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ENVIRONMENTAL IMPACT OF COVID-19 PANDEMIC IN INDIA

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Abstract: The ongoing pandemic caused by COVID-19 virus has paralyzed everyday life across the globe. To limit spread of infection, the Government of India issued a Nation-wide lockdown, on March 24th, which ensued a complete halting of human activities in India. Soon reports of unusual drops in pollution levels and rare animal sightings were recorded by the media. In this review article, authors explore both direct and indirect environmental impacts of this pandemic. With a halt in manufacturing industries and automobiles plying, air pollution levels went down drastically. Water pollution levels were also recorded to be on the down trend. Unusual sightings of the Himalayas from towns, hundreds of kilometers away were a sight missed for several decades, exemplifying the effect of drop in particulate matter that reduce long range visibility. With the increase in COVID cases, more and more biomedical wastes were also produced, causing a major biomedical hazard threat to an infrastructure not built to handle such volumes of infective wastes. The extent of the environmental impact of this pandemic is too soon to be assessed properly, but this review delineates the initial environmental impact that this deadly pandemic has thrown upon mankind.

Keywords: COVID-19, Environmental impact, Lockdown, Pandemic.

INTRODUCTION

The threat of a public health crisis in the form of a pandemic with the advent of the 2019 novel Corona Virus (2019-nCoV) also dubbed as SARS-CoV-2 has spread fast from its provenance in Wuhan City of Hubei Province of China to the entire world in a matter of weeks (Singhal, 2020). On 31st December, 2019, the Chinese Government relayed to the World Health Organization (WHO) the extent of pneumonia like cases amongst retailers of Huanan seafood market showing unknown etiology (Srivastava and Reddy, 2020). As of 24th May 2020 more than 5.4 million cases have been reported worldwide with a staggering death toll of more than 3,44,000. On the basis of its spread, WHO categorized the COVID-19 into four stages.These stages include Stage 1 (imported cases), Stage 2 (local transmission), Stage 3 (community transmission) and Stage 4 (transmission out of control). The virus spread exponentially in Italy, China, Spain and America which saw Stage 3 Community Transmissions (Kumari and Shukla, 2020).

The Indian Government with a rise in cases issued a countrywide lockdown starting from midnight of 24th March, 2020 in a bid to arrest cases by enforcing social distancing (Pulla, 2020).

Extensive restrictions in travel were implemented probably for the first time since World War II, with all eateries, theatres and pubs being closed around the globe.Worldwide flights are being cancelled or returned mid-air, crumbling the aviation sector with international tourists stuck mid-holiday. India with $2.94 trillion economy (by IMF) ranked 5th among the highest polluted countries, now under lockdown stares at both public health and an economic shock. The subsequent lockdown meant cessation of almost all non-essential industrial activities and a sudden drastic drop in human traffic in and around the busy cities due to closure of almost all non-governmental and governmental offices with a strict "Work-From-Home Policy"(Roy *et al.,* 2020).

With the restriction of movement, closure of factories and curfew timings, the environment seemed to alter itself from the routine of anthropogenic pollution. Increased animal sightings due to lack of human movements have been reported from around the world. Reports have been published about the lowering of pollution levels post-lockdown. However, on the other hand, a monumental increase in medical waste has posed a threat to the environment, adding the fear of re-infection as well as inadequate logistics for its disposal (Yu *et al.*, 2020). Here, in this article authors discuss the various environmental impacts of COVID-19.

AIR POLLUTION

Reduced Carbon Emission

With the closure of factories and restriction of vehicle movement there has been a significant impact on the carbon emissions, with China reporting a 25% reduction in its carbon emissions. Kolkata, a metropolitan city in Eastern India with a population of 14.9 million that nears the global CO_2 emission average of 417.31 ppm (https://www.co2.earth/) as per the record of 30thApril, 2020, recorded a significant decrease in CO_2 emissions post lockdown with an average of more than 40% reduction in emissions as sampled from three different locations (Dhar *et al.,* 2020). Another independent study shows a range of decrease percentage in CO_2 emissions in Kolkata from 24.56% (at Deshbandhu Park) to 45.37% (at Sealdah Station). This range can be attributed to the density of vegetation in the different sampling areas (Mitra *et al.,* 2020a).

