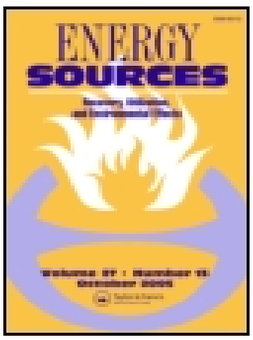

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Exploitation of artificial intelligence for predicting the change in air quality and rain fall accumulation during COVID-19

Manavalan Saravanan [a], Velmurugan S[a], Bhanupriya P[b], and Booma Devi P [c]

[a]Department of ECE, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, India; [b]Department of ECE, SRM Institute of Science and Technology, Chennai, India; [c]Department of Aeronautical Engineering, Jeppiaar Educational Trust, Chennai, India

ABSTRACT

This article describes the effect of lockdown measures in major cities on air quality along with rainfall accumulation. The impacts COVID-19 on the environment during lockdown conditions have been compared without lockdown conditions with respect to variable time duration and meteorological conditions. Particulate matter concentration of Chennai, Bangalore, Delhi, and Melbourne were assessed during the lockdown period. The mitigation measures taken by governments resulted in improved air quality particularly PM2.5 due to decreased road traffic. In addition, the rainfall and ground water accumulation were investigated during the lockdown period. The finding of this paper signifies the impacts of measures taken by government and provides detail view on death rate with respect to air quality reduction. The rainfall data were accessed in the four parts of India such as the South peninsula, North-West, East and North-East, and Central India. Besides, the anomaly between the observation periods was represented along with the temperature distribution. Compelling all it is evident that the COVID-19 reduced the concentration of the pollutants emitted from various sources. This eventually leads to excess rainfall in most regions around India compared to 2019. On the other end, COVID-19 does not create any significant impact of ozone layer improvement.

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Air quality; water quality; rainfall; particulate matter; COVID-19; airborne transmission; coronavirus

Introduction

The novel cornovirus called COVID-19 (209-nCoV) or SARS-CoV-2 originated in the Wuhan city in the end of December 2019. As on the August 2020, 26,655,911 cases had been reported worldwide with the mortality rate of 4%. Among the other countries, USA, Brazil, and India topped the total number of cases with 6,39,519, 4,054,474, and 4,014,744 confirmed cases, respectively (Andersen et al. 2020; Chen et al. 2020). With regard to the death count, USA reported worse rate of 191,478 confirmed deaths. COVID-19 is an RNA virus with spike protein projections on its surface. It generally ranges from 60 to 140 nm in diameter (Mahmood et al. 2020; Manigandan et al. 2020). In early 2020 many countries were imposed the lockdown to prevent the transmission of the virus. For this reason, the world traffic is reduced enormously. This article focuses on the effect of the COVID-19 on the environment (Zhou et al. 2020). Further, due to the reduction of the green house gases, there were drastic changes in the rainfall had been reported. It is generic that the pollutant concentration is reduced due to the stay indoor orders. To emphasize clearly the attempt had been made in the article to visualization the change in the NO_2, PM and CO concentration using AI technology. In addition to above, the rainfall accumulation also made for the entire parts of India. Despite the many recent

CONTACT Manavalan Saravanan msarawins@gmail.com Department of ECE, Vel Tech Rangarajan Dr. agunthala R&D Institute of Science and Technology, Chennai

articles on COVID-19 directs effects of the environment, the rainfall accumulation and AI technology prediction is very limited in terms of authors knowledge.

Artificial intelligence in air quality prediction

AQI and health risk calculation

Based on the range the index the quality of the air classified as good (0–50), satisfactory (51–100), moderate (101–200), poor (201–300), very poor (301–400), and severe (401–500).

Sub index air quality index (AQI_i) given by

$$AQI_i = \frac{I_{HI} - I_{LO}}{BR_{HI} - BR_{LO}} * (C_{i-} BR_{LO}) + I_{LO}$$

C_i – Concentration of pollutant 'i'; I_{HI} and I_{LO}- AQI index greater and smaller corresponding values; BR- Break point concentrations.

