Trans. Inst. Indian Geographers
ISSN 0970-9851
Indexed in Scopus

Water quality assessment of selected polluted river stretches in West Bengal, India, during the COVID-19 lockdown

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Abstract

Water quality assessment is essential to maintain and regularly check the health status of a river. The national lockdown imposed from 25th March 2020 in India was aimed at suppressing the outbreak of the Coronavirus infections 2019 pandemic. An unintended consequence of the lockdown, however, has been a substantial rise in the amount of pollutants in most rivers in India, including those in the southern part of West Bengal. This research was undertaken to analyze the status of the water quality of six rivers in South Bengal, namely Ganga, Damodar, Dwarka, Jalangi, Bidyadhari, and Kansi, by comparing the pollution level before, during, and after the lockdown phases using the Overall Index Pollution method. It was found that throughout the period of lockdown, water quality declined greatly in the Ganga, though it was within acceptable limits in the Kansi and Dwarka rivers. On the other hand, the quality of water in the Jalangi and Damodar rivers was found to be excellent during this period of lockdown. Contrastingly, the water of the Bidyadhari river was significantly polluted at all stages of its course. The study identified Tribeni, Palta, Paltashitalatala, Dakshmineswar, Shivpur, Gardenreach, and Durgachak as the most heavily contaminated sites of the Ganga River during the confined period. The extent of contamination coming from industrial effluents was much less due to restricted industrial activity, and hence it is quite possible that continual discharge of anthropogenic waste resulted in considerable deterioration in river water.

Keywords: *Water quality; lockdown; overall index pollution, sewage treatment plants.*

Introduction

The present research investigates the alterations in water quality experienced in the wake of the lockdown following the advent of the Coronavirus pandemic during 2019-21. The study compares the quality of water during the period of lockdown to that before and after the lockdown. Needless to mention, the pandemic has had an unprecedented impact on human lives as well as livelihoods. While the efficacy of the lockdown in controlling the spread of the virus is debatable, it certainly had a positive impact on the ecosystem and environment, including rivers. Under normal conditions, industries discharge a lot of untreated wastewater into the adjacent river system. The existence of multiple major and minor factories along the river courses, as well as significant towns that serve as sources of industrial and municipal effluent, is the primary cause of water quality degradation. The imposition of strict lockdown during the pandemic therefore

