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Imprints of pandemic lockdown on subsurface water quality in the coastal industrial city of Tuticorin, South India: A revival perspective

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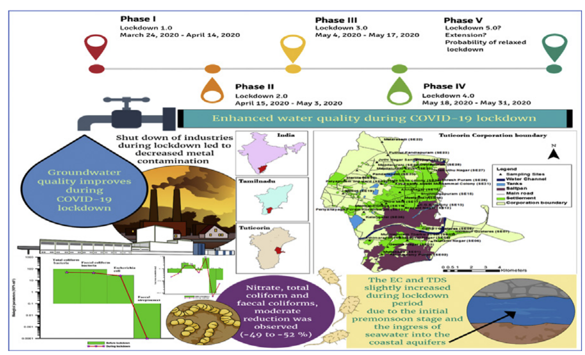
HIGHLIGHTS

- As, Se, Pb and Fe mirrored reduction in industrial waste during COVID-19 lockdown.
- NO_3 and *coliform* reduced due to closure of industrial activities including fisheries.
- Area under industrial use and surface water availability exhibited better imprints.
- Factor analyses illustrated diminishing of water quality contrast following lockdown.

GRAPHICAL ABSTRACT



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ABSTRACT

Globally, the incidences of environmental improvements owing to seizing the anthropogenic activities during the lockdown have been reported through news articles and photographs, yet a formal scholarly study has been lacking to substantiate the imprints of lockdown. We hereby present the imprints of lockdown on water quality (both chemical and biological) parameters during the nationwide lockdown (COVID-19 epidemic) in India between 25th March to 30th May 2020. The present study describes the changes in chemical and biological water quality parameters based on twenty-two groundwater samples from the coastal industrial city of Tuticorin in Southern India, taken before (10 and 11th February 2020) and during the lockdown (19 and 20th April 2020) periods. The physico-chemical parameters compared are pH, total dissolved solids (TDS) and electrical conductivity (EC), nitrate (NO_3), fluoride (F), chromium (Cr), iron (Fe), copper (Cu), zinc (Zn), cadmium (Cd), lead (Pb), arsenic (As), and selenium (Se), and the bacterial parameters are *total coliforms, fecal coliforms, E. coli*, and *fecal streptococci*. Among the metals, the significant reductions in Se (42%), As (51%), Fe (60%) and Pb (50%) were noticed probably owing to no or very less wastewater discharges from metal-based industries, seafood-based industries and thermal power plants during the lockdown. Reduction in NO_3 (56%), *total coliform* (52%) and *fecal coliforms* (48%) indicated less organic sewage from the fishing industries. Contents of Cr, Cu, Zn and Cd, however, remained similar and fluoride did not show any change, probably as they were sourced from rock-water interactions. Similarly, we did not observe alterations in *E. coli* and *fecal streptococci* due to no significant change in domestic sewage production during the lockdown. The multivariate analyses aptly illustrated this and the principal component analyses helped to identify the sources that controlled water qualities of the lockdown compared to the pre-

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lockdown period. Our observation implies that groundwater is definitely under active interaction with surface waters and thus a quick revival could be observed following the seizing of anthropogenic activities.

1. Introduction

While the dreadful global lockdown to reduce the casualties from the novel coronavirus (SARS CoV-2) is ongoing, a few efforts are also being made to understand the positive effects of seizing the anthropogenic activities during this unprecedented Corona Virus Disease 2019 (COVID-19) pandemic. Although, in general, the webpages and newsprints around the globe are filled with pictures, essays and opinions in support of the positive impacts of lockdown on several environmental dimensions, yet a scholarly work explicitly focusing on highlighting the difference in the groundwater chemistry is completely lacking. In the mere sense, no one would have planned a study before and during lockdown due to the surprise element involved with COVID-19 lockdown, yet we have been lucky to have sampled the groundwater from the city of Tuticorin in Southern India in February to be compared it later after a month of lockdown.

Now this is well-known that COVID-19 was first reported in Wuhan (China) during December 2019 and the number of cases in India increased three-fold between 30 January and 3 February 2020 (Kachroo, 2020; Sinha, 2020). It amplified to 23,077 confirmed cases by 24th April 2020 and included 17,610 active cases, 4748 recovered cases and 718 deaths with an average doubling rate of 10 days. As of third week of May 2020, the total number of worldwide reported cases exceeded 5 million marks, the death toll also surpassed 0.28 million. Irony is that some of the developed countries on planet including the United States are the worst affected. The number of cases and deaths exceeded >1.7 million and >100,000 respectively in the US, and the higher numbers of cases in Spain (with 283,339 cases 27,117 deaths), Brazil (394,507 cases with 24,593 deaths), UK (265,227 cases with 37,048 deaths), Italy (230,555 cases with 32,955 deaths) and France (182,722 cases with 28,530 deaths) indicated the effect of this pandemic in different parts across the world. (Our World in Data, 2020; Gayathri, 2020; Worldometer, n.d). Overall, the ongoing pandemic COVID-2019 has created a global health emergency in >200 countries around the globe and infected a large number of hosts (>5 million people) with a mortality rate of ≥3.6% (Kumar et al., 2020a, 2020b). The Indian government implemented the nation-wide lockdown from 25th March to 30th May 2020 by reducing public transportation and closing the industries to restrict the social contacts. During the lockdown time, the industrial hubs witnessed decrease in pollution from the closure of factories as well as ban on the free movement of workers.

