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Healing of Rivers during Coronavirus Lockdown in India: A Statistical Approach

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Abstract

Human life came to a standstill as many countries implemented lockdown due to the novel coronavirus disease pandemic (COVID-19) which hit the world severely in the first quarter of 2020. All types of commercial and domestic movement came to a standstill, perhaps for the first time in history. This shutdown for sure made a positive impact on environment. The present study, is an attempt to statistically analyse the parameters of four major rivers of Uttar Pradesh, India. Ganga, Hindon, Gomti and Yamuna at different site locations, data before and after lockdown was compared and results were motivating as almost all rivers showed an improvement in water quality parameter before and after lockdown. Although the partial lockdown has contributed to a positive impact on water quality. Reduction in economic activities and improved water quality across the river water environment because of decrease in flow of pollutants in rivers also seems to be responsible for these results. Following parameters were analysed pH, COD(mg/l),temperature, BOD, chlorides(mg/l), calcium as Ca(mg/l), DO, Alkalinity as $CaCO_3$(mg/l), magnesium as Mg(mg/l), hardness as $CaCO_3$(mg/l), TDS(mg/l), feacal coliforms (MPN/100ml), total coliforms (MPN/100ml) . Surprising results came out where river Yamuna showed a record breaking decline of 98% in coliform content after lockdown, perhaps creating history. River Ganga showed a sharp decline in TDS (Total Dissolved salts) before and after lockdown followed by coliform content decline once again indicating that lockdown allowed these rivers to breathe which was not fulfilled by so many projects in the past years. Our findings suggest that there is ample scope for restoring the global environment from the ill-effects of anthropogenic activities through temporary shutdown measures

Keywords: Coronavirus, Water quality, DO, BOD,COD, Coliforms.

INTRODUCTION

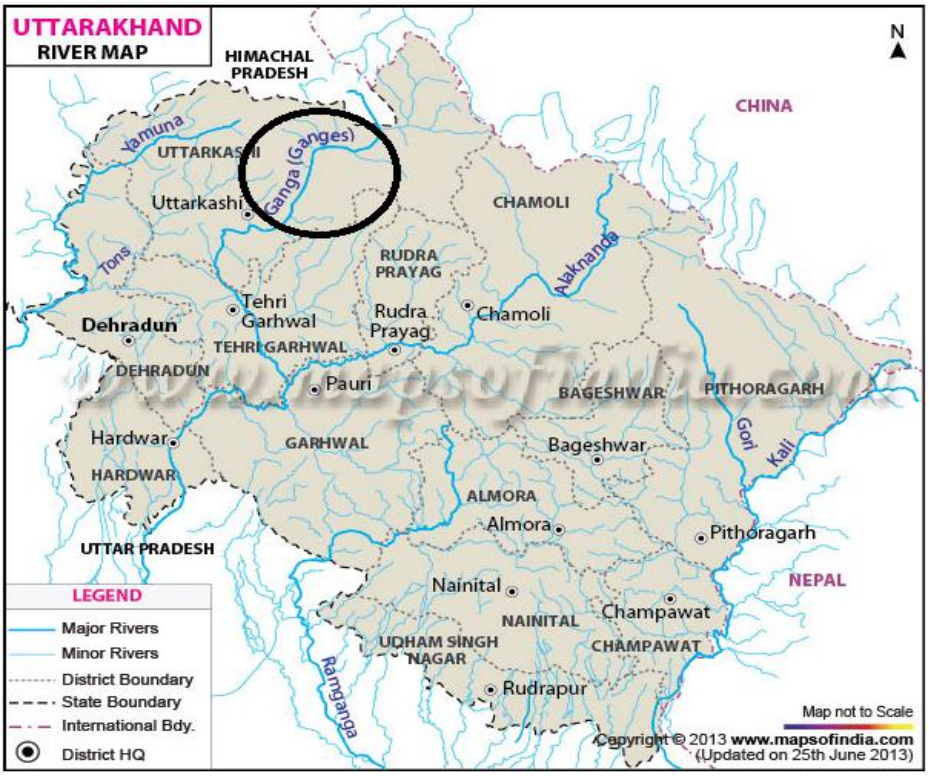
The novel corona virus disease (COVID-19) has put millions in the throes of adversity and still [1], we can say that there is a reason to celebrate. Over a month into lockdown one can find reports coming up of clean environment , water bodies , air quality and other pollution levels. India's water bodies have always been in a poor state [2] due to industrial and sewage waste being dumped in them. In the name of economic growth, most rivers and streams have almost turned into sewer canals [3] and it is getting difficult to treat them. The present work is an attempt to evaluate the impact of the lockdown due to the COVID-19 lockdown on water quality parameters.

With country shutting down schools, industries, businesses, travels, and the international and state boundaries closed, it is stated and proved in several studies that anthropogenic activities are considered as one of the key drivers of pollution in all spheres of the environment [4]. The nationwide lockdown was imposed on March 25, 2020, and within 10 days, signs of improvement in water quality started surfacing. According to the real-time water monitoring data of the CPCB, out of the 36 monitoring units placed at various points of the Ganga river, the water quality around 27 points was found suitable for bathing and propagation of wildlife and fisheries.[5] Since people's movements and industrial activities were closed for weeks, it is expected that pollution loads to the environment got decreased. While these improvements in environmental pollution are considered to be temporary, the current level of pollution in the atmosphere, biosphere, and hydrosphere could be much lower than the pre-COVID-19 period.

