JOURNAL OF MECHANICS OF CONTINUA AND MATHEMATICAL SCIENCES
www.journalimcms.org

ISSN (Online) : 2454 -7190 Vol.-16, No.-12, December (2021) pp 49-58 ISSN (Print) 0973-8975

IMPACT OF LOCKDOWN RESTRICTION OF COVID-19 ON SELECTIVE DISSOLVED HEAVY METALS IN COASTAL WEST BENGAL

Nibedita Mukhopadhyay[1], Abhijit Mitra[2]

[1]Post-doctoral fellow, Department of Oceanography, Techno India University West Bengal, India

[2]Faculty Member & Former Head, Department of Marine Science, University of Calcutta, India

Email: [1]nibedita.mukherjee@yahoo.co.in, [2]abhijitresearchmitra@gmail.com

Corresponding Author: **Nibedita Mukhopadhyay**

https://doi.org/10.26782/jmcms.2021.12.00004

(Received: October 1, 2021; Accepted: November 28, 2021)

Abstract

In this study, the effect of COVID-19 lockdown (2020) on dissolved heavy metal load (Zn, Cu, and Pb) in the coastal West Bengal were analyzed concerning the pre-COVID 19 phases (2016-2019). Two stations namely Shankarpur (Stn.1) and Haldia (Stn. 2) were selected for the study as both have two contrasting operational features. Haldia is an important port-cum-industrial complex whereas Shankarpur is an important fish landing station-cum-tourism site. The results showed that in both the stations there was a drastic fall in the metal concentrations due to lockdown implementation, but in Haldia, the aquatic health exhibits much improvement as in lockdown there was complete shut-down of the industries. ANOVA results also highlight significant variations between the two stations as well as between the pre COVID-19 (2016-2019) and COVID-19 lockdown phases.

Keywords: Dissolved heavy metals, Covid-19 lockdown, coastal West Bengal, ANOVA

I. Introduction

The estuaries are one of the most biogeochemically active zones of the earth, wherein the terrestrial effluents bearing the anthropogenic signatures of pollution meet the comparatively less polluted marine water. Besides being polluted, the estuaries and the adjoining landscape, usually, exhibit rich biodiversity, in terms of both flora and fauna. Our area of concern, the Hooghly-Matla estuarine complex along with the Sundarbans mangroves forms one of the most diverse and vulnerable ecosystems in the world and it is also considered as one of the most important fishing grounds of north-east India, mainly because of the presence of large shallow parts of Bays, which provide extensive growths for benthic and planktonic community and thus makes it a highly productive area. Indiscriminate industrialization along the bank of the adjoining rivers, lack of proper infrastructure for pollution abatement, land-runoff, and freshwater discharge through the rivers allow the pollutants to end up in the aquatic column of the estuaries throughout the world. Among all the water pollutants heavy metals have received significant attention from environmental chemists because of their toxic nature. These are the naturally occurring elements that have a very high atomic weight and a very high density, which is five times greater than that of water. Heavy metals are usually present in a very minute quantity in natural waters but many of them are very toxic even in very low concentrations. Metals such as Arsenic (As), Lead (Pb), Cadmium (Cd), Nickel (Ni), Mercury (Hg), Chromium (Cr), Cobalt (Co), Zinc (Zn), and Selenium (Se) are highly toxic components even in minor quantity. We have highlighted in this study a few of these heavy metals (Zn, Cu, and Pb), which pollute the Hooghly-Matla estuarine system to a greater extent and pose a significant risk to human health as they have a very long residence time in nature and tend to bioaccumulate in the several flora and fauna through multiple biogenic pathways [XI]. Heavy metals have a high probability to cause cancer and maybe the reason for various types of diseases related to the digestive system, excretory system, and cardiovascular system in human beings when consumed through food [VI].

Most of the anthropogenic activities that introduce mobile heavy metals in the environment include agricultural run-off, the unplanned proliferation of urban and industrial set-ups, the use of antifouling paints to the fishing vessels and trawlers, etc. Apart from the anthropogenic discharge, the rise of the carbon dioxide level also results in more complex reactions in nature. It is because of complex reactions the pH level of the aquatic phase goes down, which releases the heavy metals confined in the sediments also.