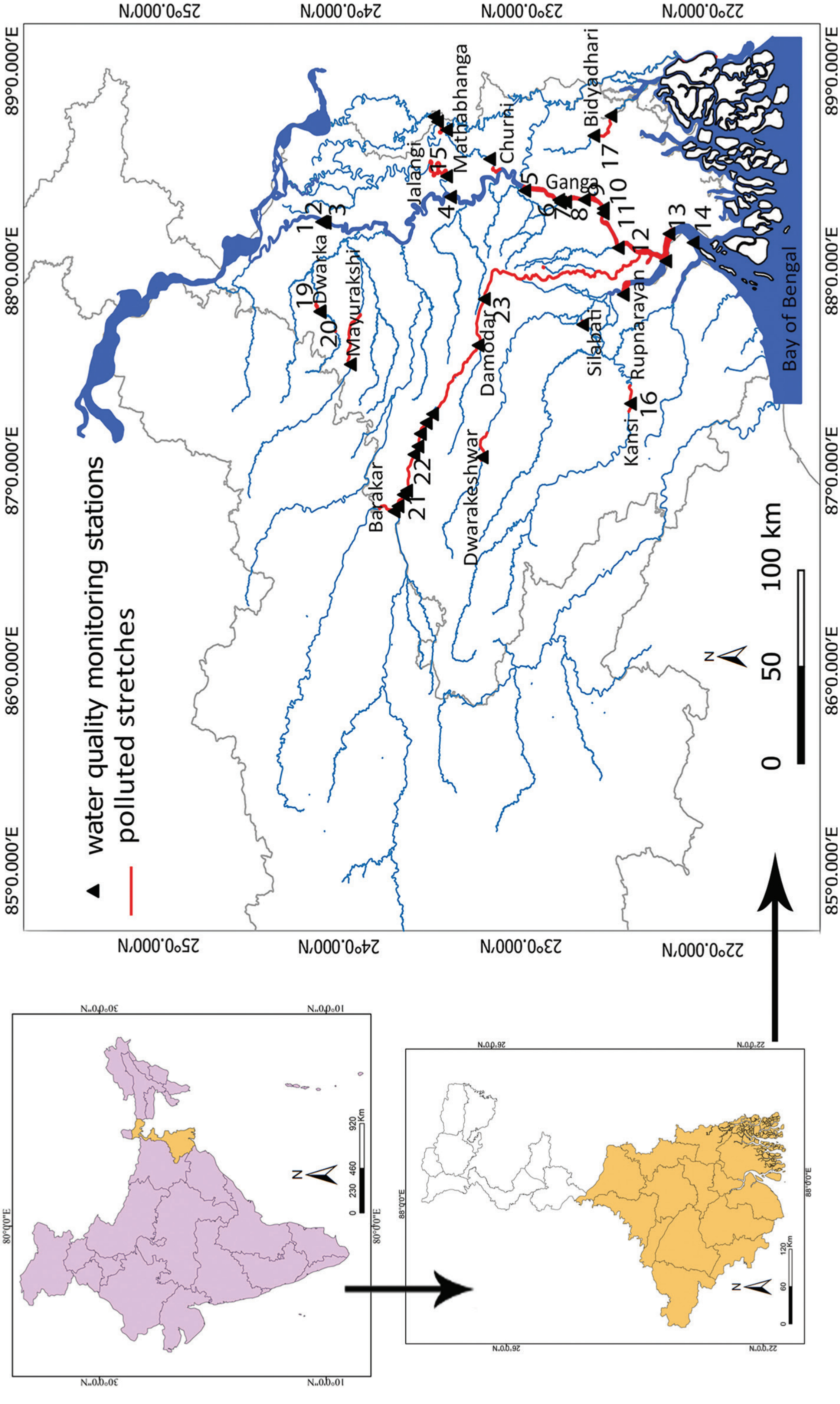

Fig. 1: Location of major polluted rivers in the southern section of West Bengal

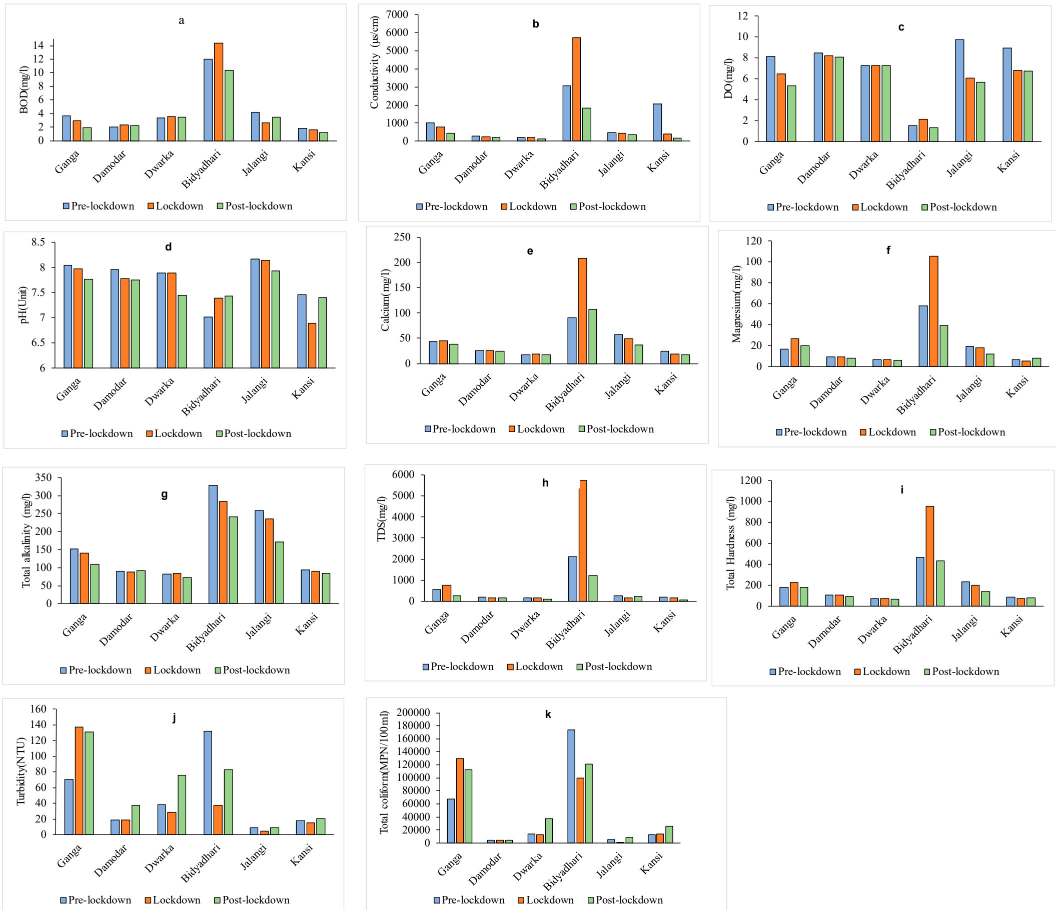

Fig. 2: Mean values of various parameters during the three consecutive phases: a) BOD, b) Conductivity, c) DO, d) pH, e) Calcium, f) Magnesium, g) Total Alkalinity, h) TDS, i) Total Hardness, j) Turbidity, and k) Total Coliform

reduced the discharge of wastewater into the river system, which eventually improved the quality of surface water (Yunus *et al.*, 2020; Tokatli and Varol, 2021). Thus, heavy mineral contamination was minimized and assisted in the rejuvenation of the surface water. This may have played a magnificent role in decreasing the pollution level, enhancing the quality of water flowing in the rivers. While this may have been true for many rivers, a comprehensive study is required to verify this claim at the micro level.

Many researchers have shown that the influence of COVID-19 improved environmental health and surface water quality in both developed and undeveloped countries. Studies on spatiotemporal changes in water quality in subtropical river basins in impoverished countries have shown a decrease in both water pollution and carcinogenic heavy metalloids (Haque *et al.*, 2022). The quality of the surface water of Turkey's Meric Ergene river basin showed a considerable improvement in the heavy

Table 1: Monitoring sites and pollution stretches of rivers (WBPCB, 2020).