Quantifying the status of pollution during the lockdown period is an important task for researchers [6] to understand the effect of the COVID-19 spread on the environment in the short- and long-term. For decades, the hydrosphere has been severely polluted because of rapid urbanization, industrialization, and overexploitation. During the lockdown period, the major industrial sources of pollution that affect aquatic ecosystems, such as industrial wastewater disposal, crude oil, heavy metals, and plastics[7-8], have shrunk or completely stopped. Therefore, the level of pollution is expected to be reduced, reappearances of many aquatic species began after lockdown[9-10]. This study made a first attempt to quantify the level of ambient water pollution during the COVID-19 spread. The objective of the study is to analyze the effect of lockdown on water quality parameters with results being statistically analyzed.

STUDY AREA

Rivers Ganga, Hindon, Gomti and Yamuna are selected as a case area to study water quality before and after the lockdown. The study area forms a part of Uttarakhand for river Ganga and parts of Uttar Pradesh for Hindon, Gomti, and Yamuna, these rivers are major rivers of north India providing water to all towns located nearby. These rivers have also served as a livelihood for the local population in the form of tourism and aquaculture being a major source of income.[12]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Chamoli
Dehradun
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PITHORAGARH
Gori
Kali
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Pithoragarh
UTTAR PRADESH
NEPAL
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UDHAM SINGH NAGAR
Rudrapur
Ramganga
LEGEND
Major Rivers
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District Boundary
State Boundary
International Bdy.
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Map not to Scale
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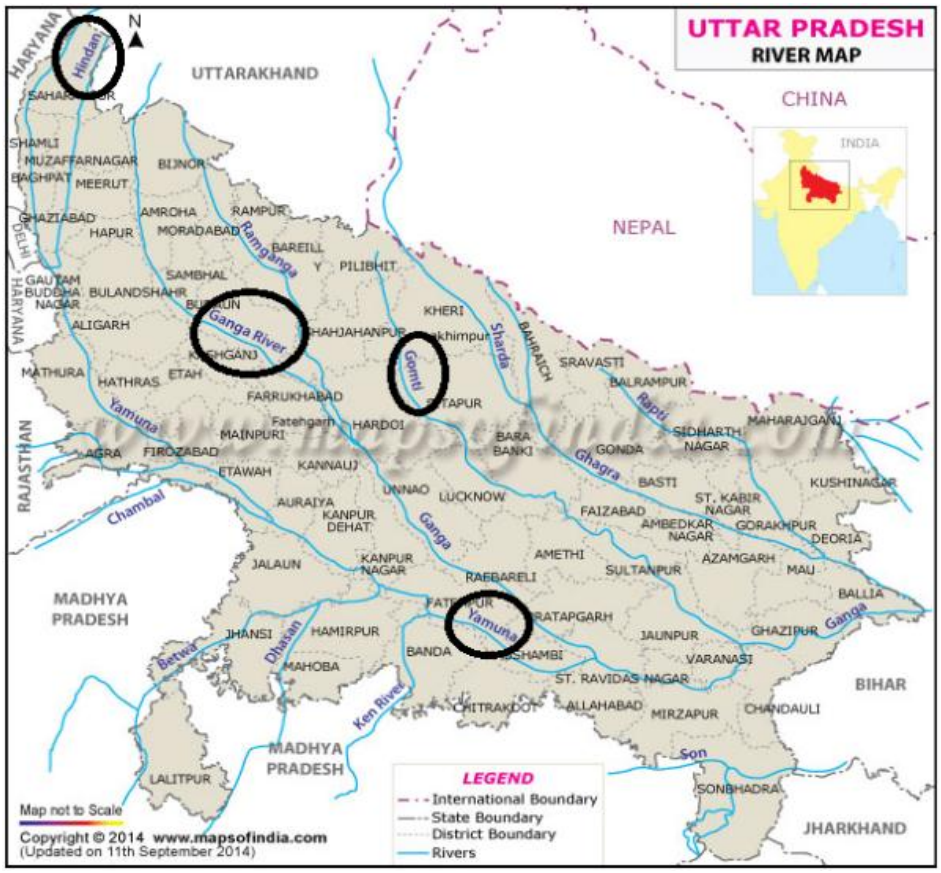
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HAPUR
MORADABAD
Ramganga
BAREILLY
PILIBHIT
SAMBHAL
GAUTAM BUDDHA NAGAR
BULANDSHAHR
ALIGARH
Ganga River
SHAHJAHANPUR
KHERI
Sharda
BAHRAICH
SRAVASTI
BALRAMPUR
MATHURA
HATHRAS
ETAH
KASGANJ
FARRUKHABAD
Gomti
Rapti
SITAPUR
Yamuna
Fatehgarh
MAINPURI
HARDOI
SIDHARTH NAGAR
MAHARAJGANJ
AGRA
FIROZABAD
BARA BANKI
GONDA
Ghagra
KANNAUJ
ETAWAH
BASTI
KUSHINAGAR
RAJASTHAN
Chambal
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LUCKNOW
ST. KABIR NAGAR
AURAIYA
KANPUR DEHAT
FAIZABAD
AMBEDKAR NAGAR
GORAKHPUR
DEORIA
Ganga
JALAUN
KANPUR NAGAR
AMETHI
SULTANPUR
AZAMGARH
MAU
RAEBARELI
MADHYA PRADESH
BALLIA
PRATAPGARH
JHANSI
HAMIRPUR
Yamuna
JAUNPUR
GHAZIPUR
Ganga
Betwa
Dhasan
BANDA
KAUSHAMBI
VARANASI
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ST. RAVIDAS NAGAR
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Ken River
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International Boundary
State Boundary
District Boundary
Rivers
Map not to Scale
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MATERIALS AND METHODS