COVID-19 caused a miserable situation since the beginning of 2020 and posed a significant negative impact on the life and lifestyle of a human being [IV]. As the virus started spreading, it reached every continent, possibly except the Antarctic, and the extent of the infection, its coverage, and the number of fatalities reported are ~ 181 million infected persons, with ~4 million fatalities up to June 29, 2021, in 183 countries and 33 territories [XIII]. India, the second-most populous country in the world, also is facing the brutal brunt of the pandemic and presently ranks second among the most affected countries in terms of the number of infected people (>30 million) and more than 394,000 deaths to date [V]. The Indian government initiated an unprecedented, 68-day long, nationwide lockdown in 2020, starting on March 24 and ending on 31 May 2020 [XII]. During this lockdown period, there were complete paralysis of the transport, industrial, and tourism sectors.

The present paper is an attempt to evaluate the quality of water in the coastal zone of West Bengal in terms of heavy metals during this COVID-19 lockdown phase.

II. Experimental Study

Study area

The total length of the tidal Hooghly estuary is about 295 km and it lies between the latitude 21^{o}31' N and 23^{o} 30' N and longitude 87^{o} 45' E and 88^{o} 45' E and covers the districts of Nadia, Hooghly, North and South 24-Parganas, Howrah and East Midnapur in the maritime state of West Bengal. The estuary bifurcates near the Sagar Island into the main Hooghly on the north and northwestern side and the river

Muriganga on the eastern side, which is connected to another river Thakuran and Matla forming the Hooghly – Matla estuarine complex. Two stations were selected for our study from this deltaic region namely Shankarpur (22°50'54.20" N & 88°27'4.54" E) (Stn. 1) and Haldia (22°4'0.0228" N & 88°4'11.3124" E) (Stn. 2) (Fig. 1). The ideology behind the selection of these two sampling sites is the contrasting nature of anthropogenic stress operating in these two stations. Shankarpur is very well known not only as a tourism site but also for extensive shrimp culture farms and a major marine fish landing station. On the other hand, Haldia is the most developed industrial belt along the coast of West Bengal and is an important trading port of the maritime state of West Bengal.

Samplings were carried out in these stations since 2016 during April, which is a premonsoon month in India, characterized by high salinity and minimum dilution factor in the coastal waters [VII], [VIII], [IX], [X].

Fig 1. Two selected sampling stations in the Hooghly-Matla estuarine complex

Sample collection

To evaluate the trend of change of heavy metals in the estuarine region due to COVID-19 lockdown, samples were collected from each of these two stations in April (premonsoon month) for a period of 4 years (2016-2019) (pre COVID-19 PHASE) and again in April 2020 during the Lockdown phase.

Water samples were analysed to determine the content of dissolved heavy metals (Zn, Cu and Pb). Before analysis, each water sample was collected and stored in clean TARSON bottles and was filtered through a 0.45 µm Millipore membrane. The filtrate was treated with diethyldithiocarbamate and extracted in carbon tetrachloride [II]. The extract was evaporated to dryness and the residue was mineralized with 0.1 ml of concentrated nitric acid. The analytical blank was prepared and treated similarly using the same reagents. Analyses were done in triplicate by direct aspiration into AAS (Perkin-Elmer Model: 3030) equipped with an HGA-500 graphite furnace atomizer and a deuterium background corrector. The accuracy of the dissolved heavy metals determinations is indicated by the good agreement between our values and reported for certified reference seawater materials (CASS 2) (Table 1).

Table - 1 Analysis of reference material for near-shore seawater (CASS 2)

Element	Certified value (µg l^{-1})	Laboratory results (µg l^{-1})
Zn	1.97 ± 0.12	2.01 ± 0.14
Cu	0.675 ± 0.039	0.786 ± 0.058
Pb	0.019 ± 0.006	0.029 ± 0.009

Data Analysis

Analysis of Variance was used as an explanatory tool to determine the variations of dissolved Zn, Cu, and Pb between the preCOVID-19 and COVID-19 lockdown phases and also between the stations ($p < 0.01$).