The relative risk of pollutants $(RRi) = \exp\left(\beta_i\left(C_i - C_{min,i}\right)\right) - 1$, $C_i > C_{min,i}$

β_i represented as exposure–response relationship coefficient (WHO 2016)

Density of vapor or absolute humidity (ρ_v (g/m3) (Ma et al. 2020; World Health Organization 2016)

$$\rho_v = 1000 * \frac{e}{R_v T}$$

Where, e- vapour pressure; R_V gas constant for water vapour; T- Ambient temperature

Due to rapid rise in population, the concern on air pollution is of growing significance. The rise in air pollution levels is due to industrialization, urbanization, and destruction of forests mainly near the major cities. The increase in annual air pollution level across the globe was around 8% according the World Health Organization global comparative analysis on air pollution (Ceylan 2020; Liu et al. 2020; Ma et al. 2020; Wu et al. 2020). Air pollution in atmosphere leads to several lung-related diseases, and it accounts for about 43%. Air pollution is considered to be a serious environmental threat and various sources of air pollution include household fires, industries, vehicles etc (Mardoyan and Braun 2015; Maroušek et al. 2020; Maroušek, Strunecký, and Stehel 2019). According to recent survey, $PM_{2.5}$ and O_3 concentration levels in atmosphere alone contributes to around 4.8 million deaths across the world. Particulate matter in atmosphere is considered to have highest impact on health next to O_3 (WHO 2016). Mass health-related issues to human beings worsely affect the country economy, in particular the countries concentrating to develop the healthcare sector to the higher level. Developing countries contribute 8% of their GDP for the health-related activities as per recent estimation by World Bank (World Health Organization 2016).

COVID-19 originated in china in December 2019 declared as pandemic by WHO. Due to high transmission rate, several countries declared a lockdown. All transportation and industrial activities were forced to stop completely during the lockdown period. The implementation of lockdown favors the reduction in quantity of air quality levels. Increased level of fine particulate in atmosphere causes myocardial infarction, heart failure, and so on. Since the tissues in the cardiac systems are very sensitive to particulate matter in the atmosphere, the investigation on reaction and health impacts of PM levels to cardiac system will help to understand the environmental threat of PM concentration in atmosphere. Previous researchers have identified the hazardous impact of PM toward the blood carrier and also on myocardium. ATP production mechanism due to reaction of particulate matter on myocardium had not been defined properly yet (Stanaway et al. 2018). Particulate matter prevents the entry of nutrients and oxygen to the child in womb and it causes premature birth. Old age and children are more vulnerable to $PM_{2.5}$ and it is necessary to precautionary steps, which include installation of air purifiers in elderly care homes and schools. PM also leads to neuro-degenerative impairment causes Parkinson disease in animals. Several other studies revealed that $PM_{2.5}$ does not have much impact on Parkinson disease (Palacios et al. 2014). Particulate matter penetrates deep in to the alveoli,

and it causes severe respiratory problems. In few cases, $PM_{2.5}$ causes cancer and gives rise in mortality rate of lung cancer.

Figure 1 shows the average concentration level of $PM_{2.5}$ in London, Melbourne, Chennai, and Bangalore. The values were taken at minimum of 14 stations in each city. After the lockdown has announced, the concentration of air pollutants in major cities started to decline significantly as compared to pre lockdown. The average concentration level of $PM_{2.5}$ in atmosphere has reduced by 11.1, 9, 21, and 19% on London, Melbourne, Chennai, and Bangalore, respectively. The $PM_{2.5}$ near industrial area was reduced significantly due to partial shutdown of factories (Wang and Su 2020; Zambrano-Monserrate, Ruano, and Sanchez-Alcalde 2020).

The variation of air pollutant level in atmosphere can be predicted or forecasted using the following AI techniques. They are deep neural network, fuzzy logic method and artificial neural networks. Recently, deep neural network algorithms were widely used mainly for the accuracy of data to solve the complex problems and based on previous researchers the most widely used deep neural network technique was Long short-term memory neural network. The time interchangeability of air quality prediction can easily be resolved by using Gated Recurrent Unit (GRU) rather than Recurrent Neural Network (RNN) and Long short-term memory neural network (LSTM) and GRU can handle metrological and statistical data effectively. Qi et.al used long short-term memory neural network and Graph convolution network combine to forecast the particulate matter concentration, LSTM technique was used to analyze temporal dependency whereas Graph Convolution Network was used for spatial dependency (Jat and Singh 2020; Kumar, Raut, and Narkhede 2020). Non-binary statistical datum was predicted using fuzzy logic technique. Time series fuzzy logic were applied by Domańska and Wojtylak to forecast the atmospheric pollutants include particulate matter, sulfur dioxide, nitrous oxide, ozone, and carbon monoxide. The most advanced and dynamic artificial intelligence techniques were deep neural network and artificial neural network. Singh et al analyzed and compared the artificial neural network, support vector machine, and multiple regression methods to predict the atmospheric pollutant level.