India, the second largest coal consumer, recorded a massive yearly decline in power generation in April 2020. With about 19% reduction in average daily power generation, there was a concomitant decrease in Industrial Coal demand with purchasing index dropping from 51.8 in March to 27.4 in April.

Air Quality Index

The Central Pollution Control Board (CPCB) along with State level pollution monitoring centres operates the NAMP (National Air Monitoring Program) that records the AQI of 24 cities across India based on eight parameters, (PM10, PM2.5, NO_2, SO_2, CO, O_3, NH_3, and Pb). High concentrations of such pollutants cause serious environmental hazards. Nox in particular can cause nutrient pollution in coastal areas, acid rain formation and smog. NO_2 acts as an indicator for all Nox gases. NO_2 emission is mostly credited to fuel usage in power-stations and from automobile exhausts (Wang and Su, 2020).

According to new satellite images taken by ESA (European Space Agency) from its Copernicus Sentinel-5P satellite, Mumbai and Delhi, the two main metropolitan cities of India, showed drops of about 40-50% in tropospheric NO_2 columns compared to the same time frame from 2019. NASA's Terra satellite retrieved data from its Moderate Resolution Imaging Spectroradiometer (MODIS) showed Aerosol anomaly post lockdown over India. Aerosols produced by the automobiles, power-plants and industrial coal usage contribute to the majority of Aerosol emission in the Gangetic plains.

A study based on the NAQI (National Air Quality Index) around NCT of Delhi showed a significant decrease in pollutants during the lockdown (study period till 14th April 2020). With an average concentration of PM10 and PM2.5 showing negative changes amidst lockdown from −51.84% and −53.11% respectively, even other pollutants NO_2 (−52.68%) and CO (−30.35%) have shown considerable negative change in concentration (Mahato *et al.,* 2020). Relative to

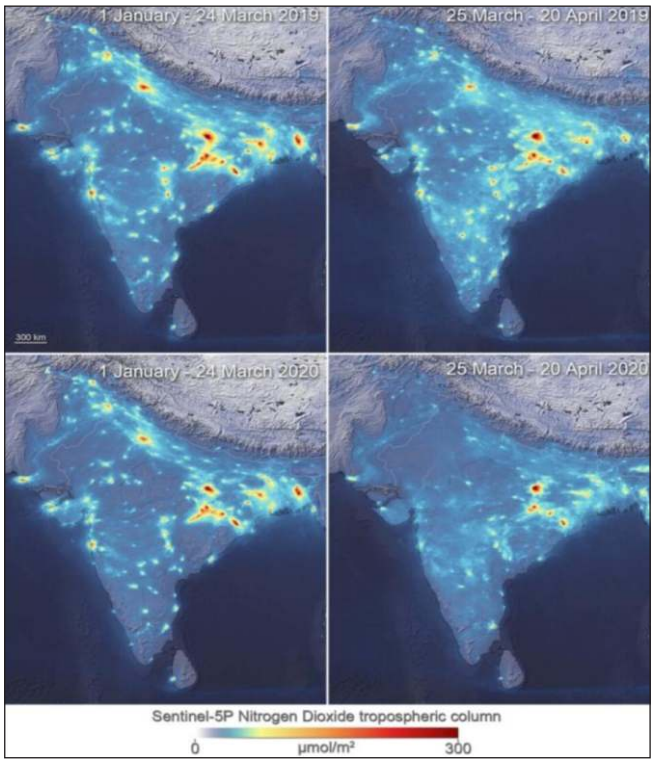

Figure 1: Nitrogen Dioxide concentrations (Source: ESA)