III. Results and Discussions

The variations of dissolved heavy metals (Zn, Cu, and Pb) in Shankarpur (Stn 1) and Haldia (Stn 2) during Pre COVID-19 period (2016-2019) and COVID-19 lockdown period (2020) are highlighted in Figs. 2 and 3.

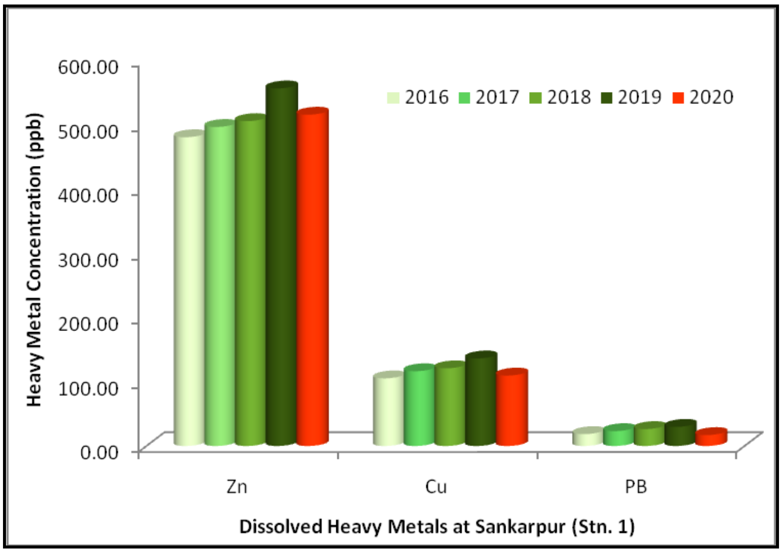

Fig 2. Dissolved heavy metal concentrations at Shankarpur (Stn 1) during Pre COVID-19 (2016-2019) and COVID-19 lockdown phases (2020)

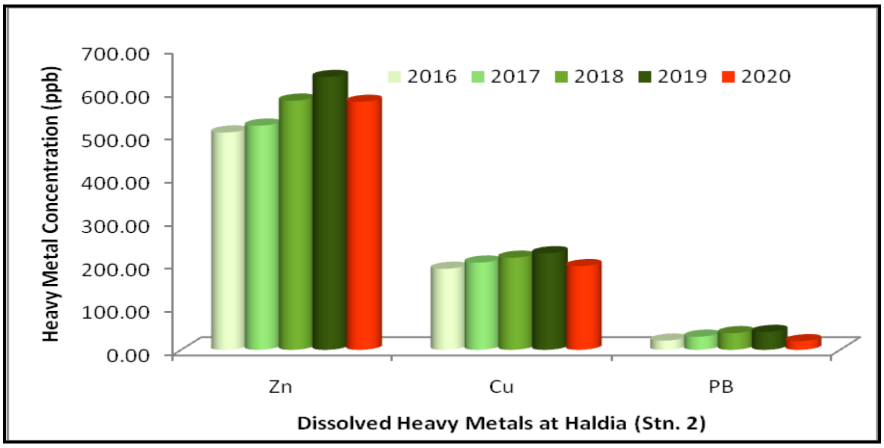

Fig 3. Dissolved heavy metal concentrations at Haldia (Stn. 2) during Pre COVID-19 (2016-2019) and COVID-19 lockdown phases (2020)