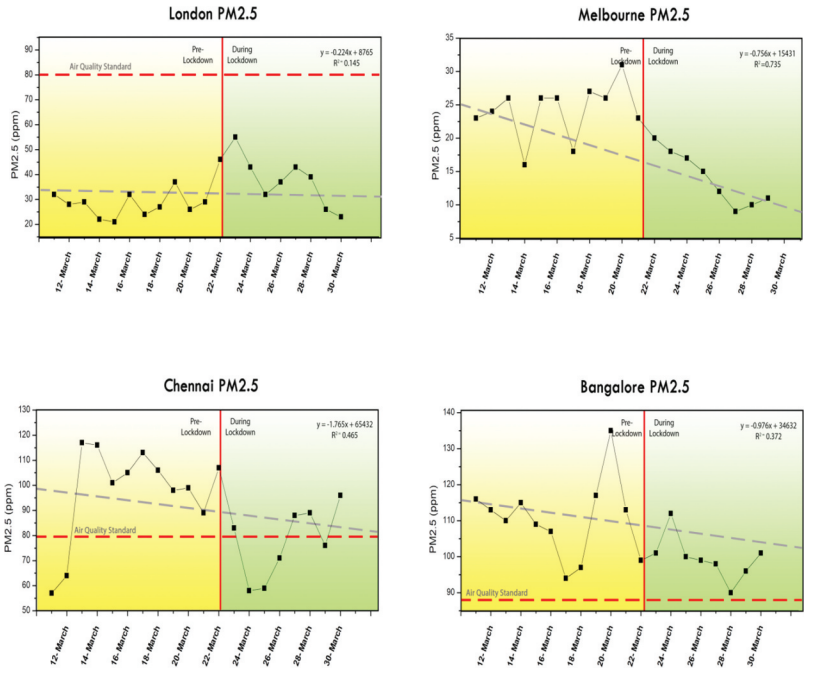

Figure 1. 24 hrs average $PM_{2.5}$ concentration of London, Melbourne, Chennai and Bangalore.

Ozone and NO_2

Ozone acts as a barrier for ultraviolet rays to enter in to ground surface and present in uppermost layer on earth termed as stratosphere. It is situated both in ground surface and upper layer and in general O_3 present in ground surface are mostly pollutants produced due to reactions of solar radiation with other air pollutants (China Faces The Challenge Of Chronic Disease | Asian Scientist Magazine | Science, technology and medical news updates from Asia n.d.; Gautam et al. 2016; Zhang et al. 2015). The contributions of ozone gas toward climate change are tremendous and the formation of such gases is mainly based on several meteorological factors. The factors which influence the ozone generation at ground level include direction of wind, wind velocity, rainfall and variation of climate. The presence of ozone gas in atmosphere has a potential to clean the atmosphere to higher extent. Due to rapid rise in industrial activities, vehicular usage and production of energy from non-renewable resources worsely affect the climate resulting in higher concentrations of ozone gas. In addition, the emissions of organic compounds and nitrous oxide damage the ozone layer in troposphere region.

Climate change in urban regions is mainly influenced by increasing emissions of nitrous oxide and ozone levels and these increased emissions lead to several respiratory diseases on humans. Several studies on epidemiology signify the correlation between air pollutants level and the respiratory diseases. The ill-effects of nitrous oxide, ozone, PM, and sulfur dioxide affecting the respiratory tract have been explored by several researchers. O_3 and NO_2 emissions levels in the atmosphere are dependent on several factors includes meteorology, boundary layer process of atmosphere, transportation rather than regional pollution sources. The air pollutants have correlation with heavy traffic conditions and high susceptibility to death rate and respiratory-related ailments investigated by several epidemiological and analytical researchers. Modern instruments ensnared in the relationship of pollution emissions and aviation route sickness considered epigenetic change of genetics by burning associated toxins and how polymorphs in genetics associated with cell reinforcement pathways and aviation route irritation could adjust reactions to air contamination introductions (Nižetić). The provocative response in lungs just as a course of ensuing reactions were mainly caused by ozone considered as a potential oxidizing agent and pneumonic irritant. The various anthropogenic agents include emissions from industry, heating equipments, and transportation along with natural agents of forest fire, chemical reaction of nitrous compounds in higher atmospheric levels and agricultural agents potentially generated nitrous oxide levels and it has short and long duration impact on lung diseases in children as well as adults. The reduction in lung function symptoms may develop due the higher proportions of NO_2 in the atmosphere and also it aggravates the bronchitis symptoms. There is