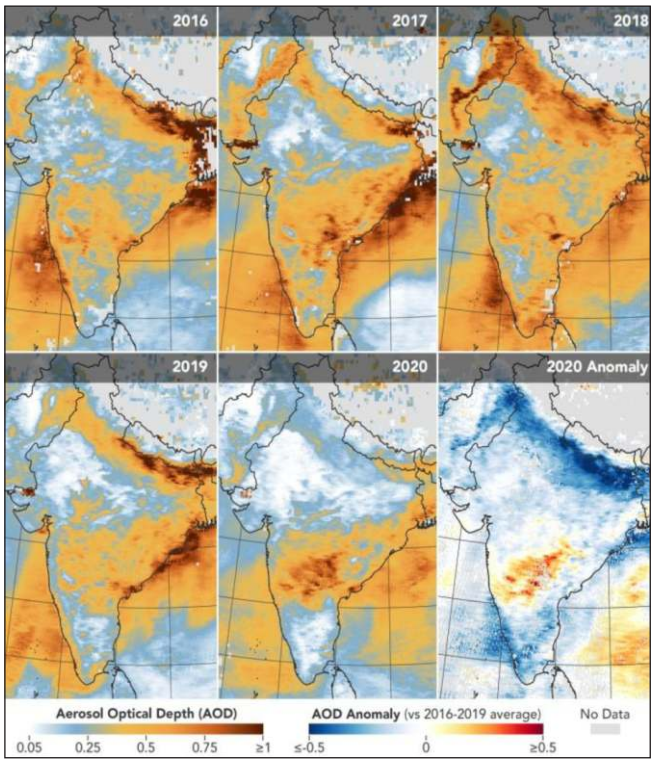

Figure 2: Aerosol Optical Depth and anomaly as seen in lockdown. (Source: NASA)

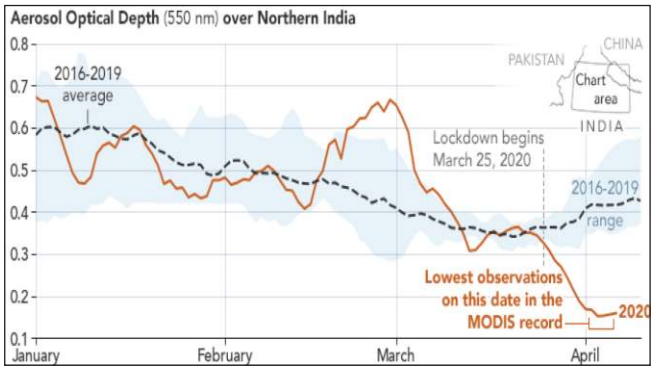

Figure 3: Aerosol Optical Depth Chart. (Source: NASA)

these trends SO_2 (−17.97%), and NH_3 (−12.33%) showed lowered reduction, with O_3(+0.78%) showing minimal but positive increased change. This can be attributed to the lowering of NO levels which acts as scavengers for O3 [NO + O3 =NO2 +O2]. (Mahato *et al.,* 2020).

CPCB Notification detailed that 47% reduction in Benzene levels have been recorded in Delhi. In NCR towns there has been an overall reduction of over 48% in PM10 and PM2.5 levels during the lockdown period. Recorded sharp improvement in Faridabad has been seen with 55% reduction in PM2.5 levels and Gurugram with 54% reduction in PM10 levels. NO_2 levels saw significant decrease in Noida (68%), Ghaziabad (60%) and Gurugram (40%). However, lower change observed in Faridabad (17%), where NO_2 emissions were found relatively higher, probably due to the gas-based power plants in and around Faridabad (CPCB).

Bengaluru also known as the silicon valley of India is one of the top most polluted metropolitan cities in India. However, a study of this city in Karnataka, showed a turn in its AQI index during lockdown with respect to levels of previous years, showing "Satisfactory" from "Moderate" levels. Significant reduction in PM10 and NO2 levels were observed during the lockdown period, with 44% reduction in PM10 and 21% reduction in PM2.5, a 53% reduction in NO_2 levels and 48% reduction in Benzene levels (CPCB).

The Super Cyclonic Storm 'Amphan' that developed over the Bay of Bengal, regarded as the most severe storm in the Gangetic Delta since 1999 Odisha Cyclone, made landfall in West Bengal on 20th May, 2020 during the nationwide lockdown amidst the COVID Pandemic causing widespread damages. There have been reports that suspect such severity of the storm to be

