Covid-19 and its related environmental quality issues along ganga river, Varanasi, India

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Abstract: COVID-19 made people around the world in terrifying and appalling circumstance which held back all collaborative stitches that is the government decreed people to stay in homes for suppressing the disease spread amid people. Pandemic situation due to Covid-19 has lead to worldwide lockdown. On the other hand, it has increased the quality of the environment especially in hydrosphere and atmosphere progressively throughout the world. The global shutdown from March to June 2020 made liable in assessing the environmental condition which is eccentric accomplishment when collating with past two decades. This study demonstrates change in the water and aerosol quality with the aid of remote sensing in Ganga River of Varanasi city, Uttar Pradesh state of India. Sentinel data obtained from February to July of 2020 used to determine the variation of pollution levels during different phases of lockdown. NO_2 levels derived from Sentinel data shows hazardous level of $5.64x10^{-5}$mol m^{-2} in March which is progressively decreased to 5.29 $x10^{-5}$mol m^{-2} for the month of April. NO_2 level further gradually increased after the unlock 1.0. Similarly, CO levels obtained from Sentinel data shows hazardous level of 0.0517mol m^{-2} in February which is progressively decreased to 0.0490 mol m^{-2} for the lockdown periods and it was gradually increased after the unlock phase. Further, Landsat data has been used to show Suspended Particulate Matter and pollution variation between lockdown phases. The high concentration of SPM value for March month ranges from -48.7773 to -48.7812, there is drastic decrease in concentration of SPM in which reflection value ranges from -48.7772 to -48.7806 in month of April noticed in the study area. Again there is drastic increase in July values ranging from -48.7753 to -48.7796 which is very high when compared to the lockdown SPM levels.The present study brought to light significant variations in the pollution level during the lockdown phases.

Keywords: COVID-19, Hydrosphere, Water quality, Aerosol quality, Suspended particulate matter

1. Introduction

The Corona virus (COVID -19) outbreak in India at its earliest stage was reported from the state of Kerala on January 30, 2020. Daily increasing cases and deaths due to COVID-19 have led to worldwide lockdown, confinement and some other restrictions. On March 2020 a nationwide lockdown for 21 days, limiting movement of industries, educational institutions, markets, transports and public gatherings which also includes holy worships. During the curfew national and international boundaries were closed except the emergency services (Police, Home guards, Civil Defence, Health Centre and Disaster Management). Lockdown period was further stretched in many phases till Jun 8, 2020 and lockdown of 75 days adhered with absolute caution. As of March 2021 the total number of COVID -19 active cases reported by World Health Organization (WHO) are 20 million including more than 2 million deaths globally. The lockdown in India is an eccentric and not happened ever before in the past. It is affirmed and manifested in several studies that anthropogenic activities are considered as one of the key drivers of pollution in all spheres of the environment (Volkamer et al. 2006). The outbreak of COVID-19 as a pandemic and consequent global shutdown, for the first time a complete confinement of extraneous activities, provided a possibility for the real time experiment of the effort of reduced emissions across the globe in abetting the environmental condition (Mandal and Pal 2020; Cheval et. al., 2020). As ensuing to that a gradual decrease in the concentration of turbidity in the water and suspended particles in the aerosols is observed in the lockdown (Patel et. al, 2020).Using Remote Sensing the water quality and the air quality is obtained with temporal variation and accuracy with the spectral characteristics of the features for the study of water quality assessment, turbidity of water as a key parameter. The turbidity is increased by silt, mud, algae, ashes, and other pollutants in the water.(Yunus et al. 2020), In this study authors attempted to understand the improvement of surface water quality using remote sensing data products. They selected Vembanad lake, located in the state of Kerala in India to evaluate the impact of the lockdown. The analysis of SPM concentrations in Vembanad lake based on the Landsat-8 OLI data revealed that the concentrations during the lockdown period were lower than those in the pre-lockdown period is observed. In many cities of India aerosol concentration level increases with NO2 and CO which are generated from vehicle emissions, industrial emissions and incomplete combustion, these are paramount sources of pollution. Avid Roman-Gonzalez et al. (2020), in this work the authors aim to show the decrease in aerosol pollution in Peru. They used remote sensing data from Copernicus Data Hub of the European Space Agency, specifically, Sentinel-5 Precursor satellite. The results show an essential reduction of aerosol pollution in different regions of Peru, especially in Lima and the Amazon regions. In this study we observe a sudden pioneer condition of environment due to pandemic lockdown. Current study is commenced to analyse the environmental impacts of COVID-19 in the Ganga river of Varanasi city using Landsat8 OLI sensor data to observe the short-term variation in water and air quality. Biswas et al. (2020), Using satellite observations for the pre-monsoon (March–

