Variation in NO 2 , AOD and O 3 concentrations in Italy during COVID-19 outbreak

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Abstract

The outbreak of novel coronavirus pandemic has caused problems all over the world. Many people all over the world have lost their lives due to the severeness of the disease. The origin of the infection was the exposure of people to Huanan seafood market in Wuhan city of China. The malady has caused huge economic losses across the globe. Since it is a respiratory disease, the air quality in the region also plays a major role in determining the degree of the severeness of disease. Many places all over the world due to high levels of pollution have reported a large number of deaths. The regions with cold climatic conditions and have reported a higher number of cases in comparison to the countries with warm climatic conditions. The climatic conditions also affect the immunity power of people living in the area. As a result of this, the people of warmer conditions have stronger immunity and thus do not suffer to a large extent from the disease. Italy has reported a large number of infected cases of SARS-CoV-2 and also uncontrolled increase in the death toll in the initial stage. This study focuses on the comparison of levels of NO 2 , AOD and O 3 in Italy during the COVID-19 malady and in the previous year to determine the reduction in levels of these as a result of lockdown. The concentration of these pollutants had a drastic impact on the severity of the disease in the country. The announcement of lockdown in the country helped in the reduction of these pollutants thereby improving the air quality. This also helped in controlling the number of infected cases and also reduces the number of deaths due to infection.

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Variation in NO_2, AOD and O_3 concentrations in Italy during COVID-19 outbreak

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Abstract

The outbreak of novel coronavirus pandemic has caused problems all over the world. Many people all over the world have lost their lives due to the severeness of the disease. The origin of the infection was the exposure of people to Huanan seafood market in Wuhan city of China. The malady has caused huge economic losses across the globe. Since it is a respiratory disease, the air quality in the region also plays a major role in determining the degree of the severeness of disease. Many places all over the world due to high levels of pollution have reported a large number of deaths. The regions with cold climatic conditions and have reported a higher number of cases in comparison to the countries with warm climatic conditions. The climatic conditions also affect the immunity power of people living in the area. As a result of this, the people of warmer conditions have stronger immunity and thus do not suffer to a large extent from the disease. Italy has reported a large number of infected cases of SARS-CoV-2 and also uncontrolled increase in the death toll in the initial stage. This study focuses on the comparison of levels of NO_2, AOD and O_3 in Italy during the COVID-19 malady and in the previous year to determine the reduction in levels of these as a result of lockdown. The concentration of these pollutants had a drastic impact on the severity of the disease in the country. The announcement of lockdown in the country helped in the reduction of these pollutants thereby improving the air quality. This also helped in controlling the number of infected cases and also reduces the number of deaths due to infection.

Keywords: COVID-19, pollution, Italy, climatic conditions, immunity.

Introduction

China reported the appearance of pneumonia-like cases in December 2019 in the city of Wuhan which was later found to be novel coronavirus infection (Li et al., 2020; Wu et al., 2020; Xu et al., 2020). The reason for this was found to be exposure to Huanan seafood market (Gautret et al., 2019). The large scale movement of the masses to and from the country resulted in the spread of ailment all over the world. Due to its similarity with the SARS (Severe Acute Respiratory Syndrome) coronavirus which was a global epidemic from 2002 to 2003, it is named as SARS-CoV-2 (Xu et al., 2020). The World Health Organisation (WHO) gave the acronym COVID-19 (Corona Virus Disease-2019) for this new ailment (Sohrabi at al., 2020; WHO,2020a). All the three viruses namely, COVID-19 causing SARS-CoV-2 virus, SARS causing SARS-CoV virus and MERS causing MERS-CoV virus belongs to the same betacoronavirus genus but, SARS-CoV-2 has a milder infection (Munster et al., 2020). The novel coronavirus is phylogenetically related to Bat SARS-like coronavirus (96%) which was isolated in China from horseshoe bats during the years 2015 -2018 and is an indication of completely different evolution with bats as a wild reservoir. To be mentioned, the SARS-CoV-2 virus has also been isolated from pangolins, which has shown similarity ~85.5%- 92.4% with the novel coronavirus genome, thus identifying pangolins as potential intermediate host of the virus (Kang et al., 2020).

As per WHO (World Health Organisation) evaluation, the reproductive number R_0 value of SARS-CoV-2 virus has come out to be between 2 and 2.5 which is greater than SARS (1.7-1.9) and MERS (<1). This reflects that the novel coronavirus has higher pandemic potential than SARS and MERS. Some studies have calculated the reproductive number R_0 of the novel coronavirus to be 4 which is greater than the values estimated by WHO. As per a recent study, the average reproductive number of SARS-CoV-2 is calculated to be 3.28, with a median value of 2.79, therefore, exceeding the WHO estimates (Petrosillo et al., 2020, Li et al., 2020, Chen et al., 2020, Wu et al., 2020, Liu et al., 2020). The mean incubation period of the COVID-19 infection causing virus is estimated to be around 3–7 days (range, 2–14 days) (Backer et al., 2020, Lauer et al., 2020), and gives a clear indication of a long transmission period of SARS-CoV-2. A very important thing has come into notice that the asymptomatic carriers of the novel coronavirus infection are equally capable of transmitting the disease while they are still in their incubation periods (Rothe et al., 2020, Quilty et al., 2020).