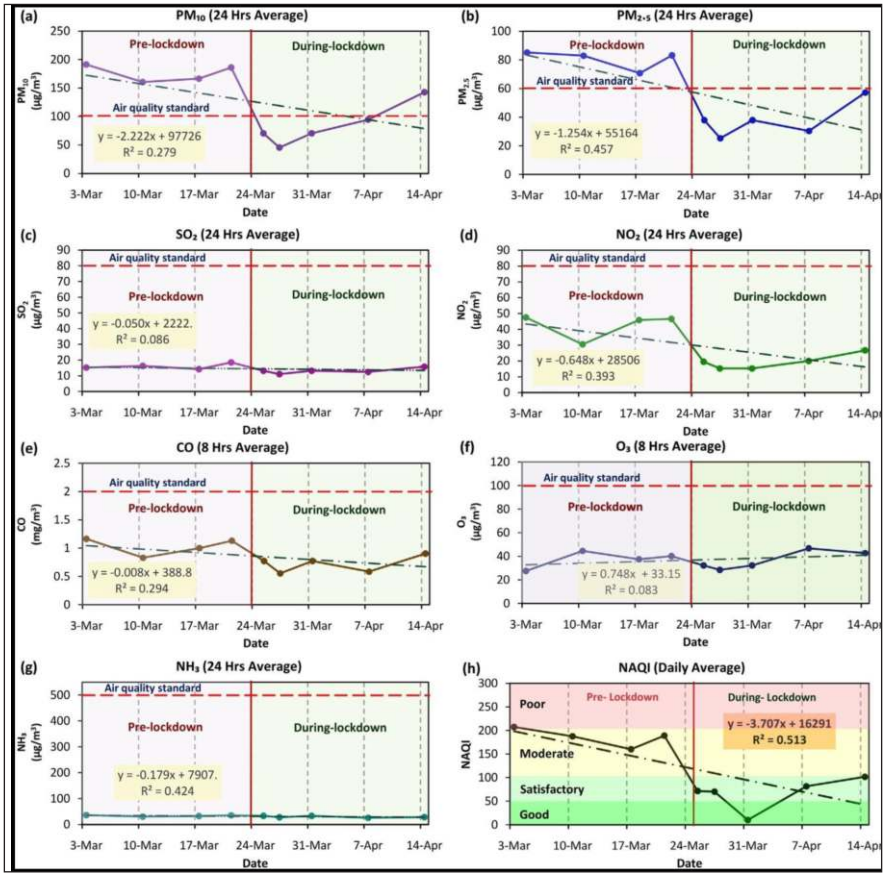

Figure 4: Trend of 24 h average concentrations of (a) PM10, (b) PM2.5, (c) SO_2, (d) NO_2, (g) NH_3& (h) NAQI and 8 h average daily maxima of (e) CO & (f) O_3 between 3rd March and 14th April (lockdown started on 24th March) in NCT (Delhi, India) (Source: Mahato *et al.*, 2020)

Date	Predominant Wind Speed (kmph)	Maximum Mixing Height (m)	Delhi	Ghaziabad	Noida	Faridabad	Gurugram
16-Mar	16	1800	139	134	118	184	165
17-Mar	12	1500	157	148	140	164	141
18-Mar	15	2000	151	172	137	164	168
19-Mar	14	3200	186	236	184	194	192
20-Mar	12	2400	192	235	195	212	175
21-Mar	16	2500	186	207	161	174	126
22-Mar (Janata Curfew)	12	2900	191	237	176	214	191
23-Mar	10	800	124	159	123	130	91
24-Mar	10	2700	122	166	130	187	127
IMPOSITION OF NATIONWIDE LOCKDOWN DUE TO COVID-19							
25-Mar	12	2500	77	86	80	100	69
26-Mar	25	1100	92	84	72	88	61
27-Mar	15	500	69	72	60	75	42
28-Mar	14	2250	45	39	38	64	54
29-Mar	20	2600	62	48	58	83	62
30-Mar	20	2100	71	64	61	97	76
31-Mar	12	1900	76	72	67	110	77
01-Apr	12	3200	73	79	73	90	69
02-Apr	20	3050	69	63	62	63	72
03-Apr	22	2100	79	104	72	97	82

Figure 5:Air Quality Index of NCR Delhi from 16th March, 2020 (pre-lockdown) to 3rd April, 2020 (Lock-down period). (Source: CPCB Bulletin).