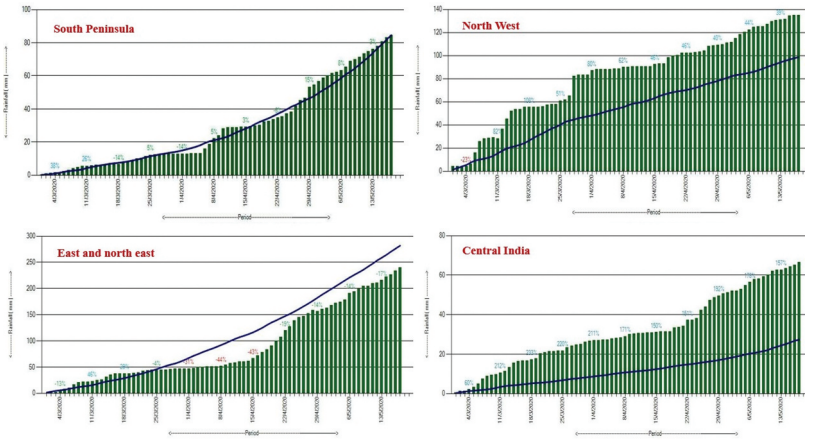

Figure 2. Rainfall deviations from April to July 2020.

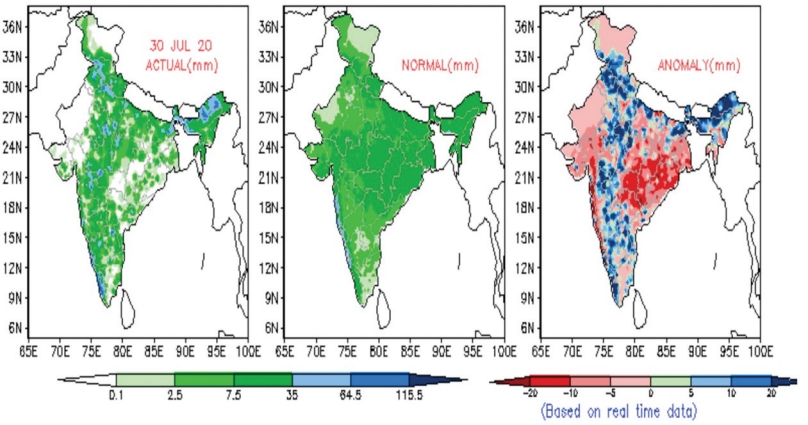

Figure 3. Distribution of rainfall in various parts of India.

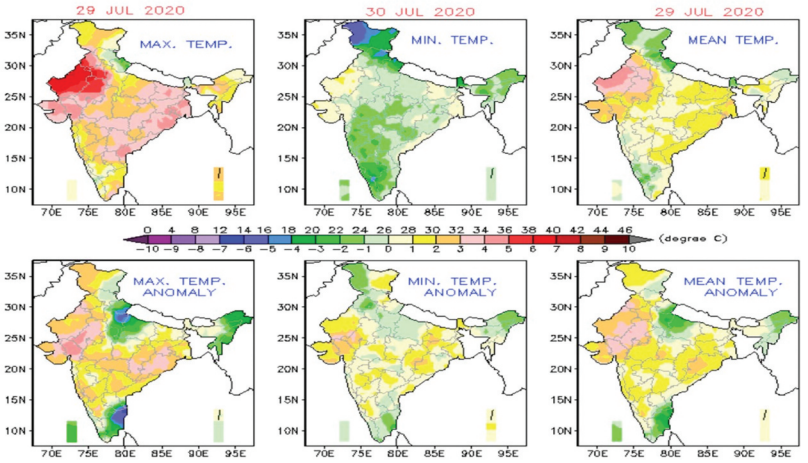

Figure 4. Surface temperature anomaly.