The COVID-19 pandemic related global lockdown is likely to begin a revival and recovery process amidst the fast-paced changes in this human "supreme" world. However, the extent and quantum of the revival is still unknown and just being speculated. The cluster lockdowns as a result of the COVID-19 pandemic has however forced us to ponder about the self-revival ability of the ecosystems, an aspect which has been taken for granted by humans since centuries. Indubitably, it can

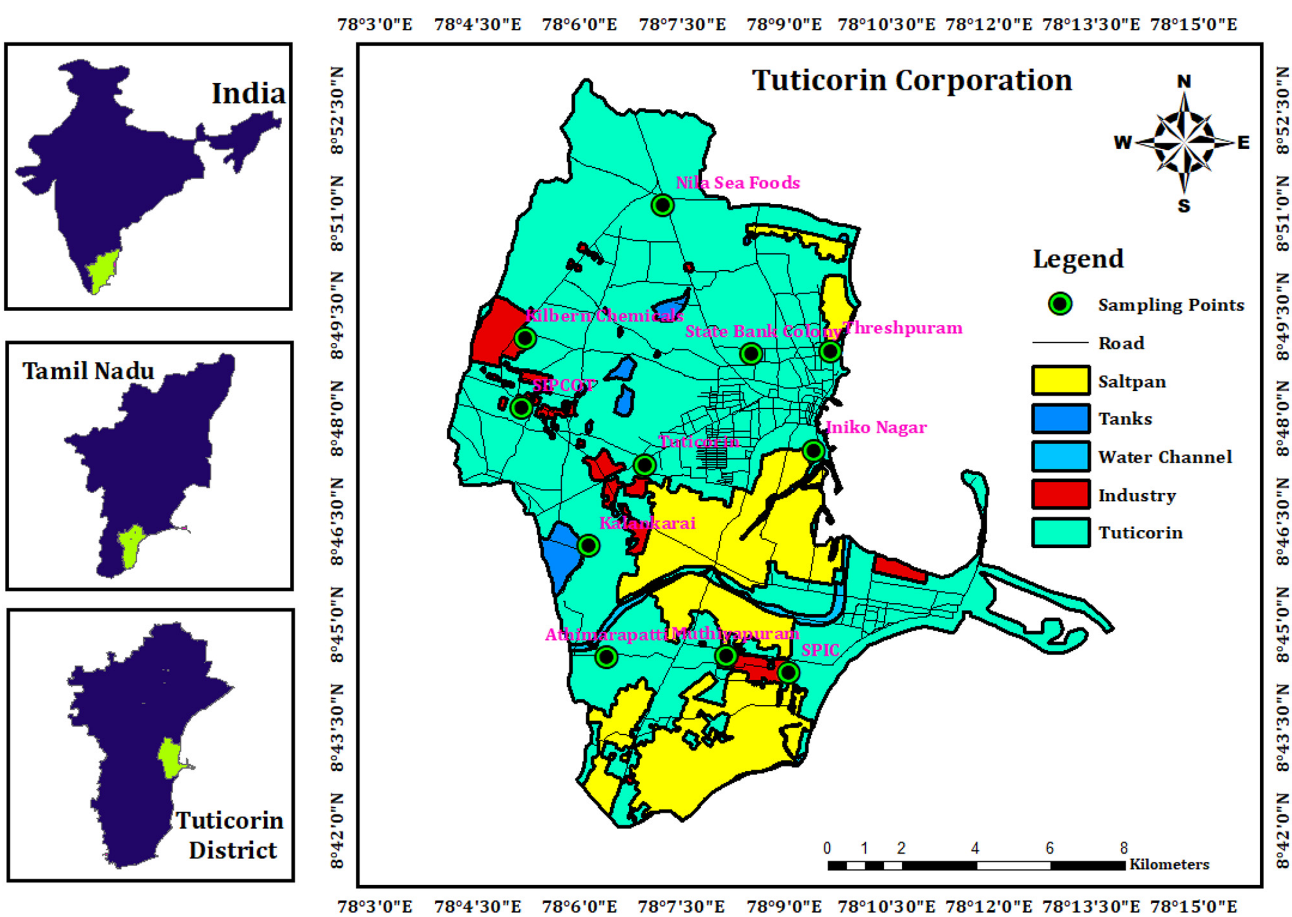

Fig. 1. Location map of the study area at Tuticorin industrial city in south India along with sampling points of groundwater and nearby industrial sectors.