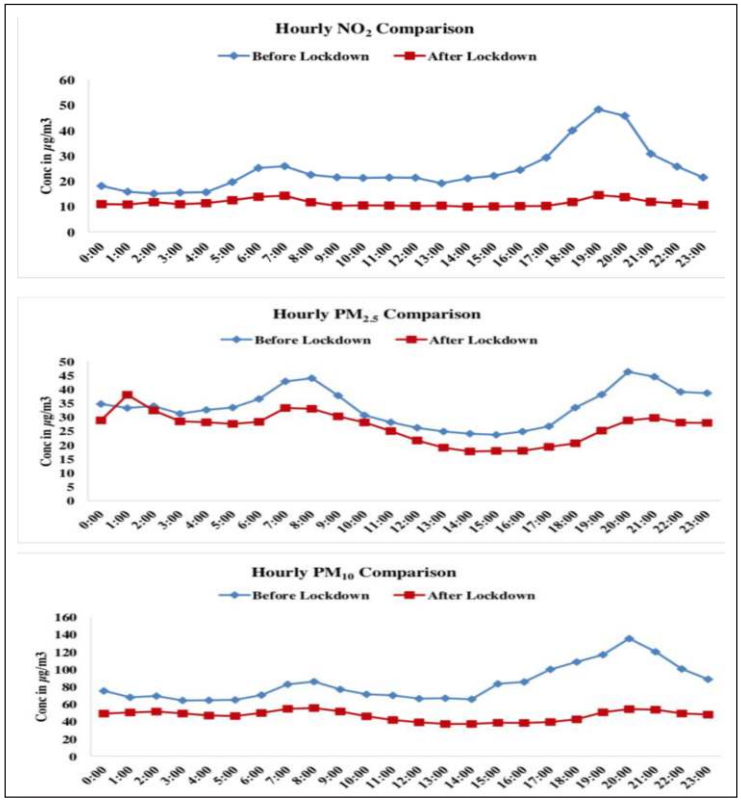

Figure 6: Air Quality Parameters comparison between Pre-Lockdown and After-Lockdown data in Bengaluru. (Source: CPCB Bulletin).

reason of the sudden climatic change impacted by the lockdown. Reports indicate at lowering of anthropogenic aerosols might have played a role in the intensification of the cyclone. A reduced pollution level and aerosol meant higher surface warming of oceans that acted as a trigger factor for the intensification of Cyclone Amphan.

Visibility of the Himalayas

The people of Jalandhar in the state of Punjab woke up on 3rd April, to the sight of the Dhauladhar mountain ranges of the Himalayas, with their snow capped peaks visible from their roof tops. On April 29th, an IFS officer took to twitter a picture of the Gangotri Peaks of the Himalayas, visible from the town of Saharanpur, Uttar Pradesh. This serene view is said to have been witnessed after three decades. The Bandarpoonch mountain massif in the Garhwal region standing at 6313 meters above sea level was visible to the residents of Saharanpur to the naked eye, its snow-clad peaks glistening in the setting sun.

Figure 7a: Himalayas visible from the city of Jalandhar (Source: CNN).

Figure 7b: Gangotri peaks visible from Saharanpur. (Source: Financial Express).

WATER POLLUTION

Impact on River Ganga

The life-line of India, the River Ganga, with 97 towns along its course copes with 3500 MLD (million litres per day) of sewage, of which about 9% accounts for industrial effluents. During the nationwide lockdown, there has been an overall improvement on the water quality with respect to the increased Dissolved Oxygen (DO) and decreased Nitrate concentration. This is mainly due to the absence of industrial discharge and agricultural runoff as well as increased freshwater input. There was recorded less Biological Oxygen Demand (BOD) as well as Chemical Oxygen Demand (COD) due to relatively less domestic wastewater influx. [Source: CPCB Report]. The water of Rapti, Saryu, Ganga and Yamuna rivers in cities also became clear and transparent due to less deposition of domestic and industrial effluents (Verma and Prakash, 2020a).