April–May) season, they explore the effect of the extended lockdown, on nitrogen dioxide (NO2), formaldehyde (HCHO), sulphur dioxide (SO2) and aerosol optical depth (AOD) over India .In this study, Observations of NO2, HCHO, SO2 and 550 nm AOD (MODIS) for the pre-monsoon period (March, April and May) of 2020 were analyzed and compared with that of (2017–2019) pre-monsoon season to evaluate the changes in trace gases and aerosol loading due to lockdown.

2. Study area

Varanasi city of Uttar Pradesh has been taken for this study to observe the quintessence of water in Ganga river and aerosol state of pandemic period. Substantially in this study we considered 510.7sqkm area in Varanasi which encompasses the Ganga river, renowned for its heritage and holistic history. The study area (Figure 1) lies between longitude of 82˚56'9"E-82˚41'52"E and latitude of 25˚28'8"N-25˚16'26"N. Many scientific works have been done in this Ganga river namely research on paleo channels of Ganga river disappeared due to (i) Take-off channels from the Ganga were cut-off, (ii) Sediment influx from higher level floodplains from either side of the Ganga river and flood accretion deposits of the Ganga from the west and south choked the channel; (iii) Piracy of tributaries by those of the Varuna in the north and of the Ganga in the south, and (iv) Neotectonic disturbances. Though Neo-tectonic disturbances are known within the Ganga plains, their signatures are not clearly visible to prove their role in the disappearance of the palaeo Ganga river (Mishra et al.2020). This area is liturgically active in rituals and people of various countries explore in this study, but due to pandemic shutdown fabricated a pioneer time to analyse the water quality and aerosol observation.

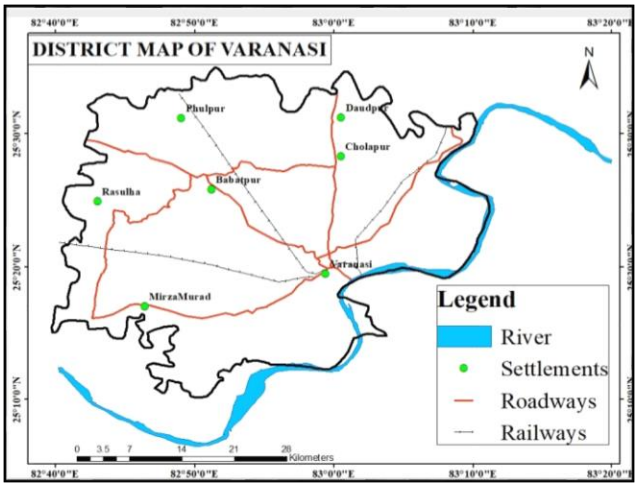


Figure 1. Location map of the study area

3. Methodology and Data Product Used

Mapping of air and water quality analysis has been carried out using Sentinel 5P and Landsat OLI data respectively. Data were collected according to the lockdown phases like pre, during and post lockdown periods. Air pollutant such as NO2 and CO has been obtained from Sentinel data whereas Suspended Particulate Matter was derived from Landsat OLI band 4. All these derivative maps were further reclassified and correlated to identify the hot spot of pollution and the effect of Covid -19 against change in environment quality.

4. Results and Discussions

4.1 Presence of NO_2 and CO Level in Atmosphere:

NO_2 and CO is one of the most important gases that affects the environment and causes many health related problems to mankind mainly asthma and lung related diseases.(Siddiqui et. al., 2020) They are mostly generated from burning of fossil fuels, industrial activities and also due to the emissions from vehicles (www.epa.gov/no2-pollution). In this COVID 19 induced lockdown there is a severe decrease in the level of NO_2 and CO concentration in all over the world (Venter et. al., 2020). Present study area, Varanasi also shows a sudden decrease of NO_2 and CO concentration during the Lockdown phase 1, 2 and 3 when compared to Pre Lockdown and Post Lockdown period. For this comparative study, many correlations are done by extracting the data from Sentinel Hub EO browser, the variations of NO_2 and CO concentration level is clearly seen in it. Data revealed that pollution levels in Varanasi were of 20 times more than WHO standards and the principal cause for that is the vehicular emissions, Industrial Pollution and the dust particles circulation over the city as per CPCB analysis. The NO_2 variation in the atmosphere is unpredictable because of the daily variations and hence the temporal range is very low and even hourly variations can be extracted (EPA air quality guide). Another impact is that because of the wind fluctuations also there may be a change in the values of NO2 in the air. Though these disparities are not steady enough they give us the outcome for our study area during the lockdown period which is quite interesting.