Following parameters were analysed pH, COD(mg/l),temperature, BOD,chlorides(mg/l), calcium as Ca(mg/l), DO, Alkalinity as $CaCO_3$(mg/l), magnesium as Mg(mg/l), hardness as $CaCO_3$(mg/l), TDS(mg/l), feacal coliforms (MPN/100ml), total coliforms (MPN/100ml) were analysed for the four major rivers before and after lockdown. Water quality analysis was carried out using prescribed standards methods (APHA, 1995/Jain & Bhatia, 1987) as referred in the CPCB Manual for the present study[13].

RESULTS

As the country went into lockdown the industrial activities shut down globally [14] Dumping of wastes into rivers became almost nil because of which all the four rivers under study showed marked improvement in river water quality parameters.

River Ganga: Seven site locations for river Ganga were chosen at various points of Haridwar. Following twelve parameters were analysed for river Ganga at site locations of Uttarakhand. pH, COD(mg/l),Temperature (^{0}C), chlorides(mg/l), calcium as Ca(mg/L), BOD(mg/l), DO(mg/l), Alkalinity as CaCO3(mg/l), magnesium as Mg(mg/l), hardness as $CaCO_3$(mg/l),TDS(mg/l), feacal coliforms(MPN/100ml), Total Coliforms(MPN/100mL).As observed from Table 1, highest percentage increase was observed for calcium 7.76% before and after lockdown followed by temperature (^{0}C) of 7.66%, COD(mg/l) increased by 4.10%, pH showed an increase of 2.2%, a minor increase of 1.38% was also observed in the chloride content. TDS showed a sharp decline of 33.89% after lockdown, followed by total coliforms decreasing by 26.92%, magnesium content by 21.44%, followed by decline in alkalinity as $CaCO_3$(mg/l) by 13.27% feacal coliforms also declined by 10.78%, BOD by 5.59%, lastly a minor decline of 3.9% was observed in DO.Figure 1, 2. As per the results , minor increase in pH could be attributed to the changes in carbonate content or hydrolysable salts,[15] increase in temperature is due to weather conditions[16] as before lockdown winter season was going on and after which temperature was soaring. Minor increase in chloride concentration could be due to road salt[17] or sewage contamination[18]. Increase in calcium content could be due to natural occurrence in earth's crust[19] Decrease in BOD is a good indicator as it increases DO concentration which is necessary for survival of aquatic life.[20] Alkalinity which is a measure of the water's ability to neutralize acidity[21]. It's decrease could be due to lack of the same in soil and bedrock through which water passes. Same can be said for magnesium and other salts. Decrease in TDS could be due to lack of human activity near the river also good indicator of decline in coliform content both feacal and total are gifts of lockdown which has decreased dumping of industrial waste in the river. Since all major polluting industries are closed, the toxic load is off the river which is clearly indicated in the results. A dip in the number of visitors at ghats in Haridwar also helped the river water quality. More than 80 per cent of pollution in the Ganga is due to domestic sewage from surrounding towns and villages.[22] The rest is contributed by industrial waste.[23] Zero industrial pollution increased quality of water in the Ganga,

"Improvement in Ganga water is a function of quality and quantity. Water is not being lifted by industries, so there is more flow in the river and pollutants are getting diluted. At the same time, effluents are not being discharged. Industrial waste, however, stopped entering the Ganga. Other activities such as tourism,[24] fairs, bathing and cloth washing near the ghats were curtailed [25] .Experts said these observations reflected that domestic sewerage was not the only cause of concern.

River Hindon: This river well known for its pollution level showed a decrease of 24.25% in its BOD level after lockdown, whereas the coliform content, both feacal and total increased by 76%. (Table 2) Figure 3, 4.This could be due to increase of human activities near river due to lockdown. During the lockdown, domestic sewage would have increased owing to increased demand for water to maintain hand-washing hygiene. River Hindon no more a river is the true sense has turned more into a canal,[26] surprisingly coliform content both feacal and total was found very high after lockdown this could be attributed to the fact that dumping of sewage waste must have increased also human activities must have gone too high during lockdown and river must not have received any running water.

River Gomti: four parameters DO, BOD and feacal and total coliforms were analysed , all four factors showed a decrease in values after lockdown. Reduction of BOD could be due to discharge of untreated waste in the river. With feacal coliforms falling to 52.59%, total coliforms to 48.38%, BOD declined by 9.46% and DO by 4.81%. (Table 3). Figure 5. Lockdown had a positive impact as far the coliform content [27]was concerned with less of industrial and sewage waste being dumped in the river.

River Yamuna: Five parameters were analysed for the same, while pH showed a minor increase of 3.67%, COD, BOD, DO and feacal coliforms all declined. Highest decline of 98% was observed for feacal coliform, DO declined by 67.93%, COD by 24% and BOD by24%. (Figure 6, 7, 8)One of the most effective result of lockdown was observed in river Yamuna with a 98% decrease in coliform content after lockdown, seems dumping of industrial waste was nil, as strict lockdown was observed also seems feacal discharge near river bed was also not there during lockdown period.