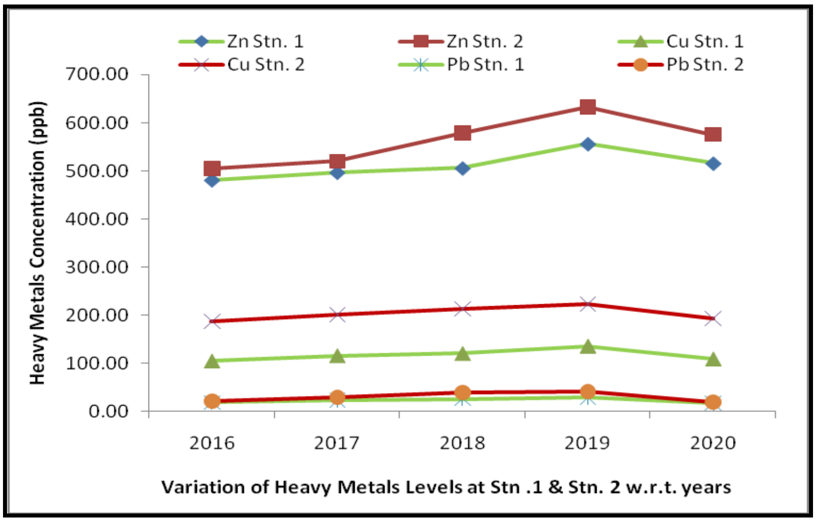

Fig 4. Variation of dissolved heavy metals at Shankarpur (Stn 1) and Haldia (Stn. 2) during Pre COVID-19 (2016-2019) and COVID-19 lockdown phases (2020)

It is evident from Fig. 2, 3, and 4 that the concentrations of heavy metals (Zn, Cu, and Pb) exhibit an increasing trend during the pre-COVID-19 phase (2016-2019) irrespective of the stations. Maximum values of dissolved Zn were found to be 556.00 ppb at Stn. 1 and 633.10 ppb at Stn. 2 at the pre-COVID-19 phase in 2019. However, the values showed a sharp decrease to 515.20 ppb and 575.38 ppb in 2020, during the lockdown period at Stn 1 and 2 respectively. Similar trends were found in the case of Cu and Pb too. The maximum Cu values were found to be 136.14 ppb (Stn. 1) and 224.09 ppb (Stn. 2) in the year 2019, which were fallen similarly as Zn to 109.56 ppb (Stn. 1) and 194.17 ppb (Stn. 2). In the case of Pb, peak values were 29.75 ppb (Stn. 1) and 41.53 (Stn. 2) in 2019, whereas it decreased to 17.00 ppb and 19.92 ppb at Stn.

1 and 2 respectively during the lockdown period (2020). A sharp decrease of the metal concentration due to imposing lockdown to minimize the COVID situation is by the similar results found by a recent study [II].

The number of fishing boats and trawlers during the COVID lockdown phase reduced from nearly 12,000 to 5,000 in the waters of coastal West Bengal. These vessels use anti-fouling paints (Fig.5) to get rid of the settlement of the biofuels like oysters, barnacles, etc., that contribute an appreciable amount of Zn, Cu, and Pb in the ambient aquatic phase.

Fig 5. Trawlers using anti-fouling paints on the body surface to get rid of biofuels

The trend of decrease of metal concentrations for Haldia (Stn.2) is far different from the decreasing trend of Shankarpur (Stn. 1). A huge number of industries are in operation near the Haldia-port-cum-industrial complex (Table 2). These proliferated industries released a huge quantum of industrial waste every day to the surrounding estuarine water containing metal wastes. However, the industries were closed down during the lockdown phase (April 2020) as Govt. strictly implemented lockdown as per the COVID protocol, which caused a significant fall of the metal level.

Table - 2 List of industries situated near Haldia port-cum-industrial complex

Sl. No.	Name of Industry	Product
1.	Indian Oil Corporation Ltd., Haldia	L.P.G., Motor Gasoline, Naptha, ATF, MTO, HSD, JBO, Kerosene, Furnace Oil, Lubes, Bitumen
2.	KoPT/Haldia Dock Complex	Port Services
3.	Tata Chemicals Ltd., Haldia	Industrial Phosphate and Acids.
4.	Exide Industries Ltd., Haldia	Automotive Batteries, Heavy Duty Batteries, Containers, Special Types of Separators, *etc*.
5.	Shaw Wallace, Haldia	Pesticides
6.	MCC PTA India Corpn. Pvt.	P.T.A