4.1.1 NO_2 and CO Concentration during Pre Lockdown

In Pre lockdown, the NO_2 and CO variation has been studied using March and February data respectively. Study area is highly (43rd critically polluted region in world) populated and also near the holy river where vehicle emissions and other industrial related activities causes pollution. NO_2 Values obtained from the Sentinel data varies from 1.79x10-5 mol/m² – 5.64 x10-5 mol/m² (Figure 2) and the CO value ranges from 0.0424 mol/m²-0.0517 mol/m² (Figure 3). The disparity recorded is of moderately high when compared to other months. This may be climatic crises or wind fluctuations. E-W profile along the Varanasi city has been generated for both NO_2 and CO parameters. (Profile 1,2).

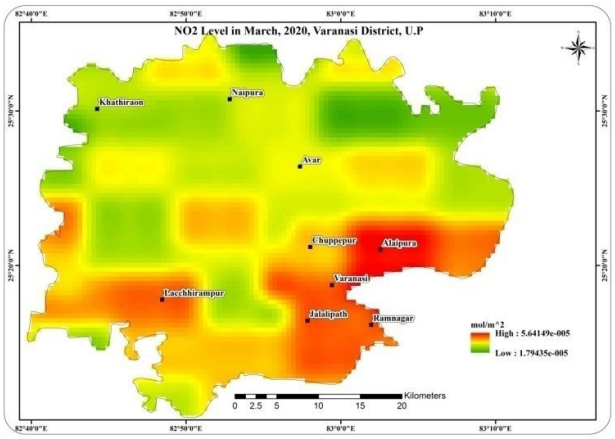
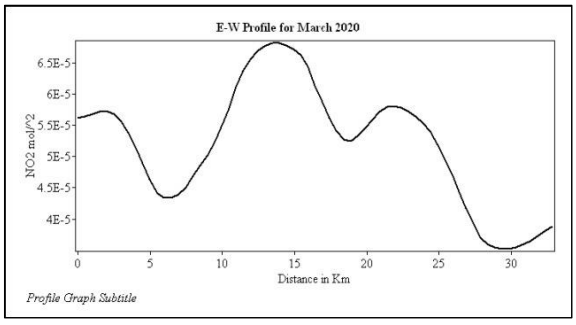


Figure 2. NO_2 Levels in March 2020



Profile 1. NO_2 – E-W Profile (March 2020)

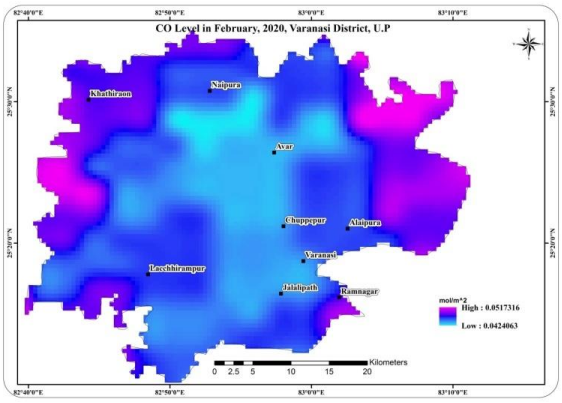
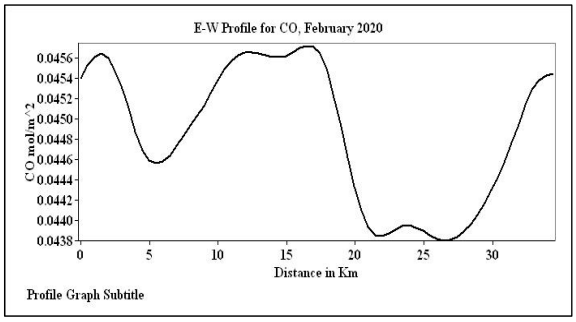


Figure 3. CO Levels in February 2020



Profile 2. CO – E-W Profile (February 2020)