be recorded that numerous problems are existing with the lockdown for both public movement and behavior, yet the unconfirmed and unevaluated changes and experiences are observed around the world in terms of environmental restoration and environmental planning. The two most readily observed aspects have been recorded in the context of ecological disturbances (air and water pollution). Therefore, we hereby present a case of groundwater restoration through chemical and biological quality parameters, under the landuse of one of the major industrial hubs (Tuticorin) in Southern India, during the lockdown period. We opted to study the groundwater rather than the surface water with a hypothesis that any change in groundwater quality is more difficult in short period than that of surface waters and that the change reflected in subsurface aquifers will also help to exhibit the extent of surface-groundwater interactions.

2. Materials and methods

2.1. Study area

Tamil Nadu (TN) state in the southern India has experienced rapid industrialization owing to shift in the focus from rural to industrial-scale farming. Several public protests and demonstrations against increasing environmental pollution over the last two decades led to the publication of formal policy documents in 2018. There are four major industrial towns in TN, i.e. Tuticorin, Chennai, Coimbatore and Erode. The industrial Tuticorin city covers about 206 km^2 of area between the northern latitude of 8° 43′–8° 51′ and eastern longitude of 78° 5′–78° 10′ (Fig. 1). The approximately 9.35 km long Buckle Canal is currently used as a drainage system in the western part of the city. However, the untreated wastewater from urban areas and neighboring industries runs through it. The Sterlite (copper), Southern Petrochemical Industries Corporation (SPIC), Tuticorin Alkali Chemicals and Fertilizers (TAC), Heavy water plant, Kalpaka chemicals, Nila seafood and Kilburn chemical products (titanium dioxide) are some of the major industries in the study area. Presence of other medium and small-scale industries also lead to the creation of product synergies. In addition, there is a significant segment of industries related to salt and household marine product, minerals (ilmenite, and grenades), dried flowers, cooking oil extraction, clothing and herbs. All these industries were closed during the lockdown of COVID-19 epidemic.

2.2. Sample collection and analysis

A total of 22 samples were collected before lockdown (10th and 11th February 2020) and during the lockdown period (19th and 20th April 2020) from open and tube wells at 11 locations in the vicinity of industrial and agricultural zones. Sampling strategy was to involve the representative samples of all the landuse and landcover features of the study area. Samples were collected after 5–10 min of purging to get the representative groundwater from the tubewells, which were then filtered using 0.45 μm filter papers and collected in in prewashed 250 ml high-density polyethylene (HDPE) bottle. We used ultrapure HNO_3 to acidify the samples in-situ to lower pH < 2 in order to prevent microbial activities and adsorption/precipitation on the bottle wall American Public Health Association (APHA) et al., 1995(APHA-2015). The Global Positioning System (HANNA 2130) was used to fix the sampling coordinates.

We used a portable multi-sample analyzer (instrument Hanna) to determine EC, pH and TDS. NO_3 concentrations were estimated in UV–visible spectrophotometer (Systronic) and F was analyzed using ion-selective electrode (ISE) - HI4110). All the measurements in the laboratory were performed as per the American Public Health Association (APHA) standard methods (APHA, 1995). Metal (Cr, Fe, Cu, Zn, Cd and Pb), metalloids (As), and non-metals (Se) concentrations were measured using Atomic Absorption Spectroscopy (AAS, Perkin Elmer, Elan Drce) and the National Institute of Standard and Technology (NIST) standard (1640a) were used as the reference material for quality assurance and quality control (QA/QC) determination. Further, "Cetripur" multi-element AAS reference material (Merck) was used for the calibration. Microbiological quality of water was determined using the Most Probable Number (MPN) methods (IOS, 2000) and by analyzing *total coliform*, *fecal coliform, E. coli*, and *fecal streptococci*. MPN method was also used to assess the presence of most likely number of coliforms of gas-producing lactose fermenters in an aliquot of 100 ml of water.