Rivers	*Selected monitoring sites*	*Pollution stretches demarcated by WBPCB*
Ganga	Khagra (1), Behrampore (2), Gorabazar (3), Nabadwip (4), Tribeni (5), Paltashitalatala (6), Palta (7), Serampore (8), Dakshmineswar (9), Shivpur (10), Garden Reach (11), Uluberia (12), Diamond Harbour (13), Durgachak (14)	Khagra To Durgachak
Jalangi	Krishnanagar (15)	Laaldighi To Krishnanagar
Kansi	Gandhighat (16)	Midnapore To Ramnagar
Bidyadhari	Haroa Bridge (17), Malancha Burning Ghat (18)	Haroa Bridge to Malancha Burning Ghat
Dwarka	Satighat (19), Sadhak Bamdeb Ghat (20)	Tarapith To Sadhak Bamdeb Ghat
Damodar	IISCO (21), Assansol (22), Burdwan Town (23)	Durgachakm To Dishergarh

Note: The monitoring stations are demarcated by the following numbers from 1 to 23

metal index at all sites, as well as a drop in the total hazard index by 67 percent for children and 69 percent for adults (Tokatli and Varol, 2021). Water quality assessments in Cork Harbour on Ireland's southwest coast showed a small improvement in quality, with most indicators remaining within permissible limits (Uddin *et al.*, 2023). In developing countries such as India, several studies on water quality suggested that water quality improved during the lockdown phase. A study of the Yamuna River during the covid phase in 20 major drains revealed a decline in effluent load, an improvement of 37 percent during the restricted phase (Patel *et al.*, 2020). Similarly, the surface water condition of the Vembanad lake recovered in lockdown, alongside the average suspended particulate matter concentration reducing across 18 zones (Yunus *et al.*, 2020). Sarkar *et al.* (2021) studied the water health status of the transboundary tributaries in the lockdown period and experienced a 70 percent reduction in Biochemical Oxygen Demand (BOD), chemical oxygen demand (COD), and turbidity, and a 40 percent reduction in dissolved oxygen (DO). The assessment of surface water of the Gomti River (Khan *et al.*, 2021), the Yamuna River (Arif *et al.*, 2020), Ganga River in the upper course (Garg *et al.*, 2020; Dutta *et al.*, 2020) improved throughout various closure periods. Shutting down public hubs and factories reduced pollutant loads, but unscientific land use and anthropogenic stress did contribute to continued poor water quality. Studies are however, few in assessing water quality in different stretches of a river using systematic parameters, and the present study undertakes such a study in the southern part of the Bay of Bengal during lockdown and unlock phases.

COVID-19 provided an opportunity to restore and revitalize the quality of surface water. The primary purpose of this research is to ascertain whether restrictions and industry closures during the restrictive period enhanced the status of the surface water in comparison to the unlock phases, offering an opportunity to repair the damaged freshwater resource. As many as eleven parameters were taken into consideration for six rivers in South Bengal, with the river Ganga as the nucleus, followed by Damodar, Dwarka,

Table 2: Calculated standard deviations of eleven monitoring parameters for three different phases

Rivers	Phase	Total Coliform (MPN/100ml)	Turbidity (NTU)	Total Hardness (mg/l)	TDS (mg/l)	Total Alkalinity (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	pH (Unit)	(DO) (mg/l)	Conductivity (µs/cm)	BOD (mg/l)
Ganga	pre-lockdown	±90330.00	±131.36	±124.53	±1222.07	±21.24	±22.50	±21.15	±0.50	±1.91	±1983.73	±1.53
	lockdown	±177520.86	±245.78	±292.69	±1846.74	±31.16	±49.71	±40.24	±0.52	±1.31	±1428.25	±1.17
	post-lockdown	±109466.84	±169.86	±277.55	±468.94	±16.79	±42.61	±43.19	±0.34	±0.90	±670.94	±0.72
Damodar	pre-lockdown	±767.75	±15.05	±7.77	±64.06	±15.66	±0.86	±2.99	±0.13	±0.29	±57.91	±0.28
	lockdown	±361.48	±2.23	±11.1	±36.81	±12.61	±1.18	±3.34	±0.26	±0.19	±62.48	±0.48
	post-lockdown	±915.15	±24.16	±15.32	±39.56	±18.49	±2.16	±3.70	±0.16	±0.15	±56.36	±0.21
Dwarka	Pre-lockdown	±5521.47	±29.56	±23.16	±67.27	±10.71	±3.11	±4.15	±0.15	±0.24	±35.26	±0.36
	lockdown	±3508.09	±8.33	±15.21	±23.29	±9.09	±1.67	±3.37	±0.08	±0.17	±54.23	±0.42
	post-lockdown	±14747.88	±33.41	±13.63	±15.89	±14.89	±1.43	±4.43	±0.12	±0.27	±20.87	±0.52
Bidyadhari	pre-lockdown	±93737.22	±100.36	±228.33	±1812.51	±32.96	±46.02	±19.60	±0.25	±1.11	±1827.94	±2.51
	lockdown	±47609.52	±5.07	±423.42	±4574.76	±62.79	±58.52	±88.61	±0.13	±1.32	±2621.01	±5.65
	post-lockdown	±23166.07	±63.35	±409.94	±1318.65	±44.46	±33.11	±112.50	±0.26	±0.57	±1450.86	±2.83
Jalangi	pre-lockdown	±6321.66	±7.84	±23.48	±52.31	±10.93	±8.03	±2.76	±0.09	±1.63	±29.16	±1.92
	lockdown	±848.53	±1.46	±72.79	±21.21	±55.94	±8.76	±14.64	±0.19	±1.27	±104.37	±0.88
	post-lockdown	±7878.03	±4.83	±22.44	±27.06	±41.05	±1.83	±10.99	±0.16	±1.16	±102.36	±2.37
Kansi	pre-lockdown	±1000	±7.05	±10.26	±93.09	±1.15	±3.61	±9.71	±0.13	±0.32	±2905.46	±0.93
	lockdown	±3535.53	±2.74	±0	±33.94	±7.07	±0.81	±1.41	±0.62	±0.28	±177.53	±0.81
	post-lockdown	±11239.81	±8.89	±5.03	±18.04	±5.29	±1.53	±1.15	±0.15	±0.71	±16.35	±0.58