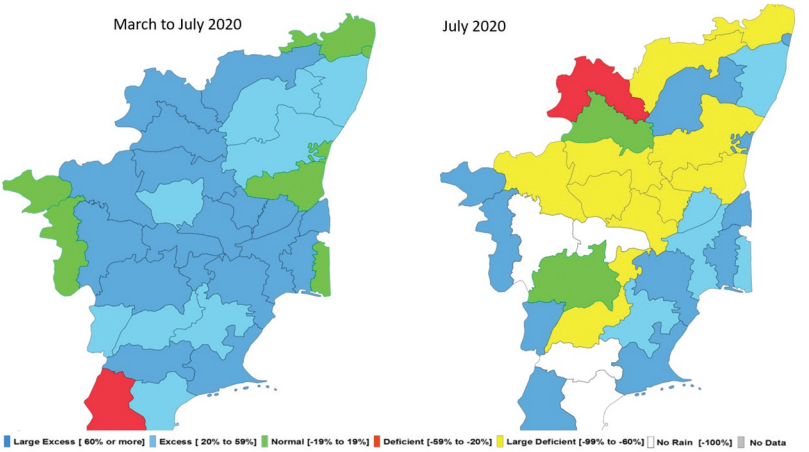

Figure 5. Spatial distribution of rainfall accumulation in Chennai, March to July 2020.

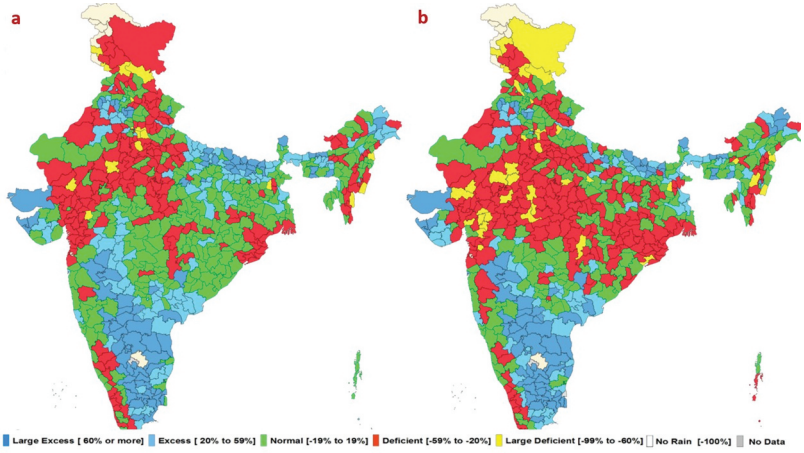

Figure 6. Spatial distribution of rainfall accumulation in India, March to July 2020.

Table 1. Statistical data of the ground water observation in the regional parts of India, Tamilnadu (Windy: Wind map & weather forecast n.d.).

Levels of observation Walls in 31 districts of Tamilnadu			
	In mts		
District	Jun-18	Jun-19	Jun-20
Namakkal	11.71	14.04	12.91
Coimbatore	15.96	13.94	12.88
Dharmapuri	11.06	13.97	12.27
Dindigul	11.65	11.64	11.72
Thiruppur	11.56	11.22	11.61
Trichy	10.25	10.75	10.62
Salem	11.69	12.46	10.05
Theni	10.72	9.87	9.67
Perambalur	9.28	14.67	9.45
Vellore	7.99	11.12	9.42
Virudhunagar	8.77	11.04	9.32
Krishnagiri	8.06	9.49	9.11
Erode	10.81	9.74	8.91
Madurai	9.28	8.55	8.46
Thiruvannamalai	7.39	10.83	7.83
Villupuram	8.09	9.98	7.76
Karur	6.36	7.27	7.23
Cuddalore	7.64	8	6.78
Pudukottai	8.84	8.98	6.69
Sivagangai	9.07	9.94	6.52
Kanyakumari	6.15	7.61	5.84
Thiruvallur	6.12	6.47	5.79
Tirunelveli	6.4	7.61	5.56
Ariyalur	5.72	7.07	5.35
Ramanathapuram	5.19	5.04	4.95
Kanchipuram	4.51	6.08	4.92
Thoothukudi	6.12	6.99	4.73
Thiruvarur	4.08	5.94	4.19
Nagapattinam	4.88	3.39	4.02
Thanjavur	3.66	3.99	3.64

no correlation between the nitrogen oxide and ozone and resembles that higher nitrogen dioxide content depresses the ozone levels. The higher death rate due to lung infections was mainly due to exposures of nitrous oxide and particulate matter.

