstream rivers. Those areas were heavily industrial in nature and a halt on commercial and industrial activities stopped industrial waste from being dumped in the river with only access to domestic waste.

On the contrary, Bihar is a state which is more agrarian rather than industrial [16]. It means that industrial waste was minimum in the state since the beginning. Hence, lockdown had no such effect on the water quality from that perspective. Yet another reason for an increase in the pollutants in Bihar can be linked to heavy migration of laborer back to the state. An increase in the population led to more water consumption and more of domestic sewage dumping in the river.

The pH level during normal days was reported between 7.0 to 9.0 [17]. The pH level (8.0 to 8.84) during lockdown in comparison to the normal situations has not witnessed any difference as such. On the other hand, Zafar and Alappat [18] revealed a lower pH during their research. They mentioned in their research that the pH level was below 8.

The data obtained in the present study showed a decrease in pH level but still fit for fish fauna (6.5 -9) and for irrigation purpose (6.0-8.2) [19]. The decrease in pH level has possibly been observed due to higher rainfall during the lockdown as the pH of rain water is slightly acidic i.e 5.5 which resulted in dilution of water [20].

In the present study, the DO value ranged from 8 to 9.7 mg/l. DO was found to be slightly lower at Digha (from 8.7 to 8.6 mg/l) and higher at Aami (from 8.2 to 8.9 mg/l) and Arrah (from 8.6 to 9.7 mg/l).

The DO level during lockdown showed a decline in some places while an increase at others. In reference to this, Alam and Pathak [21] reported a lower level of DO in the year of their research while Li et al. [22] Behra et al. [23] revealed a higher level of DO in other rivers which they took for the study.

An increase in DO confirms that the water is less polluted whereas a decrease in level means that the water is more polluted [24]. According to the WHO standard, the DO level should be > 6.5 mg/l for drinking purpose and 4.0mg/l for fish and aquatic life.

The analysis of the findings stated that there was not much improvement in DO levels. The observed findings were under the permissible limit but it stated regular discharge of domestic sewage which may result in decrease of DO level at one site. The other sites showed an increase which may possibly be due

to rainfall in those areas which dilute pollutants and also create waves in water. 60% excess rainfall observed during the lockdown period in most of the district fall under the Ganga basin [25].

In the present study, the BOD value ranging from 1.2 to 2.2 mg/l. BOD was found to be slightly higher at all the stations, Digha (from 1.4 to 1.6 mg/l), Aami (from 1.4 to 1.8 mg/l) and Arrah (from 1.6 to 2 mg/l).

An increase in BOD confirms that the water is more polluted whereas a decrease means that the water is less polluted [26]. According to the WHO standard, the BOD level should be 2 mg/l for drinking water.

BOD level rose to a great extent in the Ganga River during the lockdown. In comparison, Sun et al. [27] studied the BOD level during different seasons and found that the level rose to the highest point in August while dipped to the lowest in November. Adding to it, they even found that the BOD. Level was low during the months from September to February. Sundarajan and Anand [28] also supported the study with similar findings in their research. On the other hand, Zafar and Alappat [18] reported a higher BOD level in some of the Indian rivers. Sinha et al. [29] also supported the study with similar findings in their research.

The increase in BOD level was under the permissible limit but an increased value clearly indicates an increase in domestic sewage discharge which can be a resultant of excess washing and bathing during the lockdown to maintain proper hygiene. Another reason for the increase in BOD level may be mentioned as migration of labours to the state from other parts of the country. The shift in the demography of Bihar increased the populace along the banks, villages, towns, outskirts, etc.

Total and faecal coliform bacteria are sensitive and commonly used indicators of bacterial pathogen contamination of natural waters. Presence of E. coli in water indicates recent faecal contamination. Their presence also indicates potential presence of micro-organisms that are pathogenic to human beings [30,31].

According to WHO, Total Coliforms organism MPN/100 ml shall be 50 or less for drinking water and 500 or less for outdoor bathing. During the course of study, the value of TC and FC were always found above the limit but there was a decrease (from 54000 to 3900 (MPN/100 ml) in Total Coliform (TC) at Digha. However, it showed an increase at Aami (from 12000 to 35000 (MPN/100 ml) and Arrah (from 7900 to 22000 (MPN/100 ml). The observation also showed declinein FC at Digha from 11000 to 2200 (MPN/100 ml) but an increase at Aami from 4400 to 17300 (MPN/100 ml) and Arrah from 2700 to 3067(MPN/100 ml).

The microbial contents showed a different view at different sites. The FC and TC were found to have increased at some sites during the lockdown while a decrease in FC and TC was reported at other sites. Jawed et al. [32] and Mishra [33] also found a high level of microbial contents in the rivers during normal days too. Contrary to this, Rajiv et al. [34] and Rani et al. [35] reported lower microbial contents in Indian rivers before the pandemic struck the world.

Rain and flood may be the cause of bringing faecal matter to the river during this period. Discharge of domestic sewage and municipal waste, decaying of organic material, increasing the river water temperature and depletion of DO may contribute a significant elevation of Total Coliform and Faecal Coliform contamination in river water bodies [36].

A large amount of increase in the TC and subsequently in FC was observed at Aami and Arrah during the course of study. The reason may be stated as a growth in the population due to the migration of laborer back to their native places in Bihar which resulted in an increase of domestic waste and particularly the faces.

6. CONCLUSION

It is very evident that the decrease in water pollution of River Ganga has been found mostly in the industrial areas as compared to the non-industrial ones. In non-industrial areas, not much improvement has been seen because the domestic waste dumping did not stop and even increased in maintenance of hygiene. Though temporarily, the river has seen good days due to the lockdown and stoppage of effluents. The findings go well with the statement of Prof. Mishra from IIT (BHU) [12] who is also the President of SMF that even though the DO in the Ganges has improved during lockdown, the FCC is still high on count. To conclude, the present study agrees with the opinion of Prof. Mishra who said that no doubt the lockdown helped in the improvement of the water quality in Ganga but the same was not true for every area and region. Artefacts have played an important role here. The water still cannot be considered so pure that it may be used for drinking because the FCC needs to be 0 for the purpose. Nonetheless, it has upgraded to the stature that it may be used for bathing as the function is possible if FCC is considered less than 500.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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