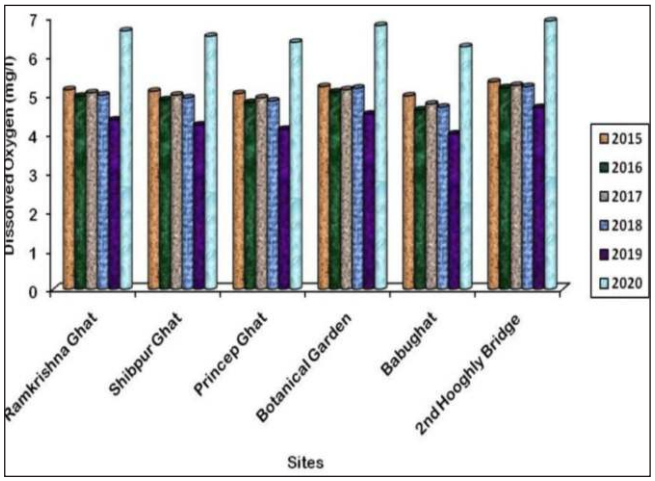

Figure 8: Spatial variation of DO level (in mg/l) in River Ganga. (Dhar *et al.,* 2020).

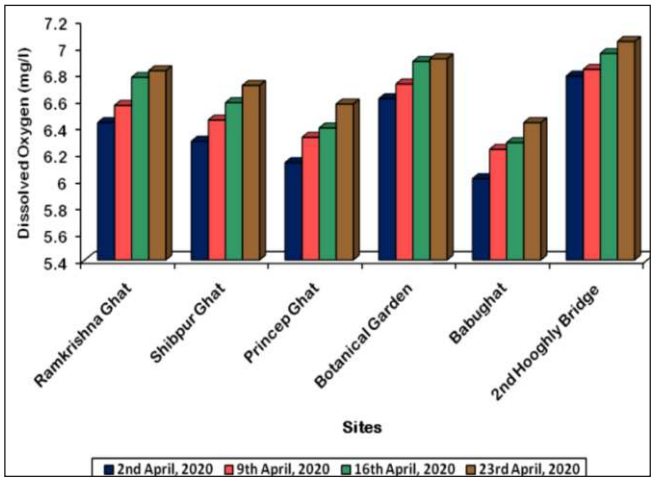

Figure 9: DO level (in mg/l) in the study sites during lockdown phase (Dhar *et al.,* 2020).

A study on Dissolved Zinc concentrations in the Estuarine System of Hooghly, which is an offshoot of Ganga, showed significant changes in the post-lockdown period. In all three sampling stations of Kakdwip, Shankarpur and Bony camp, the investigation showed a sudden dip in the otherwise increasing trend of dissolved Zinc all through the 1st to 4th week April, 2020 (Agarwal *et al.,* 2020).

With increased climatic change and waste water disposal, Ganga has seen a concomitant increase in acidification of its waters with increase in its dissolved CO_2 content (Dutta *et al.*, 2020). Post-lockdown investigation from three points along the banks of Hooghly River in Kolkata showed a reversal in acidification from all three sites. The data set from 18th March (Pre-lockdown) to 30th April (Post-lockdown) showed 2.84%, 3.46% and 4.99% at Ramakrishna Ghat, Botanical garden and Babughat, respectively. This might be due to the complete stoppage of industrial discharge as well as absence of fishing trawlers and recreational activities along the ghats (Mitra *et al.,* 2020b).

With news on social media circulating about a sudden clean Yamuna front, the CPCB team

Dissolved Oxygen concentrations remained above bathing water criteria norms (5 mg/l or more) at all locations during the lockdown period, however only marginal improvement was seen in most stations along Uttar Pradesh, and significant improvement in only a few monitoring stations (*i.e.* in West Bengal) only after the 2nd week of lockdown. Marginal reduction in BOD was seen in only the 4th week onwards. A decreased trend of Nitrate concentration was recorded (except in West Bengal). [Source: CPCB Report]

A study conducted along six ghats in and around Kolkata, showed significant increases in DO post-lockdown. DO increment of 35.71%, 35.06%, 33.97%, 35.06%, in Princep Ghat, Botanical Ghat, Babughat and 2nd Hooghly Bridge respectively during April, 2020 was recorded (Dhar *et al.,* 2020).