2.3. Principal component analyses

Factor analyses are the uncorrelated (orthogonal) variables, obtained by multiplying the original correlated variables with the eigenvalue (loadings or weightings). The eigenvalues of the FA are the measure of their associated variance. The participation of the original variables in the FA is given by the loadings, and the individual transformed observations are called scores (Wunderlin et al., 2001; Singh et al., 2019; Kumar et al., 2016, 2019; Das et al., 2016, 2018). FA was performed on normalized (z-scale transformation) variables for 17 parameters after sorting out the highly correlated variables from the data sets. Factors with eigenvalue >1 were retained. The contribution of each factor at every site (factor scores) was computed, and score plots of first three factors were constructed. FA was performed to assess the compositional differences among different parameters, spatial variations in water quality, and the influence of anthropogenic activities due to the COVID pandemic lockdown. The results FA were produced by SPSS (Ver.20).

3. Results

We evaluated the differences in groundwater quality during the lockdown (19th and 20th April 2020) and before lockdown (10th and 11th February 2020) periods with reference to the WHO (2017) guidelines for drinking water. Table 1 presents the electric conductivity (EC), hydrogen ion concentration (pH), total dissolved solids (TDS), nitrate (NO_3), fluoride (F), and concentrations of As, Cr, Fe, Cu, Se, Zn, Cd, Pb, *total coliform, fecal coliform, E. coli and fecal streptococci* in groundwater.

3.1. Physico- chemical parameters

The pH of samples before the lockdown (7.1–8.9) and during the lockdown (7–8.5) were almost similar (Table 1), with a slight decline in the maximum value. Lack of significant change indicates that the boreholes were operational even during the lockdown period to serve the need for drinking water. On the other hand, the upper limits of EC and TDS increased during the lockdown period i.e. EC changed from 410–4210 μs/cm before the lockdown to 350–5687 μs/cm during the lockdown and likewise, TDS increased from 420–5456 $mg \cdot L^{-1}$ to 450–6520 $mg \cdot L^{-1}$ during the lockdown (Fig. 2). Increased values of EC and TDS at Muthiyapuram, SPIC, SIPCOT and Threshpuram were due to positive imbalance towards seawater intrusion into the coastal aquifers than the flushing. At the same time, Tuticorin City witnessed several rainfall events during the lockdown period (AccuWeather, 2020) leading to leaching of salts present in interstice or pores of clay to the groundwater. The most interesting observation has been the increase in the spatial variability of EC and TDS during the lockdown owing to variation in the leaching, rainfall dilution and seawater incursions in different parts of the study area. It implies that in absence of anthropogenic factors natural hydrogeochemical processes govern the water quality leading to better contrast in the aquifer hydrogeochemistry.

Fluoride (F) concentrations almost remained similar (0.5–1.1 $mg \cdot L^{-1}$ and 0.4–1.0 $mg \cdot L^{-1}$) during the lockdown as well as pre-lockdown, suggesting the natural rock weathering processes rather anthropogenic factors responsible for F concentration in the groundwater. Therefore, the variations in F are owing to differences in the

Table 1
Analytical data from physio-chemical, heavy metals and biological parameters during COVID-19 before and after lockdown period.

Water quality parameters	Before lockdown			During lockdown			Variation in unit	Variation in %
	Minimum	Maximum	Average	Minimum	Maximum	Average		
pH	7.1	8.9	8.1	7	8.5	7.7	−0.4	−10%
EC	410	4210	1466	350	5687	2943	+1477	25%
TDS	420	5456	1815	450	6520	2879	+1064	19%
NO_3	35	98	84	20	42	28	−56	−49%
F	0.5	1.1	0.8	0.4	1	0.7	−0.1	−2%
As	0.012	0.083	0.071	0.001	0.042	0.03	−0.041	−51%
Cr	0.010	0.080	0.030	0.01	0.07	0.020	−0.01	−5%
Fe	0.123	0.458	0.381	0.102	0.251	0.174	−0.207	−60%
Cu	0.123	0.299	0.186	0.111	0.288	0.175	−0.011	−6%
Se	0.002	0.152	0.114	0.001	0.092	0.054	−0.06	−42%
Zn	0.568	0.95	0.68	0.523	0.934	0.664	−0.016	−8%
Cd	0	0.002	0.002	0	0.001	0.001	−0.001	−50%
Pb	0.006	0.019	0.017	0.004	0.008	0.006	−0.011	−50%
Total coliform bacteria	6.2	189	138	1.2	98	47	−91	−52%
Fecal coliform bacteria	8.9	165	119	5.3	85	39	−80	−48%
Escherichia coli	0	55	43	0	50	38	−5	−10%
Fecal streptococci	0	Est <10	Est <10	0	Est <10	Est <10	0	0%

Units: Physical, chemical and metal parameters are expressed in mg. L^{-1} except pH in µs/cm. Biological parameters are expressed in MPN ml^{-1} except *Fecal streptococci in* CFU ml^{-1}.