4.1.2 NO_2 and CO Concentration during Lockdown

During the Lockdown period, (April 22, 2020 For NO_2) (April 15, 2020 For CO) data has been analyzed and indicates there was a sudden decrease of NO_2 and CO concentration in the entire Varanasi area which is due to pandemic induced lockdown. Movement of vehicle and all other activities were restricted which leads to the change in the atmosphere quality. The values range from2.81411e-005 mol/m² - 5.29437e-005 mol/m² for NO2 and 0.0413725mol/m² - 0.0490361 mol/m² for CO and is lesser when compared to the Pre-lockdown phase (Figure 4,5), (profile 3,4) Similarly, Lockdown data from May 16, 2020 shows further reduction in the NO2 and CO concentration. Lockdown Phase in the month of May 16, 2020 data indicates slight increase of NO2 and CO concentration in Varanasi area when compared to Lockdown Phase at April and Lockdown at 16th May for NO2 and May 2nd for CO but not as high as Pre lockdown. This slightest increase is due to the relaxation in the Lockdown. The values noticed in this are ranges from 2.70014 e-005 mol/m² - 6.91935 e-005 mol/m² for NO_2 and 0.0390097 mol/m² - 0.0457312 mol/m² for CO, when collated with other months. E-W Profile traversing along the Varanasi region indicates significant variations in the pollution level of NO_2 and CO (Figure 6, 7), (Profile 5, 6).

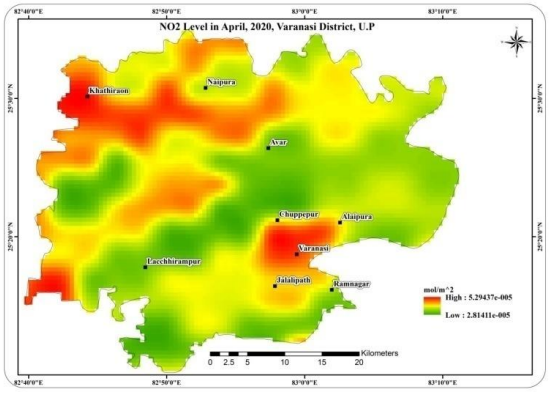
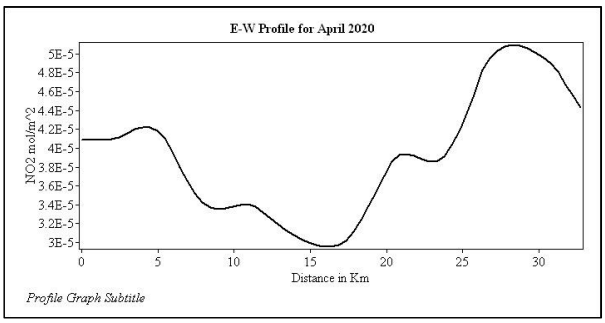


Figure 4. NO_2 Levels in April 2020



Profile 3. NO_2 – E-W Profile (April 2020)

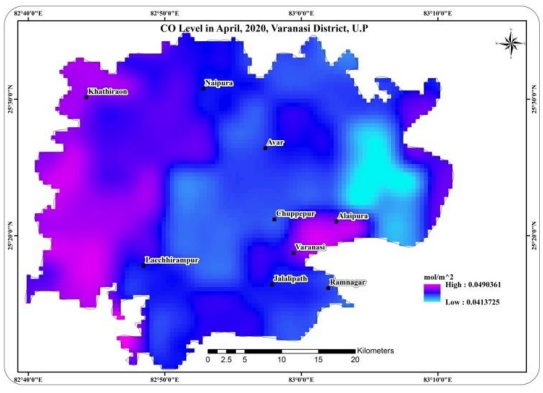
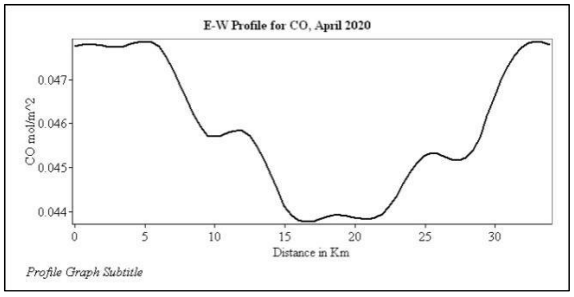


Figure 5. CO Levels in April 2020



Profile 4. CO – E-W Profile (April 2020)