Out of the four rivers studied Ganga, Hindon, Gomti and Yamuna, it was surprising to find that DO (Dissolved Oxygen) was found to decrease for all four [28] rivers after lockdown. 3.9% for Ganga, nil for hindon before and after lockdown, 4.8% decrease for Gomti, and a massive decrease 67% for river Yamuna. The reason could be attributed to the fact that inverse relationship that exists between dissolved oxygen and temperature. As the temperature of the water increases, dissolved oxygen levels decrease, because cold water holds more dissolved oxygen than warm water, also aquatic animals use up oxygen while living in water [29]also at times due to extra salts less oxygen is held by water[30]. The study suggests that seeing the results of water quality parameters before and after lockdown, that in order to improve the water quality of rivers Industries need to strictly adhere to discharge norms accompanied with strong enforcement of laws and regulations vis-à-vis strong

monitoring and vigilance framework, education and awareness needs to be carried out strategically.

COVID-19 is a global pandemic and serious threat to human health [31-32] which halt the economic activities, however it can also be considered as a "Blessing in Disguise", where pollution is reducing and nature is reclaiming itself. This positive impact on water bodies may be temporary but governments and individuals should learn from this lockdown on how to reduce pollution on long term basis. Our findings suggest that there is ample scope for restoring the river water quality from the ill-effects of anthropogenic activities through temporary shutdown measures.

Our findings also draw further attention to what will happen after the lockdown period. The rivers are surrounded by densely populated areas. The industries, tourism activities, and other businesses like hotels and restaurants especially around Ganga will start to re-open in a phased manner from mid of 2020, because of which the pollutants will eventually return to the river from the industrial and human activity. Our work showed that the pollutant level decreased considerably when industries and other activities were suspended. A sustainable solution has to be reached considering the big tourism economy in and around Ganga. This study gives confidence to the regulatory bodies that a significant improvement in water quality in India could be expected if strict execution of rotatory lockdown measures is implemented near riversides.

CONCLUSION

Significant water quality improvements were observed during the partial lockdown. Out of the parameters judged for the four rivers, river Yamuna showed most outstanding result with coliform content decreasing to 98% after lockdown. Similarly, for river Gomti the coliform content decreased by about 50%. For river Ganga both TDS and coliforms showed a decline after lockdown which is a good indicator of rivers health in COVID times.

Table 1: Comparative study of significant parameters for River Ganga before and after lockdown in terms of percentage deviation

Parameters	**River Ganga**		
	Before Lockdown	**After Lockdown**	**% increase**
pH	7.52	7.685714286	2.203647416
COD(mg/L)	4.665714286	4.857142857	4.102878138
Temp.(^{o}C)	18.04571429	19.42857143	7.663077897
Chlorides(mg/L)	9.088571429	9.214285714	1.383212826
Calcium as Ca(mg/L)	60.18285714	64.85714286	7.766805925

	Before Lockdown	**After Lockdown**	**% decrease**
BOD(mg/L)	0.953333333	0.9	5.594405594
DO(mg/L)	10.13857143	9.742857143	3.90305763
Alkalinity as CaCO3(mg/L)	84.99285714	73.71428571	13.27002269
Magnesium as Mg(mg/L)	34.18714286	26.85714286	21.44080899
Hardness as CaCO3(mg/L)	94.37714286	91.71428571	2.821506418
TDS(mg/L)	106.75	70.57142857	33.89093342
Fecal coliforms(MPN/100mL)	36.61571429	32.66666667	10.78511698
Total Coliforms(MPN/100mL)	86.664	63.33333333	26.92082833

Table 2: Comparative study of significant parameters for River Hindon before and after lockdown in terms of percentage deviation

Parameters	**River Hindon**		
	Before Lockdown	**After Lockdown**	**% decrease**
BOD(mg/lt)	56.33	42.66666667	24.25587313
	Before Lockdown	**After Lockdown**	**% increase**
Total Coliforms(mpn/100ml)	170000	300000	76.47058824
Feacal Coliforms(mpn/100ml)	140000	246500	76.07142857

Table 3: Comparative study of significant parameters for River Gomti before and after lockdown in terms of percentage deviation

Parameters	**River Gomti**		
	Before Lockdown	**After Lockdown**	**% decrease**
DO(mg/lt)	**8.51**	**8.1**	4.81786134
BOD(mg/lt)	3.645	3.3	9.465020576
Total Coliforms(mpn/100ml)	15500	8000	48.38709677
Feacal Coliforms(mpn/100ml)	8333.3	3950	52.5998104

Table 4: Comparative study of significant parameters for River Gomti before and after lockdown in terms of percentage deviation

Parameters	**RIVER YAMUNA**		
	Before Lockdown	**After Lockdown**	**% increase**
pH	7.548148148	7.825555556	3.675171737
			% decrease
COD(mg/l)	82.55555556	61.11111111	25.97577389
BOD(mg/l)	27.92962963	21.18888889	24.13473014
DO(mg/l)	13.1	4.2	67.9389313
Feacal Coliform/100ml	410787937.7	5201376.667	98.73380492