distribution of fluorine-bearing minerals, extent of weathering and variation in leaching. Fortunately, the samples from both the intervals had F within the potable water (<1.5 mg/l) as per World Health Organization, 2020 WHO (2017). However, the concentration of NO_3 decreased from 35–98 $mg \cdot L^{-1}$ before the lockdown to 20–42 $mg \cdot L^{-1}$ during the lockdown (Table 1 and Fig. 2) period in the urban aquifer probably due to drastic decrease in the use of farmyard manure like urea, diammonium phosphate, superphosphate and other N-bearing fertilizers. Likewise, the oxidation of ammonium present in the unsaturated zone and the urban wastewaters contribute to higher NO_3^- to groundwater. A reduction by 56%, within eight weeks following the lockdown implies minimal agricultural activity (e.g. Athimarapatti and Kalankarai) and less urban wastewater from the domestic and industrial activities (e.g. Tuticorin, Iniko Nagar, Threshpuram, Muthiyapuram) during the lockdown period.

3.2. Metals

Concentrations of Cr, Cu and Zn did not change significantly during the lockdown compared to the respective values before the lockdown (Table 1). Almost similar values of these metals in the groundwater suggest the persistent and non-biodegradable nature of metals. Metals essential for biota like Fe did show decrease owing to lockdown from 0.12–0.46 $mg \cdot L^{-1}$ to 0.10–0.25 $mg \cdot L^{-1}$ (Fig. 3). Arsenic on the other hand was also found 51% lower than the concentration before lockdown. However, the maximum decrease of 60% is noticed in the case of Fe. WHO (2017) recommends the maximum allowable As of 0.01 $mg \cdot L^{-1}$ and Fe of 0.30 $mg \cdot L^{-1}$ in the groundwater. The groundwater sampled near the Nila Seafoods, SIPCOT, and Kilbern Chemicals exhibited higher values than the permissible limits for As and Fe on both sampling occasions. Thus, the spatial features seem to be effective due to infiltration of better water quality like rain or pond or river.

Although selenium (Se) showed almost 42% of decrease during the lockdown, yet some samples illustrated Se concentration above the allowable limit (<0.01 mg/l) of WHO (2017) in both occasions. This may be attributed to natural Se present in the clay/shale of the aquifer systems at Athimarapatti, Muthiyapuram and SPIC. The decrease is because of dilution at locations with high recharge potential and stronger surface water interactions. Cadmium (Cd) did not change much but remained below the permissible limit of WHO (2017), most likely

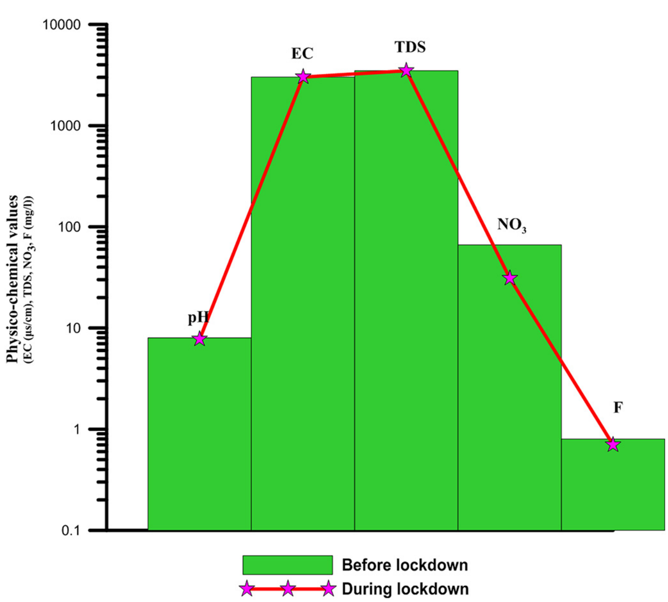

Fig. 2. Statistical significance of physio-chemical parameters in groundwater samples before and during the lockdown period related to COVID-19.