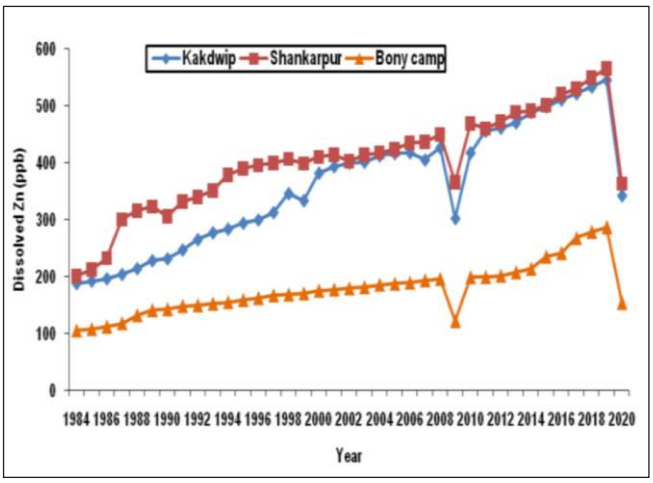

Figure 10: Variation of dissolved Zn during the study period (1984-2020). (Agarwal *et al.*, 2020).

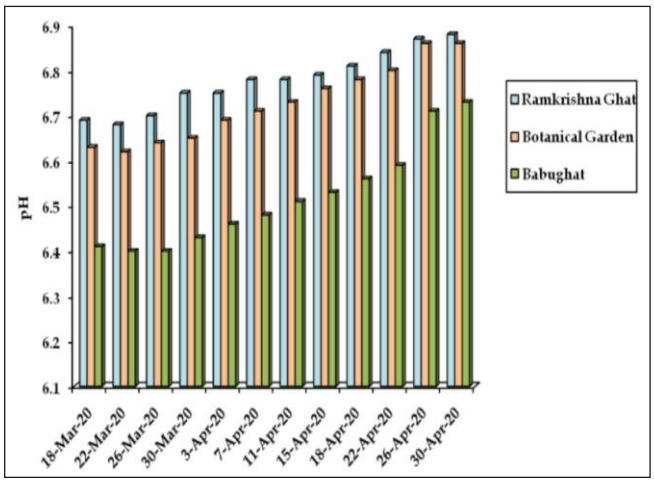

Figure 11: Spatiotemporal variation of pH during the study period. (Mitra *et al.*, 2020b)

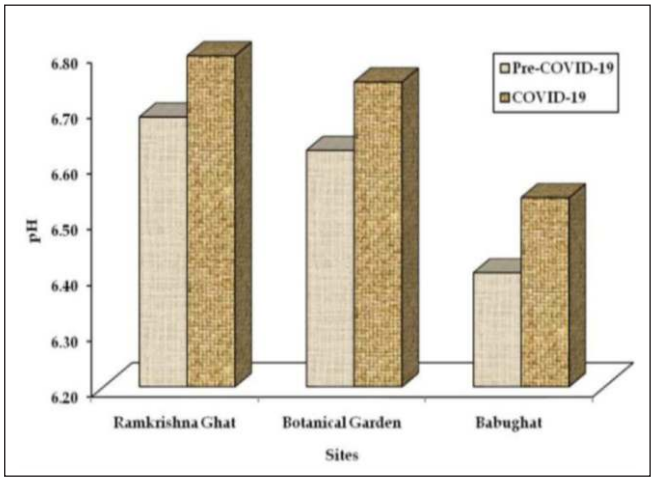

Figure 12: pH variation in the three selected sampling sites between pre-COVID-19 and COVID-19 lockdown period. (Mitra *et al.*, 2020b)

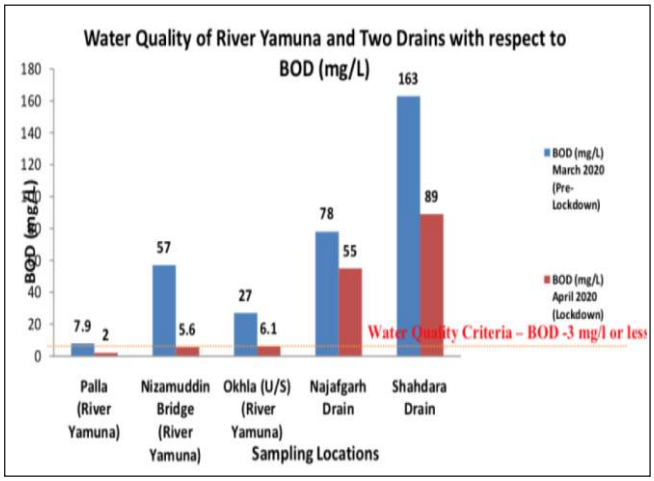

Figure 13: Figure : Water Quality Trend of River Yamuna and Two Drains with respect to COD (during Pre-Lockdown and Lockdown) Source: CPCB Bulletin