Jalangi, Bidyadhari, and Kansi. River Ganga passes through major industrial belts, towns, and cities in the southern part of Bengal, supporting the culture, economy, and multi-regulatory services to millions of people dependent on it. Thus, the river quality of respective monitoring stations and monthly variation seen in the river Ganga are studied for selected parameters during the three crucial phases of lockdown- before, during, and after. The overall index of pollution (OIP) approach is applied in the assessment.

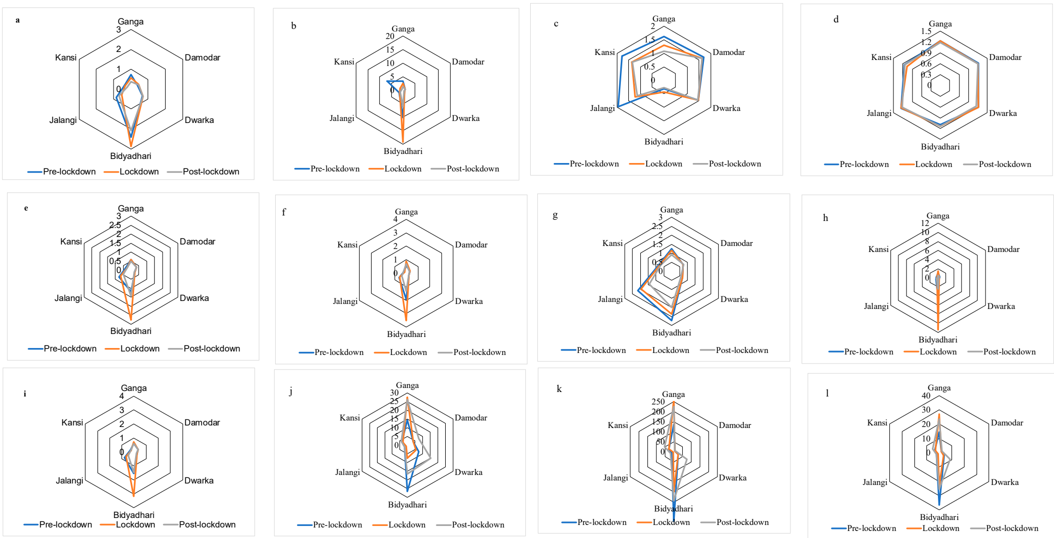

Fig. 3: Pollution index (pi) of all the parameters carried out during the three phases: a) BOD, b) Conductivity, c) DO, d) pH, e) Calcium, f) Magnesium, g) Total Alkalinity, h) TDS, i) Total Hardness, j) Turbidity, k) Total Coliform, and l) OIP

Materials and methods

Study area

The River Ganga passes through important cities like Haridwar, Kanpur, Varanasi, and Patna. The river enters West Bengal near Rajmahal hills, and from Murshidabad district, it bifurcates into the river Padma that flows into Bangladesh and continues as the Bhagirathi–Hooghly in West Bengal. The main cities through which it flows in West Bengal are Murshidabad, Behrampore, Nabadwip, Serampore, Howrah, Hooghly, Kolkata, and Diamond Harbour, before it empties into the Bay of Bengal. The Damodar River is an important feeder of the Ganga, originating near the Chotanagpur plateau and flowing through different districts of West Bengal. Dwarka, which rises in the Jharkhand highlands, is another prominent tributary in West Bengal. River Jalangi departs from the Ganga, that debouches into the river Bhagirathi and nourishes its lower channel. The headwaters of the Kansi River are in the highland regions of Purulia district, passing through the middle of the district and along the town of Purulia. The northern section flows towards the river Rupnarayan, and the southern segment joins the Haldi River. The Bidyadhari River originates near Nadia district and joins the river Raimangal (Fig. 1).

The rivers of the southern section of Bengal provide an abundant ecological service to the people in West Bengal. Hence, deterioration of Ganga's water quality constitutes a potential threat not only to the people directly, but also indirectly by adversely affecting the surrounding ecology. The terrain morphology, transportation accessibility, and connectivity make this zone ideal for industrial and agricultural activities. Major industries such as the jute industry along the Jalangi River, mining industries along the Dwarka River, and wastewater from tanning plants in and around the megacity of Kolkata all drain to the Bidyadhari River, resulting