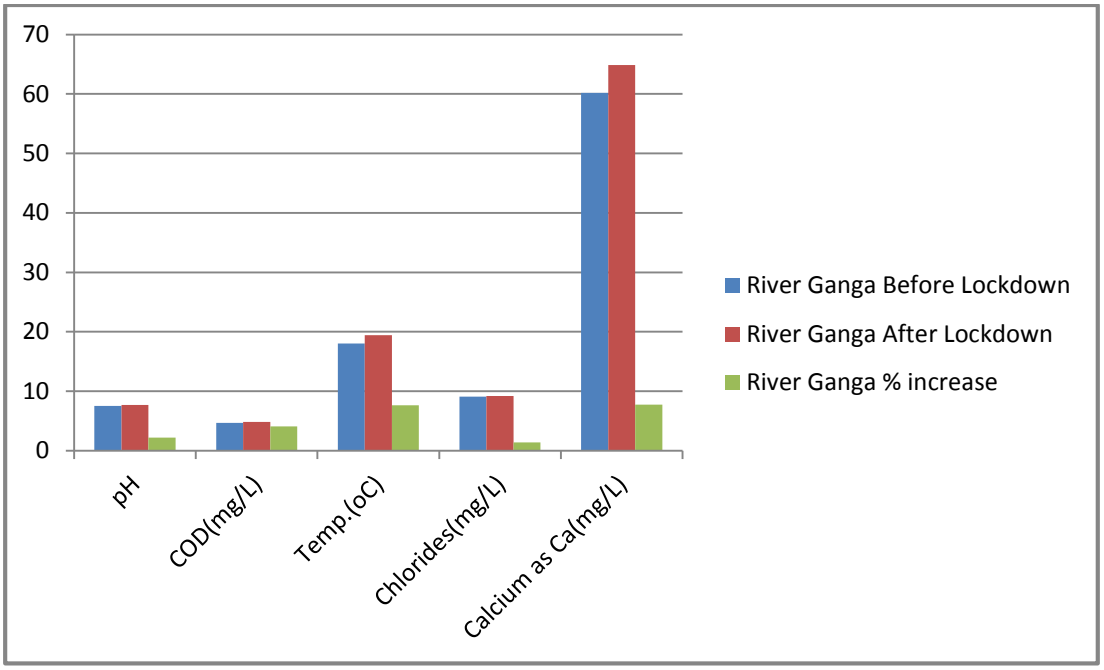

Figure 1: Variation of significant parameters for River Ganga before and after lockdown

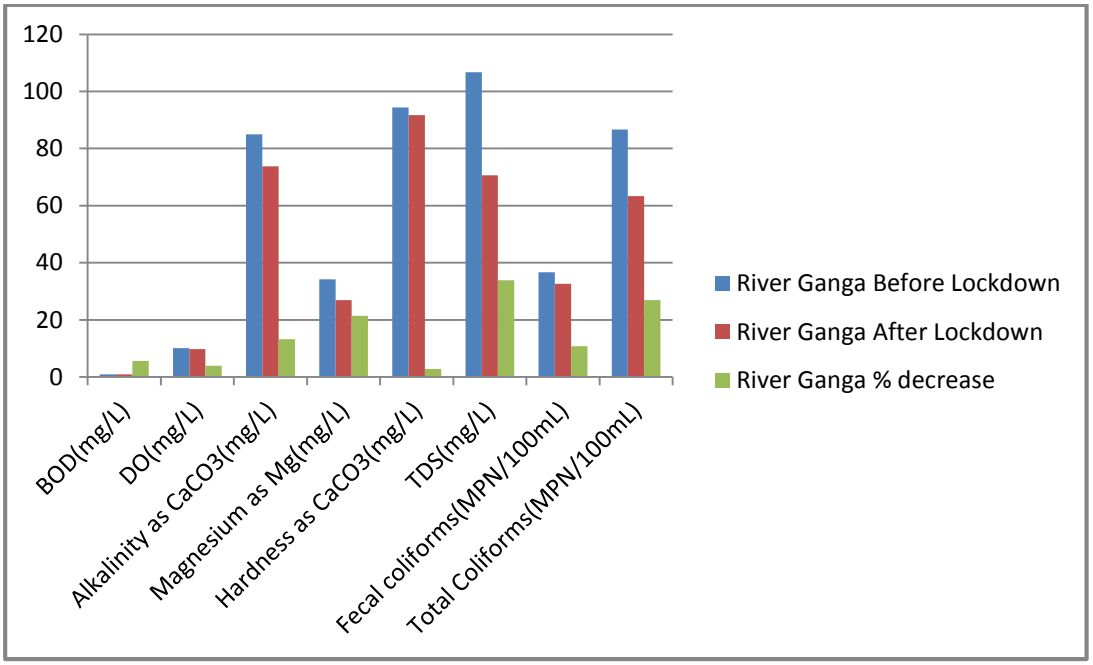

Figure 2: Variation of significant parameters for River Ganga before and after lockdown