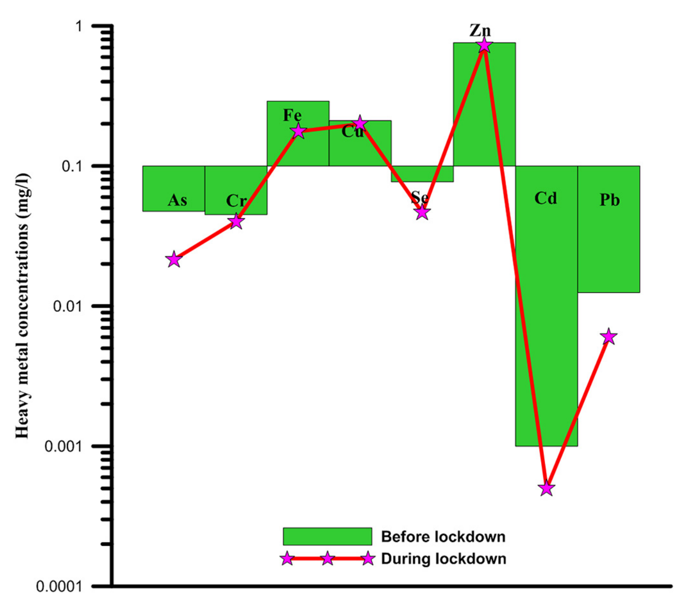

Fig. 3. Statistical significance of heavy metal concentration in groundwater samples before and during the lockdown period related to COVID-19.

owing to its non-biodegradability and persistency (Table 1). However, another metal of anthropogenic origin i.e. Pb illustrated a 50% of decrease i.e. from 0.006–0.019 mg. L^{-1} before lockdown to 0.004–0.008 mg. L^{-1} during the lockdown. Samples with Pb concentrations exceeding the permissible limit decreased and became permissible during the lockdown at Threshpuram, Iniko Nagar, SIPCOT, Tuticorin, Muthiyapuram and SPIC, which did indicate the environmental revival reaching to the subsurface environment.

Overall, an argument may be made that while some metals showed dilution, why other metals like Cd did not. Although, a pointwise comparison of each parameters under the light of specific surface and subsurface features must be made to understand and specifically reply to the question, as of now level of concentration and nature of elements seems to be playing governing role in the observed variation.

3.3. Biological parameters

Among the biological parameters, the range of *E. coli* remain unchanged in samples collected before the lockdown (0–55 MPN ml^{-1}) and during the lockdown (0–50 MPN ml^{-1}). The contents of *fecal streptococci* were <10 CFU ml^{-1} on both sampling locations. No significant variation in biological parameters may be attributed to the Buckle channel which continued as a sewage system during the lockdown period. However, *total coliform* bacteria decreased by 52% from 6.2–189 MPN ml^{-1} to 1.2–96 MPN ml^{-1} between the two sampling occasions. Similarly, the contents of *fecal coliform* bacteria reduced by 48% from 8.9–165 MPN ml^{-1} before the lockdown to 5.3–85 MPN ml^{-1} during the lockdown period (Fig. 4). The primary sources of these bacteria are animal and human wastes. Higher values in samples before the lockdown period at Threshpuram and Iniko Nagar, were indicative of high organic compounds in the groundwater close to fishing industries. Thus, the reduced *total coliform* and *fecal coliform* could be due to minimal activities in the fishing industries as well as lack of tourism during the lockdown period.

4. Factor analyses

Four factors contributed for 88.46 and 90.20% of the total variance in the dataset of before and during the lockdown periods. Factor 1 combinations remained similar as depicted by strong positive loading on pH, EC, TDS, Se, As, Fe, Cd and Zn (0.51–0.96) and pH, EC, TDS, Fe, Cu, Se, Zn, Cd and Pb (0.58–0.90) for samples collected before and during the lockdown, respectively. Factor 2 exhibited positive loading for *total coliform bacteria, fecal coliform bacteria, E. coli and fecal streptococci* for both sampling occasions (Fig. 5). During the lockdown period, the pathogens loading slightly decreased due to the minimal amount of fishing activities . Factor 3 showed the strong loading of As and Cr, indicating the anthropogenic sources of contamination from leachate percolation and abattoir waste dumped in the landfill. Factor 4 showed strongly positive loadings of Cu and Cr (0.52–0.82) and moderate loadings of NO_3 and As (0.34–0.36) before the lockdown period, implying processes associated with the anthropogenic activity. Strong loading of Cu and moderate loading of As showed anthropogenic inputs possibly through percolation from industrial effluent dumped in the landfill site. It also indicates anthropogenic inflow from municipal landfill leachate as well as the fertilizers from agricultural land. High load of nitrate was mainly found in the nearby groundwater samples (Athimarapatti, Kalangarai and Tuticorin) which again indicate landfill as the main source of nitrate percolation in groundwater. Overall, the multivariate analyses aptly illustrated that and the principal component analyses identified the sources operating in the study area as well as the differences observed among the water qualities between the pre-lockdown and lockdown periods.