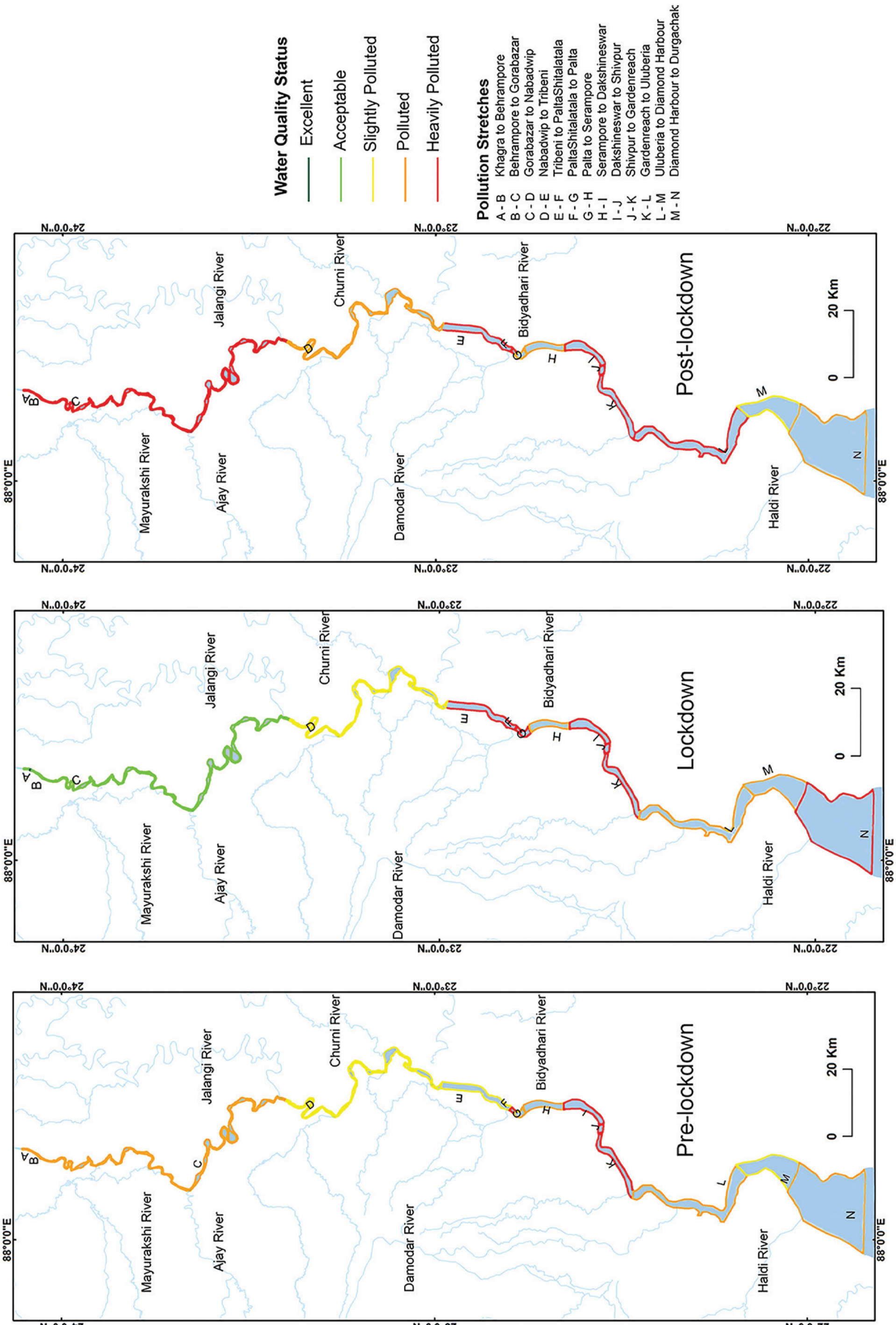

Fig. 4: WQI of the river Ganga examined from Khagra to Durgachak monitoring sites

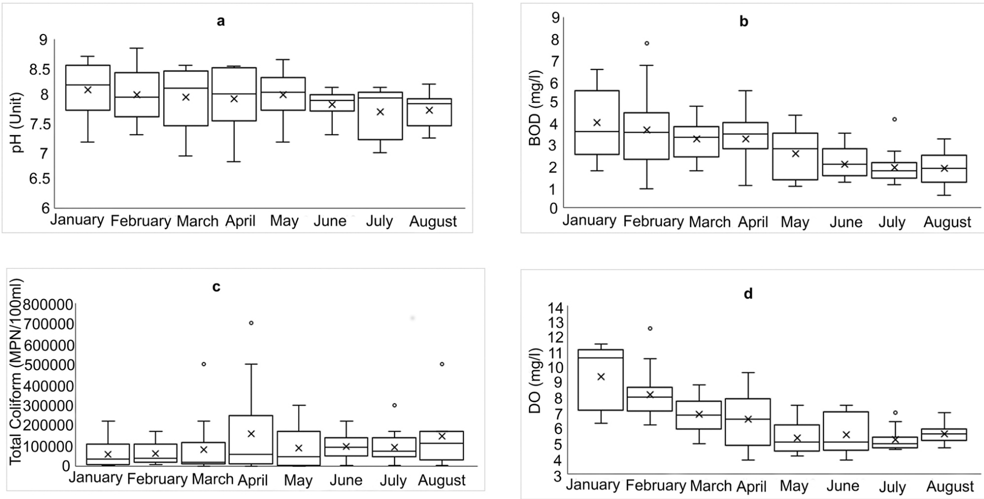

Fig. 5: Monthly variation of four parameters of the river Ganga:
a) pH, b) BOD, c) Total Coliform, and d) DO

in a decline in water quality. The upper and middle catchments of the Damodar River are rich in minerals and Gondwana coal reserves. These minerals promote the growth of big industries and urban centers. High population density and untreated sewage from adjacent settlements pollute the Kansi River.