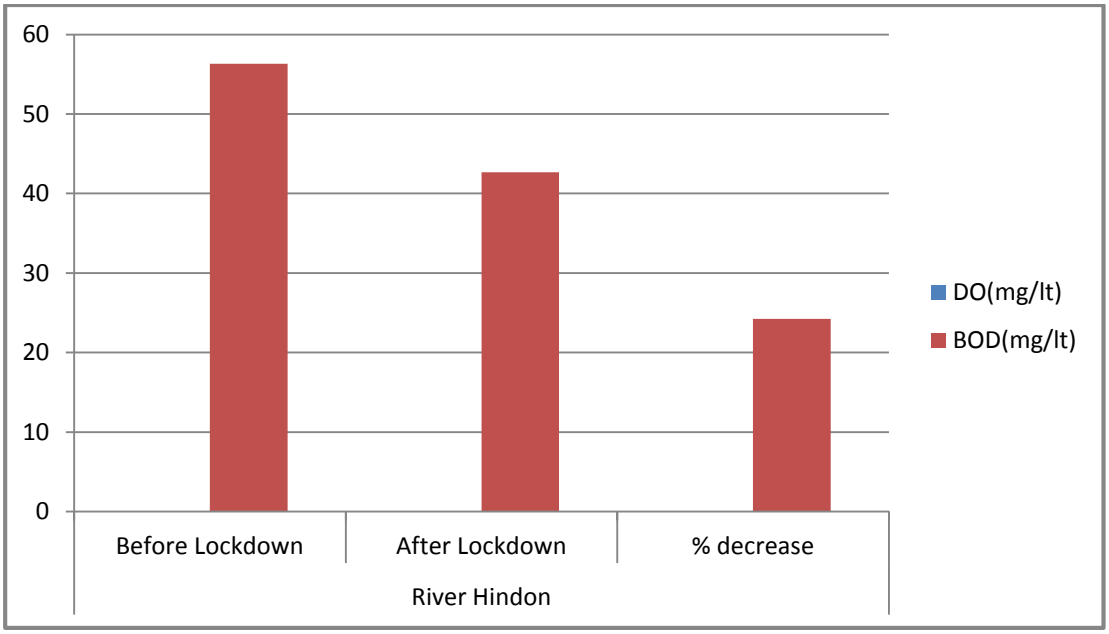

Figure 3: Variation of significant parameters for River Ganga before and after lockdown

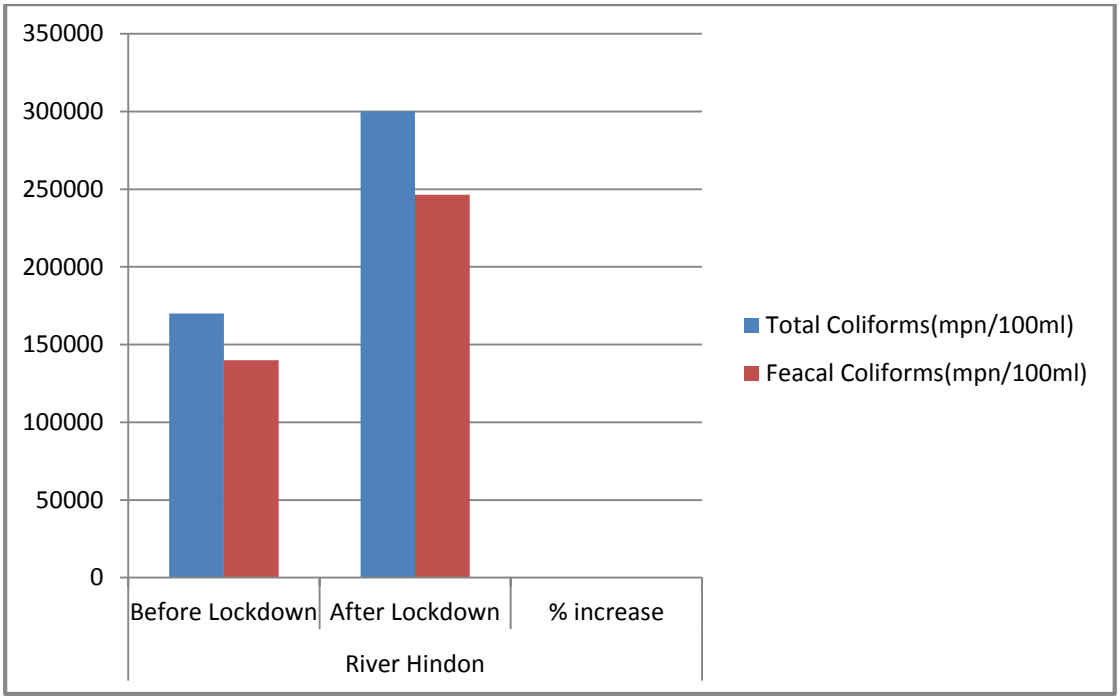

Figure 4: Variation of significant parameters for River Hindon before and after lockdown