	Ltd., Haldia	
7.	Haldia Petrochemicals Ltd., Haldia	LLDPE, HDPE, Naptha Cracker *etc.*
8.	IOCL, Paradip-Haldia Oil Pipeline	Petroleum Storage and Transportation
9.	IOC Petronas Ltd., Haldia	L.P.G
10.	Shamon Ispat Ltd.	Steel Rolling
11.	Dhunseri Petrochem and Tea Ltd.	Petroleum residues
12.	Greenways Shipping Agencies Pvt. Ltd.,	Containers Freight Station (CFS)
13.	IOC Ltd., Haldia	Petroleum Storage
14.	Hindustan Petroleum Corporation Ltd.	Petroleum and allied products
15.	Bharat Petroleum Corporation Ltd., Haldia	Petroleum and allied products.
16.	Hindustan Unilever Limited.	Detergents
17.	Marcus Oils and Chemical Pvt. Ltd.	Polyehylene Waxes
13.	IOC Ltd., Haldia	Petroleum Storage
18.	Ruchi Soya Industries Ltd.	Edible Oil
19.	Manaksia Ltd.	Aluminum and Steel
20.	Sanjana Cryogenic Storages Ltd	Ammonia Storage and handling terminal
21.	R. D. B. Rasayans Ltd.,	PP Jumbo Bag and Small bag.
22.	Reliance Industries Limited	Storage and handling Petroleum Product
23.	Adani Wilmar Ltd.	PE edible Oil Refinery
24.	Electrosteel Castings Ltd.	Coke Oven Plant, sponge iron plant, power plant
25.	URAL India Ltd.	Automobile
26.	K.S. Oils Ltd.	Edible Oil Refinery
27.	DPM Net Pvt. Ltd.	Fishing net
28.	Hooghly Met Coke and Power Co. Ltd.	Coke Oven Plant
29.	Ruchi Infrastructure Pvt. Ltd.	3rd Party liquid storage tank terminal.
30.	Shree Renuka Sugars Ltd.	Sugar Refinery and Food Complex.
31.	Gokul Refoils and Solvent Ltd.	Edible Oil Refinery
32.	Emami Biotech Ltd.	Bio-diesel Plant.
33.	Ennore Coke Private Ltd.,	Coke Oven Plant.
34.	West Bengal Waste Management Ltd.	Industrial waste / municipal waste management complex.
35.	Lalbaba Seamless Tubes Pvt. Ltd.	Seamless Tube
36.	Modern India Con-cast Ltd.	FerroAlloy Plant
37.	Rohit Ferro Tech Ltd.	FerroAlloy

Source: Haldia Development Authority - An Autonomous Body Under Government of West Bengal, India [XIII]

Two-way ANOVA without replications was computed to determine the variations in metal concentrations between the years and between the stations.

ANOVA for dissolved Zn (Table 3a) shows that there is high significant variation between the stations as F- calculated value (19.86445) is much higher than that of the F-critical value (4.708647) ($p < 0.05$). A pronounced variation of Zn concentration between the years ($p = 0.01$) also indicates the effects of lockdown.

Table - 3a ANOVA of dissolved Zn between stations and between pre-COVID-19 (2016-2019) and COVID-19 lockdown phases (2020)

Source of Variation	SS	df	MS	F	P-value	F crit
Between Years	12475.51	4	3118.876	9.262261	0.026636	6.388233
Between Stations	6688.948	1	6688.948	19.86445	0.011187	7.708647
Error	1346.918	4	336.7295			
Total	20511.37	9				

Significant variations concerning Cu concentration ($p < 0.01$) and Pb concentration ($p < 0.05$) are also observed between the years and between the stations (For Cu, $p < 0.01$ and for Pb, $p < 0.05$)) (Table 3b and 3c), which indicates the impact of lockdown on the water quality.

Table - 3b ANOVA of dissolved Cu between stations and between pre-COVID-19 (2016-2019) and COVID-19 lockdown phase (2020)

Source of Variation	SS	df	MS	F	P-value	F crit
Between Years	1393.398	4	348.3494	47.51481	0.001257	6.388233
Between Stations	18871.2	1	18871.2	2574.03	9.03E-07	7.708647
Error	29.32554	4	7.331385			
Total	20293.93	9				

Table – 3c ANOVA of dissolved Pb between stations and between pre-COVID-19 (2016-2019) and COVID-19 lockdown phase (2020)

Source of Variation	SS	df	MS	F	P-value	F crit
Between Years	453.9834	4	113.4959	10.75254	0.020488	6.388233
Between Stations	138.6818	1	138.6818	13.13864	0.022264	7.708647
Error	42.22104	4	10.55526			
Total	634.8862	9				

IV. Conclusion

The effects of COVID-19 lockdown analyzed concerning the selected dissolved heavy metal concentrations (Zn, Cu and Pb) in the Hooghly-Matla estuarine complex showed a dramatic alteration both at the Haldia port-cum-industrial complex and Shankarpur with few noted features as highlighted here.