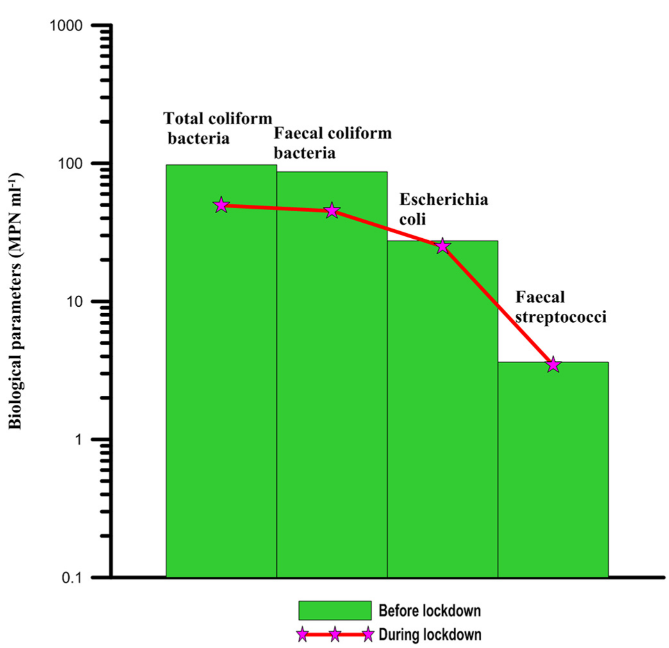

Fig. 4. Statistical significance of biological parameters in groundwater samples before and during the lockdown period related to COVID-19.

5. Discussion

We understand that changes in the subsurface environment, especially the revival would need much longer period than the relatively smaller span of lockdown. However, an imprints of revival could be witnessed in the subsurface environment owing to the facts that our samples had representation of locations that are under very active surface-groundwater interaction, sea-water intrusion , and >80 large and small-scale industries causing pollution of metal and biological pathogens (Balasubramanaian et al., 1993; Mondal et al., 2011; Puthiyasekar et al., 2010; Magesh et al., 2013; Singaraja et al., 2015; Selvam et al., 2015, 2017, 2018; this study). EC and TDS remain unchanged due to seawater influence and long seated salinity. No activities on beaches and relatively less fecal polluted seawater are also some of the impressions in this coastal city.

The study area has higher As, Se, Pb, B, Al, Fe and V (Gajendran et al., 2019) compared to the WHO permissible limits. It is mainly attributed to high wastewater discharges from industries related to chemical, fertilizer, copper, and seafood as well as the thermal power plants and to the absence of wastewater treatment plants. During the lockdown period, the large and small industries, garages, schools and colleges, large businesses and administrative blocks of government were shut down that reduced the amounts of industrial sewages and level of certain pollutants. Variations observed in metals and biological parameters reflected reduction in the industrial and anthropogenic activities. As Pb smelters and industrial waste cause the emissions of Fe, As and Pb, these metals exhibited significant reduction in the order of ~50% following the lockdown. However, the vicinity of change remains in the most polluted sites or near the municipal solid waste dumping sites like SIPCOT (Selvam et al., 2018). The concentrations of Cr, Cu, Cd and Zn, as well as the physical parameters such as EC and TDS were not related to the anthropogenic activities, i.e. industrial effluents/wastewater, and that is why they illustrated minimal reduction during the lockdown.

However, sensitive parameters of strong anthropogenic origin like concentration of NO_3, total coliforms and fecal coliforms did exhibit a clear reduction implying a revival perspective of COVID-19 pandemics. We do agree that our study is not extensive owing to lack of human power, very limited time for analytical facilities, yet we were passionate about indicating the revival imprints of lockdown in the subsurface environment. Such revival was noticed more significantly at more polluted cities or locations with good recharge and surface water availability. We have specifically pointed out that frequent rainfall accelerated such