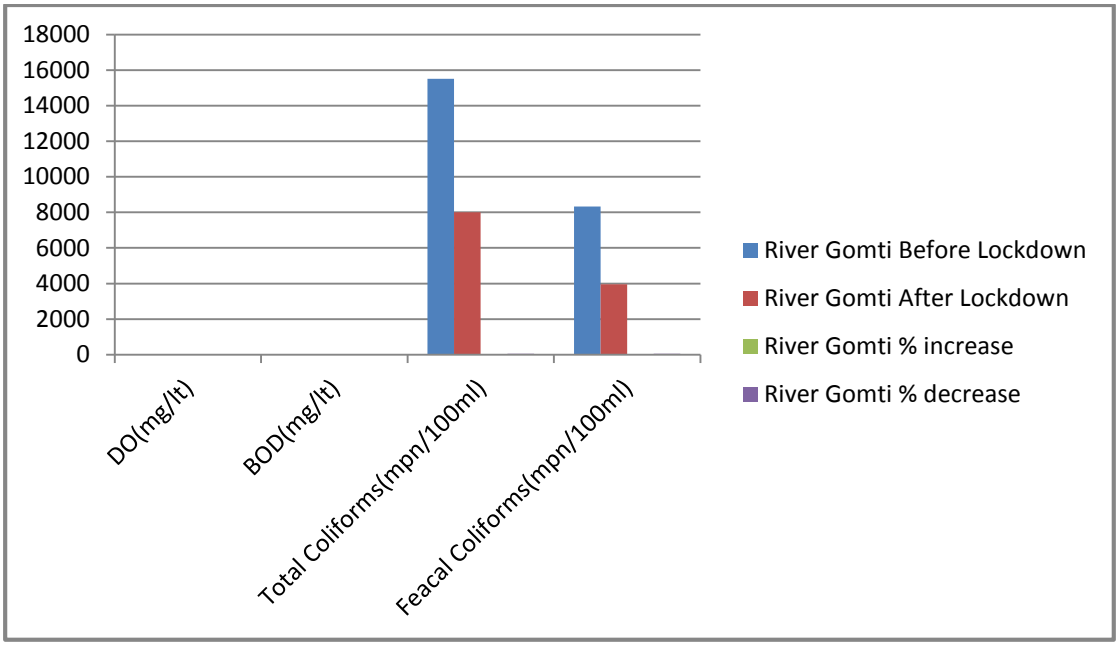

Figure 5: Variation of significant parameters for River Gomti before and after lockdown

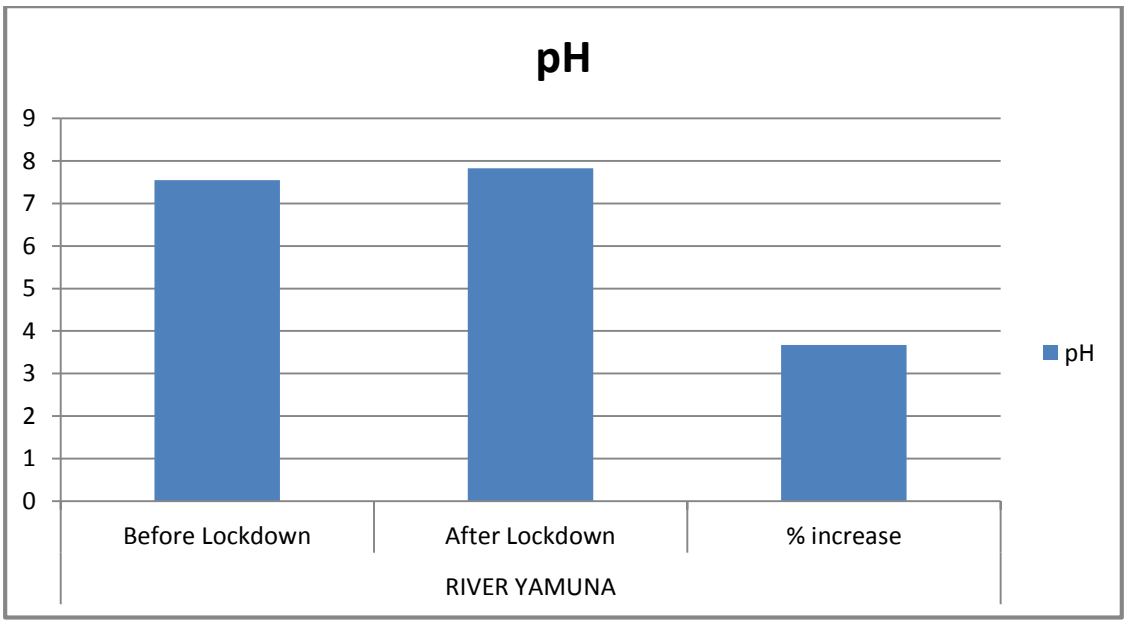

Figure 6: Variation of significant parameter for River Yamuna before and after lockdown

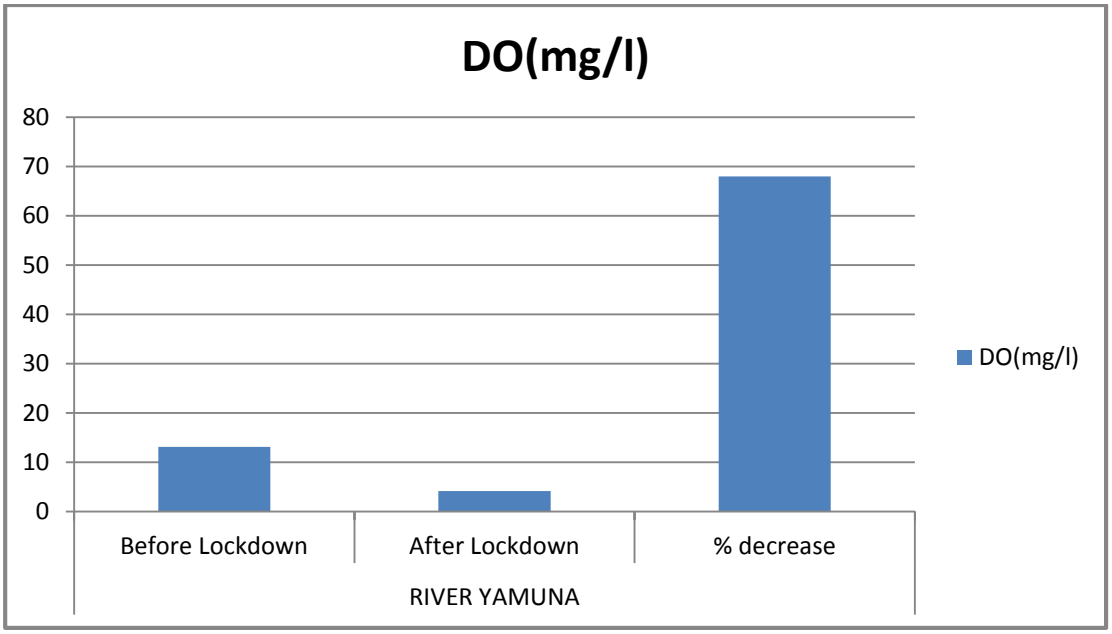

Figure 7: Variation of significant parameter for River Yamuna before and after lockdown