1. Though in both the selected stations, the effects of lockdown are evident, but the positive effects on the environment are much more pronounced in Haldia.
2. There is a significant improvement in the estuarine water quality during the COVID-19 lockdown phase (2020) in terms of heavy metals.

Conflicts of interest

The authors declare that they have no conflicts of interest to report regarding the present study.

References

I. Adla Rajesh, R. Shashi Kumar Reddy, M. Shiva Chander. : 'SIGNIFICANT CHANGES IN INDIA DURING LOCK DOWN PERIOD WITH AN IMPACT OF COVID-19'. J. Mech. Cont.& Math. Sci., Vol.-15, No.-8, August (2020) pp 8-16

II. Agarwal, S., Pramanick, P., Mitra, A., "Alteration of dissolved Zinc concentration during COVID-19 lockdown phase in coastal West Bengal", NUJS Journal of Regulatory Studies, Special Issue, pp: 51-56, 2020

III. Chakraborti, D., Adams, F., Mol, W. V., Irgolic, K. J., "Determination of trace metals in natural waters at nanogram per liter levels by electrothermal atomic absorption spectrometry after extraction with sodium diethyl-dithiocarbamate", Analytica Chimica Acta, vol. 196, pp: 23-31, 1987

IV. Diffenbaugh, N. S., Field, C. B., Appel, E. A., Azevedo, I. L., Baldocchi, D. D., Burke, M., Burney, J. A., Ciais, P., Davis, S. J., Fiore, A. M., "The COVID-19 lockdowns: A window into the earth system", Natures Reviews Earth & Environment, vol. 1, pp: 470–481, 2020

V. India: WHO Coronavirus Disease (COVID-19), Available online: https://covid19.who.int/region/searo/country/in, (accessed on 26th June, 2021)

VI. Izah, S. C., Chakrabarty, N., Srivastav, A. L., "A review on heavy metal concentration in potable water sources in Nigeria: Human health effects and mitigating measures", Exposure and Health, vol. 8, no. 2, pp: 285–304, 2016

VII. Mitra, A., "Estuarine Pollution in the Lower Gangetic Delta", Springer International, ISBN 978-3-319- 93305-4, vol. XVI, pp: 371, 2019

VIII. Mitra, A., "Sensitivity of Mangrove Ecosystem to Changing Climate", Springer New Delhi Heidelberg New York Dordrecht London, 2013 edition, ISBN-10: 8132215087; ISBN-13: 978-8132215080, 2013

IX. Mitra, A., Zaman, S., "Basics of Marine and Estuarine Ecology", Springer India, ISBN 978-81-322-2707-6, pp: 1-481, 2016

X. Mitra, A., Zaman, S., "Carbon sequestration by Coastal Floral Community, India", The Energy and Resources Institute (TERI) TERI Press. ISBN 978-81-7993-551-4, 2014

XI. Olayinka-Olagunju, J. O., Dosumu, A. A, Olatunji-Ojo, A. M., "Bioaccumulation of Heavy Metals in Pelagic and Benthic Fishes of Ogbese River, Ondo State, South-Western Nigeria", Water, Air, & Soil Pollution, vol. 232, no. 2, pp: 1–19, 2021

XII. The Financial Express, Lockdown 5.0 Guidelines in India (State-Wise): New Lockdown Extension Rules Announced, Night Curfew Relaxed. 30 May 2020, Available online: https://www.financialexpress.com/lifestyle/health/lockdown-5-0-guidelinesstate-wise-lockdown-extension-5-0-rules-latest-updates/1975135, (accessed on 26th June, 2021)

XIII. WHO. Coronavirus Disease (COVID-19) Situation Report-197, Available online: https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200804-covid-19-sitrep-197.pdf?sfvrsn=94f7a01d_2, (accessed on 26th June, 2021)

XIV. www.nltr.org