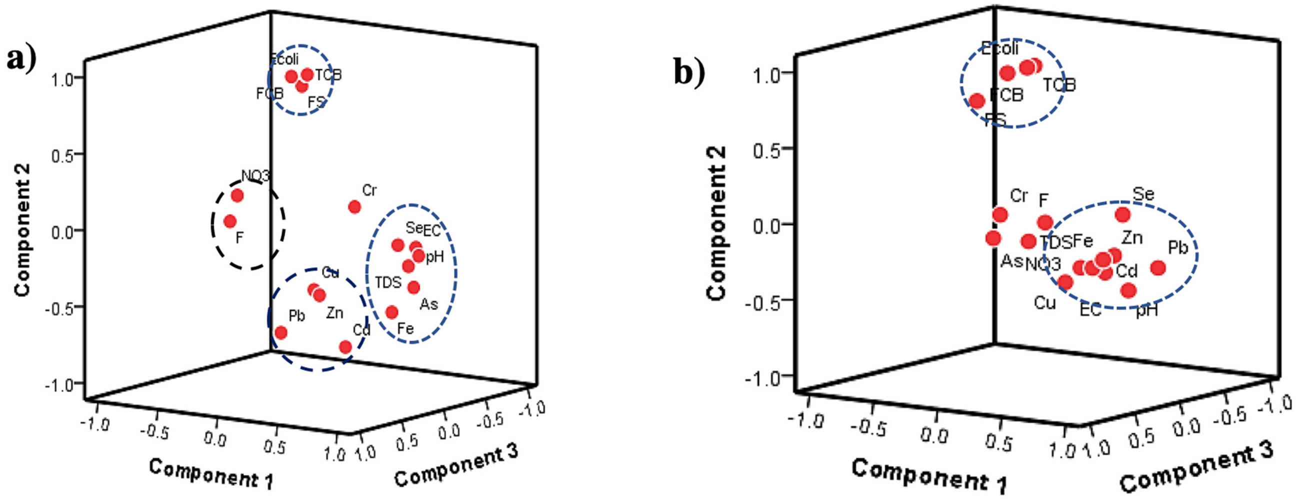

Fig. 5. Factor analyses loading (a) before the lockdown (b) during the lockdown period.

changes and the infiltration of pre-monsoon rainwater was substantially responsible for the observed changes. Residential and industrial areas such as Nila Seafoods, Kilbern Chemicals, Threshpuram, Iniko Nagar, SIPCOT, Tuticorin, Muthiyapuram, SPIC, and State Bank Colony are located nearby the highly polluted Buckle canal, and hence they did not show much change in biological parameters.

Variation observed in pathogens such as *total coliform* and *fecal coliform* bacteria in groundwater samples from Threshpuram, Iniko Nagar and Tuticorin were influenced by bacterial contamination from the fisheries. Fishing is one of the major occupations and this region reported a total fish production of 58,252 tons in 2018–2019 (Singaraja et al., 2015). Most of the wastes released from fisheries are not adequately processed and the discarded wastes off the shore contaminate the groundwater. Significant reduction in the *total coliform* (52%) and *fecal coliform* (48%) during the lockdown period reflected the minimal amounts of fishing activity. Despite the reduction in fecal contamination, the continuous consumption of water with *total coliform* and *fecal coliform* might pose health risks by causing urinary tract infections, pulmonary infections, abscesses and skin-wound infections to the residents, especially children (Kumar et al., 2020c). Even though the lockdown could not limit the growth in the number of infected cases of COVID-19, we observed significant changes in groundwater quality, mainly in samples collected from the industrial area. It was not possible to assign individual parameters of the changes in groundwater quality to different effects of the imposed restrictions as some of the changes might be due to seawater intrusion and the rock-water interactions. A thorough analysis, however, could separate the effects anthropogenic activities and natural processes on the groundwater quality of this region.

6. Conclusion

In summary, the groundwater quality of the Tuticorin industrial city in south India with respect to NO_3 and concentrations of As, Fe, Se, Pb, *total coliforms* and *fecal coliforms* improved during the COVID-19 lockdown period. Reduction in pollutant levels was due to restrictive measures to limit the anthropogenic activities and closure of several large and small-scale industries. It provided a unique opportunity to assess the impacts of several wastewater sources on the groundwater quality and the results might help to formulate new water quality policies for the region. However, the formulation of water quality policy is a long-term process as the instant effects of present and past emergencies on the water quality can also be adverse. The government should implement water policy after considering the effects of COVID-19 lockdown from different industrial cities of India, including the Tuticorin. The waste recycling process, including pollution from heavy metals and pathogens must be considered for both the human health and resource conservation. We assigned the concentrations of Se, As, Fe and Pb to the metal-based industrial activities and contents of NO_3, *total coliform* and *fecal coliforms* to organic sewage from the fisheries. The continuation of lockdown might still lower these pollutant levels in groundwater. Some of the parameters such as Cu, Zn, Cd and F, however, are geogenic and they reflected rock-water interaction in the region or seawater intrusion. Factor analyses aptly illustrated that the groundwater quality was generally governed by four major sources i.e. agriculture, chemical industry, thermal power plants and municipal sewage. The pollutants in groundwater started decreasing in the lockdown probably from the complete closure of first two sources. The lockdown of COVID-19 pandemic has converted the world into new experimental laboratories, which may continue to reveal surprising temporal and spatial data. We presented here the preliminary observations of such an experiment associated with water quality revival owing to lockdown and work from home scenarios.

CRediT authorship contribution statement

S. Selvam: Conceptualization, Writing - original draft, Project administration.**K. Jesuraja:**Investigation. & Resources. **S. Venkatramanan:**Investigation, Writing - review & editing, Data curation.**S.Y. Chung:** Visualization.**P.D. Roy:**Writing - review & editing.**P. Muthukumar:** Data curation & Resources.**Manish Kumar:**Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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