The West Bengal Pollution Control Board (WBPCB, 2020) identified major polluted stretches in West Bengal based on industrial clusters, sewage outfalls, and the location of major towns and cities, as well as effluent discharge levels. The six main rivers were chosen because of their national importance, susceptibility to pollution, and data availability.

Data collection, monitoring river quality, and its parameters

The water quality index is a valuable tool for measuring water quality parameters. Various researchers have employed different methods to measure water quality. The Horton water quality index first emerged in 1960, following the National Sanitation Foundation (NSF) index and the Dinius index. Nowadays, diverse water quality indexes have been used, like the Oregon Water Quality Index (OWQI), the British Columbia Water Quality Index (BCWQI), the Canadian Council of Ministers of the Environment Water Quality Index (CCME-WQI), the West Java Index, and the Weighted Arithmetic Index. The overall index pollution (OIP) method has been found more useful to measure the condition of the surface water, dealing with multiple treatment level categories, and is increasingly adopted by scholars (Kamboj and Kamboj, 2019; Sargaonkar and Deshpande, 2003; Shukla *et al.*, 2017).

Calculation of WQI

$$OIP=\Sigma pi/n \qquad (1)$$

Where Pi = pollution index of each parameter and n = number of parameters

$$Pi = Vn/Vs \qquad (2)$$

Where Vn = Observed value of parameter, Vs = Standard Value of parameter

Data on different parameters is collected from (https://www.wbpcb.gov.in/) for the months of January to August 2020 to study the water quality of six rivers. Different points of monitoring stations and pollution stretches are designated based on Google Earth. The six rivers, namely Ganga, Bidyadhari, Dwarka, Jalangi, Damodar, and Kansi, are analyzed. The water quality index (WQI) was measured using eleven vital physiochemical parameters in fourteen stations from the Ganga River (known as Bhagirathi-Hooghly in West Bengal), three from Damodar, two from Dwarka, two from Bidyadhari, and one station from Jalangi and Kansi (Table 1). Water quality values for each river were collected for the months under each successive period, and then the mean value was calculated for each specific parameter. Lastly, data were aggregated, and phase-wise WQI for monitoring stations was calculated. The data from the monitoring sites is utilized for assessing the water quality condition of each river. WQI is estimated for three periods: pre-lockdown (January to March 2020), lockdown (April and May 2020), and post-lockdown (June to August 2020). The parameters are analyzed following the Bureau of Indian Standards (BIS, 2020; Kamboj and Kamboj, 2019). The pollution sites (stretches) for the river Ganga have been marked as A (Khagra station) to N (Durgachak station) to assess its quality. The WQI of 14 monitoring stations of the Ganga River has been individually focused on and presented. Lastly, the four main parameters, Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), pH, and Total Coliform (TC), have been selected to examine the monthly variation for the Ganga River (January to August) and the correlation among water quality parameters is studied. The parameters are examined from the 14 monitoring stations along the Ganga River.

Result and discussion

Mean value and standard deviation of parameters

The average values (pH) of River Ganga before lockdown are 8.0 ±0.50, during lockdown is 7.98 ± 0.52, and in post-lockdown are 7.77 ±0.34. The Damodar River shows more or less equal pH values for the pre-lockdown phase. The pH value for the Bidyadhari river is 7.39 ±0.13 (lockdown) and 7.43 ±0.26 (post-lockdown phase), indicating its alkalinity nature. Jalangi shows the highest alkalinity value with 8.17 ±0.09, in pre and 7.93 ±0.16 in post-lockdown (Table 2). It is clear that Jalangi, Kansi, and Bidyadhari have reduced their turbidity (T) levels during lockdown. The mean values of electrical conductivity (EC) of the river Ganga are 999.24 ±1983.73 µS/cm (pre-lockdown), 785.51±1428.25 µS/cm (lockdown), 416.30 ±670.94 µS/cm (post-lockdown) phase respectively. For the Damodar and Dwarka rivers, the content of total dissolved solids (TDS) is within the permissible limit. The mean concentration for Bidyadhari is quite high during lockdown (Table 2). During the study, the higher BOD level during the lockdown in the Bidyadhari river was 14.40 ±5.65 mg/l, and the lowest BOD in the Kansi river was 1.15 ±0.58 mg/l. In the Ganga, there is a slight increase in the alkalinity level for pre-lockdown and during lockdown, 151.09±21.24 mg/l and 141.01 ±31.16 mg/l, respectively (Fig. 2). The Bidyadhari River is the most polluted river as it contains 173333.33 ±93737.22