Effect of rainfall and ground water accumulation during COVID-19

As discussed above, there was a major change in air quality due to the lockdown and work at home strategy. In this study, we focused on the rainfall data only in India. The rainfall was predicted based on two factors such as water vapor and total energy spent from top to surface. Due to water vapor and excess greenhouse gases, the rainfall will be increased. Due to the COVID-19, the surface temperature was changed which altered the rainfall accumulation throughout the world. As per the India Meteorological department data, the 77% excessive rainfall has been reported in the month of March followed by hail, thunder, and lightning storms. Figures 2 and 3 show the deviation of the rainfall due to the profound change in the surface temperature as observed in Figure 4. This sudden change in the rainfall damaged many agricultural crops led to huge financial failure to many farmers. To be precise, the state territory Uttar Pradesh and Delhi recorded profound changes of 698% and 621% excess rainfall in the periods of March 1 and March 19, 2020. Nevertheless, some of other parts of India, the rainfall is short which is shocking. The states such as Manipur, Tripura and Mizoram rainfall deficits are 77, 84, and 99%, respectively. Since the COVID-19 impact less than a year, it is very difficult to predict how the CoV-2 changes the rainfall pattern worldwide. More data are required to form a conclusion. However, based on the study we can predict the change in climate when the next virus outbreak arrives.

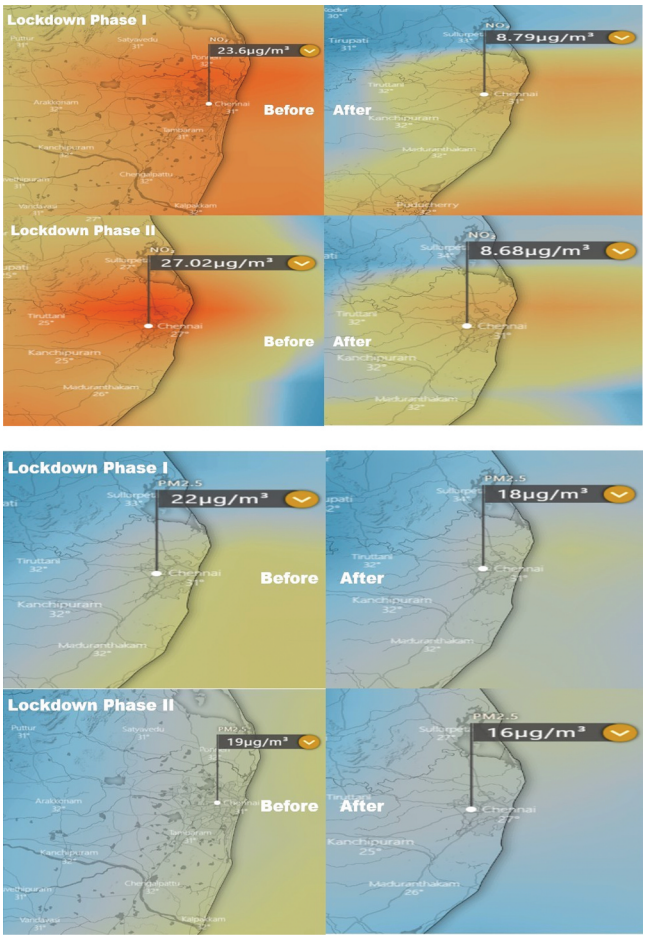

Figure 7. Effects on COVID-19 on environment, Chennai a) $PM_{2.5}$ b) NO_2 c) Ozone layer d) Aerosol (Windy: Wind map & weather forecast n.d.).