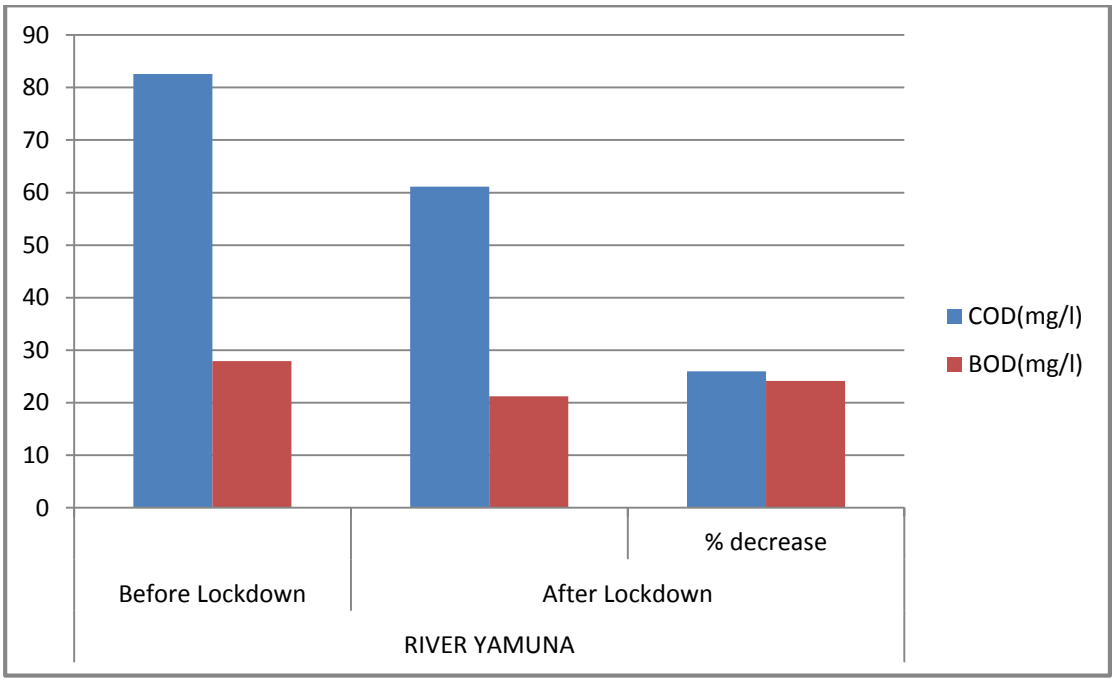

Figure 8: Variation of significant parameter for River Yamuna before and after lockdown

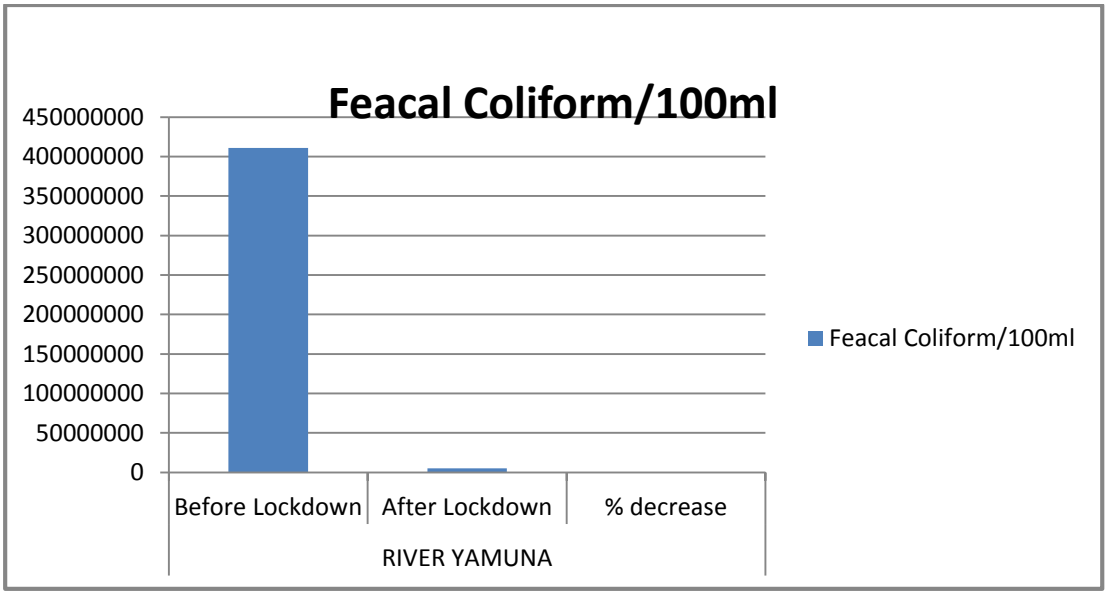

Figure 9: Variation of significant parameter for River Yamuna before and after lockdown

Conflicts of Interest: The author declares that there are no conflicts of interest regarding the publication of this article.

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