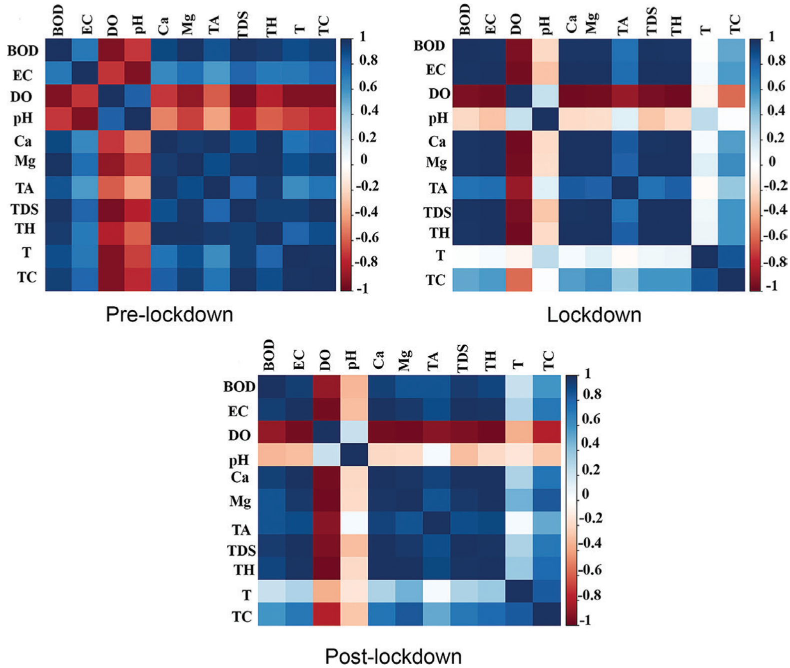

Fig. 6: Determination of Pearson correlation among different variables of water quality

MPN/100ml in pre-lockdown, 100000 ±47609.52 MPN/100ml during lockdown, and 121666.67 ±23166.07 MPN/100ml in post-lockdown.

Water Quality Index analysis

Bidyadhari River's pollution index (pi) for BOD value was 2.4 prior to lockdown and 2.8 during lockdown. The river has the maximum conductivity value of 19.16 (pi) during the lockdown. The value of dissolved oxygen shows a slight increase from 0.3 (pre-lockdown) to 0.43 (post-lockdown) for this river (Fig. 3). The pollution index of pH value for all the rivers varied between 1.08 and 1.26 during all three phases. The highest pollution index for calcium (Ca) (2.77) and magnesium (Mg) (3.52) is during lockdown for the Bidyadhari River (Fig. 3). The highest total alkalinity (TA) value is shown in the Bidyadhari River, which was 2.73 during pre-lockdown and 2.01 during lockdown. The two main rivers that have a high TDS pollution index are the Ganga (1.51) and Bidyadhari (11.44) during the lockdown. Out of all the rivers during lockdown, the Bidyadhari River has the highest pollution index for total hardness (TH). The pollution index of total coliform is highest during lockdown, with 259.63 for Ganga and 200 for the Bidyadhari river (Fig. 3). The Ganga shows that during lockdown, the value increases to 27.07. The maximum OIP value for Dwarka River is 8.67 in the post-lockdown phase, whereas it is 36.24 for Bidyadhari River before lockdown and 23.12 during lockdown. The OIP values of other rivers are listed in Fig. 3. The WQI of 14 assessment sites of the river Ganga has been considered and explained separately (Fig.4). The whole stretch seems to be polluted and heavily polluted except the lower part (Fig. 4). WBPCB assessed the water quality at the tracking stations of the rivers in West Bengal and declared them unsuitable for bathing. The agricultural waste, effluents from various industries, and neighbouring urban area carried and discharged pollutants into the Bidyadhari river through the sewage canal, which are not so high in mercury content for sediment contamination but concern in terms of water quality (Bhattacharya *et al.*, 2014).

Monthly variation for selected parameters

Four parameters were utilized in this study to compare the monthly fluctuation in water quality of the Ganga River using the Central Pollution Control Board's (CPCB) class B water standard for outdoor bathing. The monthly discrepancy in the data range for BOD, DO, total coliform, and pH is measured and interpreted on the basis of the percentage of deviation (Fig. 5). The post-lockdown phase from June to August shows the lowest mean BOD level with a -58.71 percent deviation from the standard value in June, -62.21 percent in July, and -63.14 percent in August, and the pre-lockdown phase shows -19.36 percent in January, -26.5 percent in February, and -35.36 in March. The mean value of pH ranges from 7.72 to 8.11 for all the months. Total coliform is the only parameter for which mean values are amplified more than their standard value. A correlation matrix with a significance level of 0.05 percent is displayed between the variables during the three subsequent stages (Fig. 6). For the pre-lockdown phase, highly positive interrelations are observed between calcium and total hardness ($r = 0.989$, $p < 0.05$), magnesium and BOD ($r = 0.983$, $p < 0.05$), TDS and BOD ($r = 0.970$, $p < 0.05$), TDS and total coliform ($r = 0.982$, $p < 0.05$), total coliform and turbidity ($r = 0.981$, $p < 0.05$) and TDS and EC ($r = 0.803$, $p < 0.05$) respectively. During the lockdown period, there is a high positive correlation between EC and TDS ($r = 0.999$, $p < 0.05$) and EC with total hardness is ($r = 0.992$, $p < 0.05$). Calcium also has a positive correlation with Total dissolved solids and total hardness.