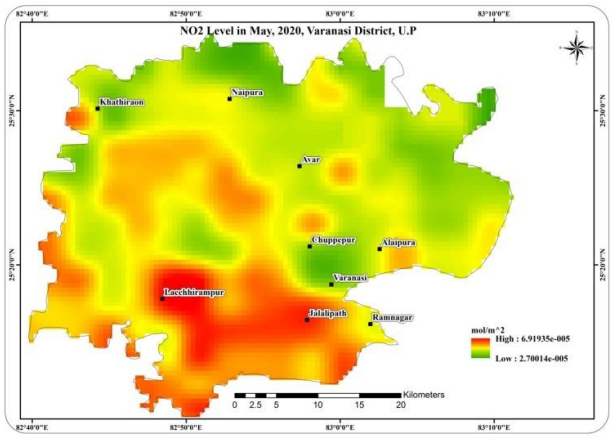
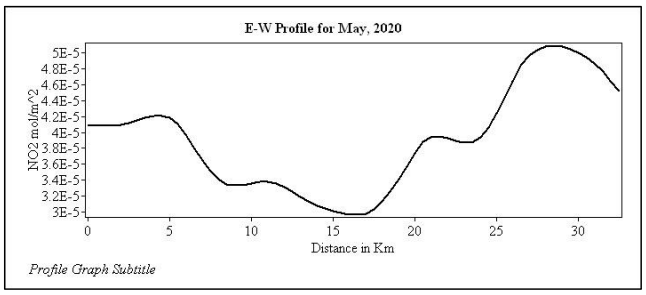


Figure 6. NO_2 Levels in May 2020



Profile 5. NO_2 – E-W Profile (May 2020)

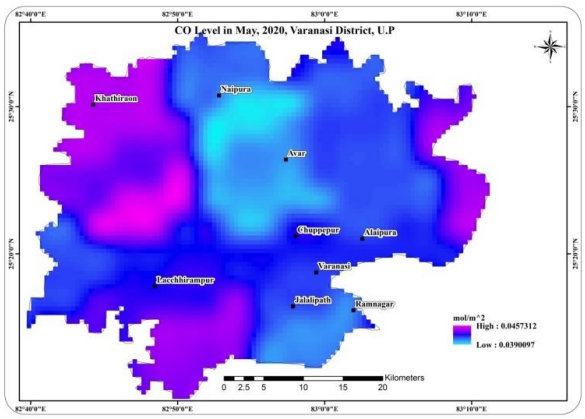
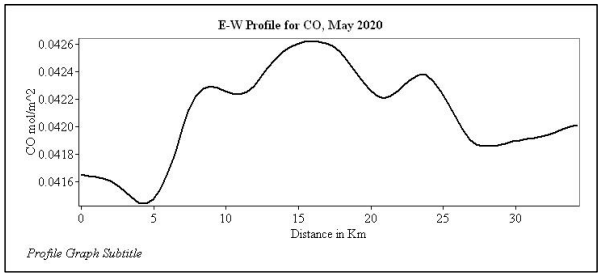


Figure 7. CO Levels in May 2020



Profile 6. CO – E-W Profile (May 2020)

4.1.3 NO_2 and CO Concentration during Post Lockdown

In Post Lockdown (June 07, 2020) for NO_2 and (July 05, 2020) for CO, there was a considerable increase of NO_2 and CO concentration in the atmosphere because of the movement of vehicles and other activities. Values are ranging from 1.14467e-005 mol/m² - 5.3627e-05 mol/m² for NO_2 (Figure 8) and 0.0368983 mol/m² - 0.0427663 mol/m² for CO (Figure 9). The typical values of CO and NO2 of pre lockdown and post lockdown ranges from 0-,0.1[mol/m^2] for CO and 0-1.0E-4[mol/m^2] for NO2.From this study we have analysed the anomalous concentration of NO_2 ranges from 1.25E-5mol/m^2 - 8.75e-5mol/m^2 and CO ranges from 0.01255mol/m^2 - 0.0875mol/m^2 at the time of lockdown. The level of NO_2 and CO concentration before Lockdown, during Lockdown and after Lockdown is clearly seen. Though this lockdown was very critical situation for many people, the environment strengthens itself to make a better place to live than before (Profile-7, 8).