conducted tests along the river at focal points in NCT Delhi. The results showed considerable improvement in the water quality in Yamuna (with respect to DO, BOD and COD). This improvement can be credited to:

a) Release of fresh water from Wazirabad Barrage
b) Absence of Industrialdischarge (~35.9 MLD pre-lockdown)
c) High Solar penetration in water-clearing out the settle able colloids in river bed.
d) Absence of human activities along the banks. Figure 13: Figure : Water Quality Trend of River Yamuna and Two Drains with respect to COD (during Pre-Lockdown and Lockdown)

IMPACT ON BIOLOGICAL LIFE

A study on Ichthyoplankton community around the Haldia port-cum industrial complex showed eco-restoration of the community due to lower oil-grease pollution in the estuarine area due to lockdown (Pal *et al.*, 2020). A similar study in Diamond Harbour along Hooghly estuary concluded a higher standing stock of phytoplankton in April, 2020.

With reports surfacing about spotting rare sights of Gangetic Dolphins around Babughat (Kolkata), to Meerut, even critically endangered species of Malabar Large Spotted Civet made the rounds of news after being spotted in the streets of Kozhikode, Kerala. It seems that increased visibility of these animals is to be credited to the

lack of human traffic in these areas and reduced levels of pollution.

In the Therthangal and Melaselvanoor-Keelaselvanoor bird sanctuary, in Ramanathapura Forest Range, forest officials observed extended stay of partial-migratory birds like open bill stork, spot-billed pelican, painted stork, grey heron, spoonbill and ibis, thanks to the clean air and low noise pollution in and around the area. In Mumbai, a record breaking 1,50,000 flamingoes migrated, turning the wetlands in a picturesque pink hue.

BIO-MEDICAL WASTES

Both electronic and biomedical wastes are big problems for biodiversity and humans (Verma and Prakash, 2020b). The sheer amount of biomedical waste that is being produced due to the uprise in COVID-19 numbers is slowly turning into a waste management nightmare. PPEs, N95 masks, gloves, disposable bedsheets make up most of the biomedical waste generated in the pandemic. Compared to a normal patient, a COVID patient produces around 14 kg of biomedical waste a day. Instances of used face masks being picked up by rag-pickers in Pune were reported. In Thane, a man was arrested for drying up 1,00,000 used face-masks for reselling. Unauthorized waste segregation of masks, used syringes and PPE was reported at the Rohingya refugee camp site of the Sharan Vihar camp, near Kalindi Kunj (Delhi). Blue medical waste bags flooded the area, ready for segregation to be later sold as plastic waste. If not disposed of properly, face masks and other medical wastes can act as a source of reinfection. The CPCB issued guidelines for the proper disposal of medical waste on 18th March, 2020. Colour coding of waste bins, using double layered bags, proper waste inventory and disinfection by using 1% Sodium Hypochlorite solution were some of the main directives (CPCB).

DISCUSSION

In this review, authors observed how a pandemic forced humans across the entire world to close its doors, and how the nature flourished. In the Indian perspective, authors took account for all the environmental impacts and observed decreasing air pollution, water pollution and animal sightings. With a boon for nature during this pandemic, medical wastes also have multiplied threatening more plastic wastes in the environment, along with a risk of re-infection. The long term effects of this lockdown on the environment due to this pandemic is yet to be ascertained, however it is evident from the short-term data that nature has seen significant impact of the lockdown as a safety measure from the pandemic, due to highly reduced human movement and anthropogenic activities. Although, environmental improvement should not be rejoiced when the entire world is gripped by this horrible pandemic, humans should in this moment gauze the impact that anthropogenic activities have on the environment, or lack thereof. This pandemic showed humanity how much there is a need for sustainable development, and how much our environment can benefit from it. As mankind grapples for breath, Nature seems to heal.

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