Factors affecting quality

Rainfall

Rainfall has a peculiar effect on river quality. Prior to the years, rainfall intensity was maximum in April and May at 421.3 mm, and the Bidyadhari river has an OIP score of 23.12. The increase in rainfall has slightly decreased the pollution status from prior to the lockdown phase to confinement. Overall, the results show that rainfall has a minimal impact on decreasing pollution levels. For example, the Kansi river has an OIP value of 3.79 during the pre-lockdown period and receives 115.5 mm of rainfall (IWD, 2016-2020); during the lockdown phase, 375.6 mm of rainfall results in an OIP value of 3.26. The Jalangi river is in excellent condition after receiving 275.90 mm of rainfall during lockdown in Nadia, although monsoon rain with a high intensity of 803.90 mm is acceptable. The pollution value and rainfall intensity in the Damodar and Dwarka Rivers are inversely related. During the lockdown, Kolkata showed significant rainfall in 2020, but the quality of surface water in the Ganga River was heavily polluted in Dakshmineswar and Gardenreach stations. Ganga River flows through those districts to achieve sufficient rainfall during all periods, but the quality of the river does not show restoration, and it increases the turbidity levels.

Industrial Sewage and Domestic Sewage

Industrial effluent and sewage generation directly into the river create high pollutant levels in the water and enhance the high organic load and low DO (Giri *et al*., 2022). During lockdown, due to the closure of large enterprises, it can be assumed that industrial effluent slowed down the contamination of water. The pollution status of the Damodar River is excellent during the lockdown and is within permissible limits during post-lockdown, as revealed from the data from the monitoring station at IISCO (Indian Iron and Steel Company), Asansol, Burdwan.

In the downstream stretch, West Bengal estimated sewage generation of 3142 million liters per day (MLD) but with a treatment capacity of 448 MLD, and a gap of 2694 MLD (Dutta *et al*., 2020). Enhancement of water quality was seen around the industrial zones with a reduction of 1300 to 1340 MLD of industrial load. Bazarpara- Garighat Drain (Dhulagarh industrial area), Dhankheti Khal (small-scale industries), Telkal Ghat Drain (Industrial area, Howrah), Kamarhati Drain, Titagarh Drain, Bally Khal, and Bhatapara Drain (Jute mills) are major contributing dischargers for both industrial and domestic sewage.

The Ganga River near the industrial area of Gardenreach and Uluberia was heavily polluted due to an increase in domestic sewage. An experiment on pollutants in Circular Canal, Dakshineswar Canal, Khardah Khal, and Ballykhal and shows an accumulation of huge BOD load, low dissolved oxygen, and high bacterial composition during the pre-monsoon compared to the monsoon season (Kar *et al*., 2022).

The major sewers in West Bengal, from which 7375 MLD of sewage (BOD discharge) is released to the river Ganga, are the major cause in the entire river system of West Bengal (MINARS, 2020). Increase in domestic sewage during the lockdown period apparently enhanced the pollution level in the Ganga River (Singhal and Matto, 2020). Out of the 34 Sewage Treatment Plans (STPs), 13 STPs were found to be nonoperational. The Ganga River sewage generation and treatment capacity in West Bengal is much worse. Kolkata generates 618.4 MLD sewage, and its treatment capacity is a mere 172 MLD- only 24 percent treatment capacity. The Kolkata region contributes (74%), 55,443 kg/day, Kamarhati 6,310 kg/day (8%), and Khardaha 2,330 kg/day (3%) (CPCB, 2013). Kolkata metropolis acts as a source of domestic sewage in the Bidyadhari River. This river serves as an extra rainwater outlet and wastewater effluent discharge from Kolkata and adjacent areas. The outflow of sewage canals is also connected with the Bidyadhari River. Bidyadhari River also comprised leather complexes and tanneries. The tributaries also failed to input fresh water to the river Ganga (Bhagirathi-Hooghly in West Bengal). The river Churni, which itself is heavily polluted in all the phases of measurement, and the river Rupnarayan also discharged extremely hazardous water with a water quality value of 17.76 during lockdown. Temporary shutdown of the crushing units and stone quarrying industries resulted in a slight increase in the WQI of the Dwarka River. The Jalangi River’s status was better during the unlock phases, and changed to an excellent water quality status due to a stop in the discharge of industrial effluent from milk producer industries in Krishnanagar. The mixing of municipal sewage and wastes from non-point sources is responsible for the polluted status during the post-lockdown phase.

Conclusion

The COVID-19-induced lockdown had a substantial impact on the water quality of West Bengal's major rivers. A comparison of water quality parameters for different phases revealed varied patterns due to diverse forces operating for different rivers and for different segments of a river. The WQI improved for the Jalangi and Damodar Rivers due to the effect of the lockdown. Kansi and Dwarka also showed acceptable WQI during the lockdown, but during the unlock phase, the quality deteriorated. During the shutdown and post-lockdown phase, however, the Ganga and Bidyadhari Rivers displayed heavily polluted water quality status. The intensity of rainfall is sufficient for dilution of pollutants in rivers, but the excess discharge of anthropogenic waste through drains and high-turbid runoff has failed to minimize the pollution levels. The major causes of deterioration in the quality of river water during the confined phase are domestic sewage, the use of excess water, the deposition of organic and inorganic matter due to sanitization, a lack of maintenance in STP (Sewage Treatment Plans), and non-functionality of various effluent drains. It may be concluded that a stretch-specific water quality assessment, identifying the socio-ecological system, implementing proper land use planning and developing a strategy for efficient water use in polluted zones with the help of scientific techniques, regular monitoring of water quality, regular checks of anthropogenic interference, and the use of organic and chemical-free pesticides are most imperative.

Competing interest

The corresponding author declares that they have no conflict of interest.

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