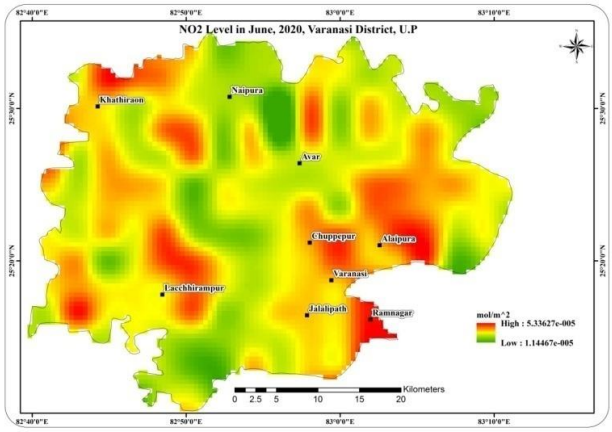
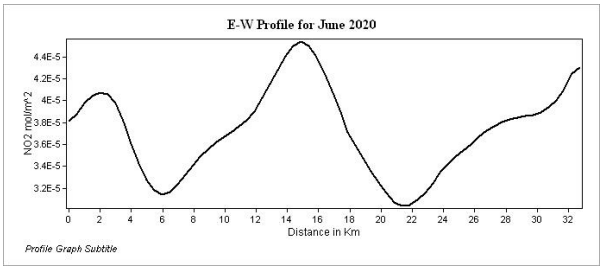


Figure 8. NO_2 Levels in June 2020



Profile 7. NO_2 – E-W Profile (June 2020)

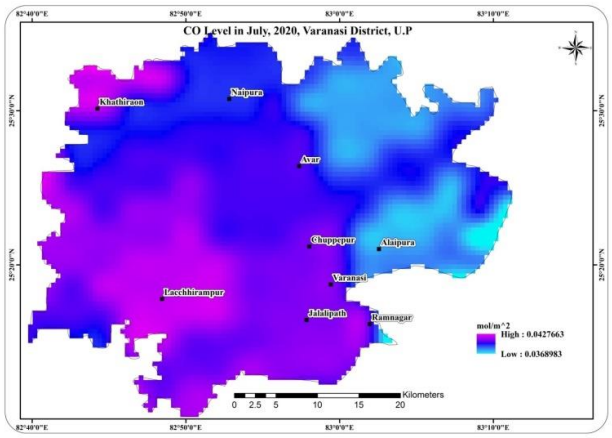
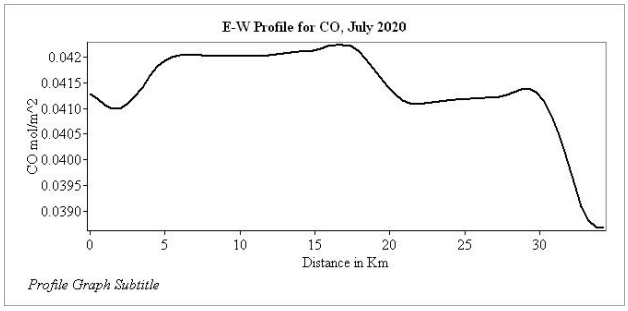


Figure 9. CO Levels in July 2020



Profile 8. CO – E-W Profile (July 2020)

4.2 Suspended Particulate Matter (SPM)

SPM is the framework that has been used to anticipate water turbidity. It is the appraising of obscure in water. Across the board, it is dearth in transparency of water due to contaminants. Suspended particulate matter play a vital role in deteriorating the environment and affects the strength of mankind causing various complications in routine life. SPM has a major aftermath not only on aesthetic nature of water bodies and also on aquatic animals and their spawning. Varanasi is a densely populated city, approximately there are 4 million addition to that this city has tourist people of approximately 5.9milion people visit globally. As the city is high in population and tourism, the city is transposed to pollution prone zone in recent years. Many researches on Ganges river of Varanasi about its quintessence of water is utmost affected by domestic sewage disposal, metal pollution, Eutrophication (Jaiswal and Pandey 2019). As it is a holistic destination for Hindus for their rituals, it is one of the major reasons for its high turbidity (Garg et. al., 2020). The SPM concentration in this study is calculated using red band of landsat8 OLI data using the formula given below. River masking has been done to avoid the other region under this study.

Formula used in Arc GIS:

(float (289.29*(Red)) / (float(1-(Red))/0.1686))

Where, Red is Red band reflectance data.
289.29 and 0.1686 are co-efficient constants (Nechad., et.al, 2010).