Compared to other countries, India went to severe lockdown from the month of March to July. As of now, still the metropolitan city Chennai was under the lockdown from the beginning of March with numerous restrictions. To analyze the rainfall data, city of Chennai was the best place since it was under lockdown since March. With that mind, the data are obtained from the metrological department. From the analyzed data, the July month was the wettest in 200 years. Figures 5 and 6 represent the change in the rainfall accumulation from March 2020 to July 2020. Despite the warm summer, the thunderstorm overtook Chennai every week which leads to the record breaking 200 years for the highest rainfall. Meanwhile, the humidity was higher than usual. As per the authentic sources, the easterly and westerly through in the state Tamilnadu leading to this rainfall. Due to good stretch of unexpected rains, most of the reservoirs are reached higher capacity compared to past decade. Besides, the ground water level was very good compared to last 3 years as shown in Table 1. On the other end, compared to the other states and cities in the world, the Chennai had undergone strict lockdown multiple times, from March to May 2020 as phase – I and June as Phase-II. During these lockdowns there was profound change in the air quality and the overall environment quality (Nižetić). Figure 7 shows the change in $PM_{2.5}$, NO_2, Ozone layer, and Aerosol from March to June. The environment quality was compared between the phase I and phase II. From the observation it is very clear that, the sudden change in the environment created excess rainfall in the city for the first time after 200 years.

Figure 7.

Discussion and conclusion

The lockdown measures taken by government provide positive impact on environment due to decreased land and air traffic, resulting in reduced health effects include myocardial infarction and lung-related ailments. The environment and ecosystem has been improved and restored significantly during the pandemic condition. The reduction of air pollutants causes unusual precipitations in several locations. The unusual precipitation significantly increases the ground water accumulation in several cities. COVID-19 pandemic causes demanding task for researchers around the globe to invent the vaccines. The pandemic situation should be effectively managed by creating awareness among the people about sanitation practices. Higher requirement of health worker to manage the pandemic or people affected by COVID-19, other treatments practices were limited, and innovative techniques need to be formulated to handle the non-communicable diseaseinfected patients. With respect to environment effect, the significant fall in air pollutant particularly PM2.5 reduction was observed in major cities. The reduction in PM2.5 was significant as compared to other major pollutants. The improvement in air quality levels causes abnormal precipitation in several places, thus improved the air quality level along with the lockdown measures taken by the government. The excess rainfall was observed as compared to previous year due to the massive change in the concentrations of the pollutants.

Notes on contributors

*Manavalan Saravanan*was born in March 1989.He received his master of engineering degree (Communication system) from Anna University, Coimbatore, India in 2012. He did his Ph.D. degree in Electronics and Communication Engineering at the Hindustan University, India. He is currently working in Vet Tech - Technical University. He had two years of teaching experience in V.S.B. of college of engineering, India and more than 5 years of research experience in the field of reconfigurable antennas. His research interests include reconfigurable antenna design, RF design.

S.Velmurugan received the B.E (Electronics and Instrumentation Engineering) Degree in 2011 from the Anna University, Coimbatore. Master Degree in VLSI Design in 2013 from the Anna University, Chennai. He completed his Doctoral degree in Faculty of Information and Communication Engineering at Anna University, Chennai. He has 7 years of teaching experience as an assistant professor. He is currently working as Assistant professor of Vel Tech in the department of ECE. His areas of interest include, Data Acquisition, Biomedical Instrumentation, Signal processing, Virtual instrumentation and Internet of Things (IoT) and he is a Life member of Indian Society for Technical Education (ISTE), Life member of International Society for Research and Development (ISRD).

P. Bhanupriya was born in December 1983. She received her master of engineering degree (Communication system) from Anna University, Chennai, India in 2017. She is currently pursuing Ph. D. at SRM - Technical University. He had 7 years of teaching experience and more than 5 years of research experience in the field of wireless communications. His wireless communications, 5G networks, sensor Networks.

Boomadevi Devi P did her post graduate in Regional Centre of Anna University: Tirunelveli. She had successfully completed her Degree of Doctor of Philosophy (2018) in Hindustan Institute of Technology & Science, Chennai. Currents she is working as an Associate Professor, Head of Department, Department of Aeronautical Engineering, School of Mechanical Engineering, Sathyabama Institute of Science and Technology, Chennai. She has Guided more than twenty B.Tech Aerospace students in the area of Aerodynamics, CFD, Aircraft Design, Polymer composites, her research interests includes Aerodynamic Analysis of wings and etc., Familiar with the following subject in teaching as Fluid Mechanics, Aerodynamics, Aircraft Performance, Flight Dynamics, Combustion, Engineering Thermodynamics, and Aircraft Propulsion, Helicopter Aerodynamics and Cryogenic propulsion. Currently her supervisor a Doctor of Philosophy scholar in the area of Aerodynamics.

ORCID

Manavalan Saravanan http://orcid.org/0000-0003-4594-9351
Booma Devi P http://orcid.org/0000-0001-9840-5353

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