4.2.1 SPM Concentration during Pre Lockdown

The results from those studies obtained from February data showed that reflectance with trivial increase in SPM in the Ganga River. Kashi Viswanath temple and adjacent area receive heavy pollution which was indicated by the reflectance value in the Landsat band 4 data. This is because the river experiences heavy water pollution in the Kashi region where there is heavy urbanization due to holistic destination for Hindus for their rituals. Low level of SPM is identified in the other regions as the river flows through less urbanized area. The SPM levels are tremendously high during normal days and low during lockdown phase. The high concentration of SPM value for February month ranges from -48.7776 to -48.7815 noticed in the study area. (Figure 10) Very high concentration of SPM has also been observed in March month which ranges from-48.7773 to -48.7812 which is estimated to be higher compared to February month SPM concentration level. (Figure 11) This high turbidity zone of red colour is in the Kashi region has more settlements and temples in its vicinity, this gives clear perspective that these settlements and temples are the absolute source of pollution for the Ganga river. Part of Ganga river over a length of 113km has been taken for this study resulted that SW and NE part of Kashi region have low level of SPM.

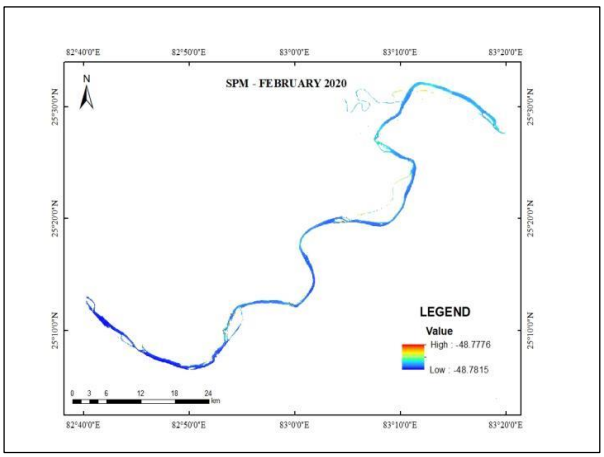


Figure 10. SPM-February 2020

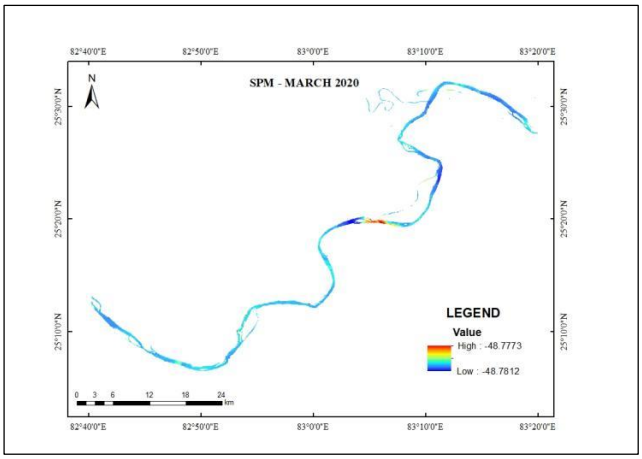


Figure 11. SPM-March 2020

4.2.2 SPM Concentration during the Lockdown period

April data has been taken up to understand the SPM level during the lockdown period which illustrates the gradual decline in concentration of SPM. Changes in the SPM level is mainly due the pandemic induced lockdown. The

values are ranging from -48.7772 to -48.7806 which are very low when compared to the pre lockdown SPM level (Figure 12). Comprehension of Ganga River near Kashi region indicates how the pollution level reduced due the restriction of vehicle and public movement to that holy place. May, 2020 data has also been taken to study the pollution level during the lockdown period but with vehicle relaxation and with basic amenities movement. SPM data which illustrates a sheer increase in the concentration of SPM in which reflection value ranges from -48.7781 to -48.7801(Figure 13).

4.2.3 SPM Concentration during the Post Lockdown period

July data has been taken up to understand the SPM level during the post lockdown period which illustrates the drastic increase in the concentration of SPM. Changes in the SPM level is mainly due the liberation in lockdown and complete release of restrictions. The values are ranging from -48.7753 to -48.7796 which is very high when compared to the lockdown SPM levels (Figure 14). Compiling all month of Ganga River near Kashi region shown in the (Figure 15) indicates how the pollution level increased due the vehicle and public movement to that holy place.

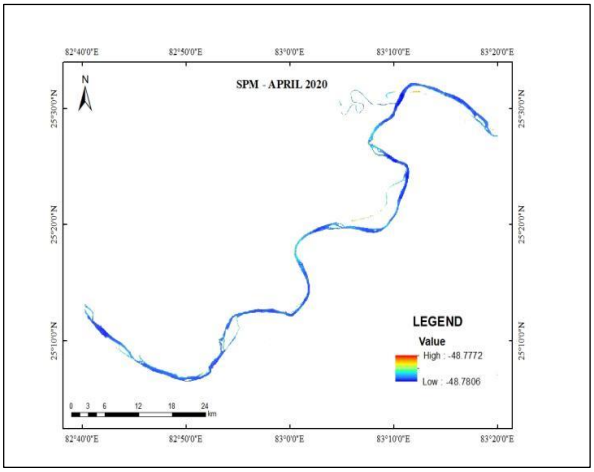


Figure 12. SPM-April 2020

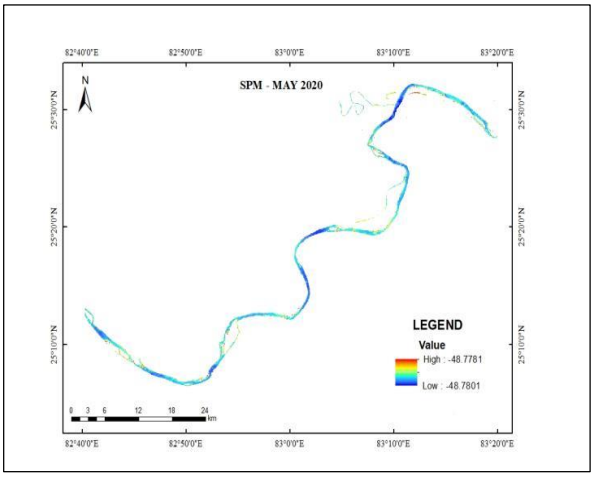


Figure 13. SPM-May 2020

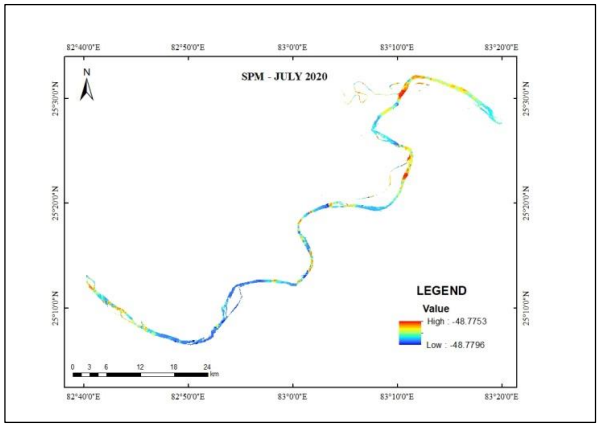


Figure 14. SPM-July 2020

5. Conclusions

Present study significantly brought to light rejuvenation of environmental quality in Air and Water due to the COVID – 19 pandemic induced lockdown. Drastic improvement in the environmental quality has been noticed during the

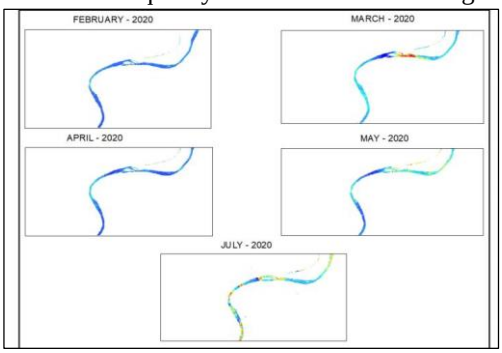


Figure 15 – Correlated Variation of SPM from February to July near Kashi temple, Varanasi, Uttar Pradesh, India.

lockdown period when compared to pre and post lockdown. In this global shut down, nature took ascendancy to improve the quintessence of environment. SPM concentration in the Ganga River decreases from April which is obtained by spectral reflectance variation in each month. Nearly about 113km stretch of river is scrutinized and the variation within pre lockdown, lockdown, post lockdown is analysed and further the turbidity concentration variation along the stretch of river due to domestic sewage inclusions and the settlements along the river bank. The aerosol data of analysing NO_2 and CO is observed to be decreasing from February month. This analysis is carried out with consummate avail of remote sensing and the results are entirely based on remote sensing principles. This is ensued as result of pandemic shutdown and it is indelible period in the history.

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