The novel coronavirus infection is a respiratory disease with symptoms similar to influenza-like illness (ILI). The ailment has a varying degree of severeness ranging from a mild upper respiratory illness to severe interstitial pneumonia and acute respiratory distress syndrome (ARDS) (Chen et al., 2020, Wang et al., 2020, Liu et al., 2020, Petrosillo et al., 2020). The degree of impact of the ailment is variable with the native meteorological conditions and geographical conditions of different places. The concentration of various pollutants in the air also plays a major role in determining the severeness of the disease. The places with higher levels of pollution have reported a higher number of deaths due to malady. The higher concentration of pollutants like PM2.5, NO_2 and SO_2 damage the respiratory system thus reducing the resistance power against bacterial and viral infections and making people more prone to respiratory infections (Ciencewicki and Jaspers 2007; Hwang and Chan 2002). The temperature and humidity at a location play a major role in the spread of infection (Lowen and Palese, 2009). Just like influenza, the spread of COVID-19 is partially affected by the ambient temperature at a place (Tang et al., 2010). When the temperature drops, the stability of the influenza virus particles may increase and the physical properties of the virus envelope may be changed promoting the movement of influenza virus (Lowen and Steel, 2014). The locations with colder climatic conditions have reported more cases of SARS CoV-2 infection than the places with warmer climatic conditions. The people living in higher temperatures develop stronger immunity as a result of which they are less affected by the ailment. Previous studies have specified that cold and dry conditions promote influenza transmission (Tamerius et al., 2011; Barreca and Shimshack, 2012; Zhao et al., 2018). Later on, a pooled analysis suggested that the influenza activity would peak in cold-dry seasons when both humidity and temperature were at least levels (Fuhrmann, 2010). The colder temperature increases the survival period of the virus, therefore increasing the chances of transmission of disease.

Italy was the first country in Europe to be affected by the epidemic Covid-19, with an impact more disastrous than in the host country China (Fanelli and Piazza, 2020; Remuzzi and Remuzzi, 2020). Other European countries and the United States rapidly registered an exponential growth of clinical cases, leading to restrictions and a global lockdown with evident social and economic repercussions (Cohen and Kupferschmidt, 2020; ECDC, 2020). There are visible regional differences in the spread of infection in the country. The maximum number of cases have been reported from the northern country due to comparatively colder climatic conditions prevailing there (Remuzzi and Remuzzi, 2020). The mortality rate varied from 18% in the northern region to less than 5% in other parts of the country (Fattorini and Regoli, 2020). The concentration of air pollutants was a major factor in determining the number of cases and the mortality rate (Conticini et al., 2020). The relation between the short term exposure to high levels of atmospheric pollution and the level of impact of the novel coronavirus infection has been studied in China as well (Zhu et al., 2020). The severity of the impact caused by the concentration of air pollutants on the human body depends on various susceptible factors such as age, nutritional status and predisposing conditions (Kampa and Castanas, 2008). The higher concentrations of the air pollutants in North Italy and the urban cities led to a higher number of infected cases in those regions (Fattorini and Regoli, 2020). The duration of exposure to pollutants also played a role in determining the level of impact of the malady. The impairment of the respiratory tract and chronic ailment due to air pollution can facilitate the viral infection in lower tracts (Shinya et al., 2006; van Riel et al., 2006). The biogas plants in southern Italy release many odorous emissions which result in increased risk due to air pollution and are inhaled by the local population (Claeson et al., 2013; Merico et al., 2020). The industrial air pollution in southern Italy also contributed to the increased air pollution in the country. The longer the exposure, the higher the chances of hospitalizations and mortality with primary impact on cardiovascular and respiratory systems making more prone to various ailments along with cancer (Brunekreef and Holgate, 2002; Kampa and Castanas, 2008). The pollutants of major concern are nitrogen dioxide (NO_2), particulate matter (PM10 and PM2.5) and ozone (O_3) which are in high concentrations around the globe(Suresh,A, 2020).The announcement of partial lockdown in the country during the outbreak of the pandemic helped to a large extent in various ways. The most important is that it helped in controlling the further transmission of the novel coronavirus infection thus controlling the number of infected cases. Due to lockdown, the recovery rate also increased. Further, it acted as a tool for controlling the ever-increasing air pollution in the country which was continuously deteriorating the respiratory and cardiovascular systems of the natives and increasing the chances of infection. The decrease in the level of pollutants in the atmosphere is quite significant when we compare it with the last year record of pollutant levels. Initially, the number of cases in the country was multiplying at a very fast rate. It was only after the lockdown, that the situations came under control. In April in both the years 2019 and 2020, as the temperature started to increase the levels of pollutants also went down. But due to lockdown, the concentration reduced more in 2020. With the increase in temperature and reduced pollutant levels, the multiplication of the number of infected cases also reduced and the recovery rate slightly began to rise. Social distancing has proved to be a big boon in breaking the transmission chain of the virus. The major weapons to fight this pandemic are social distancing and lockdown. Meanwhile, the countries continue to use hydroxychloroquine vaccine as an effective treatment for the ailment, the development of the vaccine is still going on. Work from home has helped in reducing the various expenses and continue the work during the difficult times of this pandemic. There is an urgent need to control the high pollutant levels in the atmosphere to decrease the severeness of respiratory ailments. The colder countries have faced more problems due to higher pollutant levels.

Methodology

Study Area

The study focusses on the European country; Italy. The geographic coordinates of the Italian Republic lie on 43 ˚ N latitude and 12 ˚ E longitude. The country has a long Mediterranean coastline. Rome is the capital of the country, with the Vatican as a landmark. As per the census report from 2019, the country has a population of 60.04M. Venice, as the city of canals and Milan as the city of fashion, is the most famous and favourite tourist destination of the world. Italy Experiences the Mediterranean climate. Winters are cool and humid while summers are hot and windy. The country is having 4 seasons; the Spring-March to April, the Summer- June to August, the Autumn- September to November, and the Winter – December to February. The average temperature of the country is marked as; Average high- 15˚C and Average low- 4˚C.

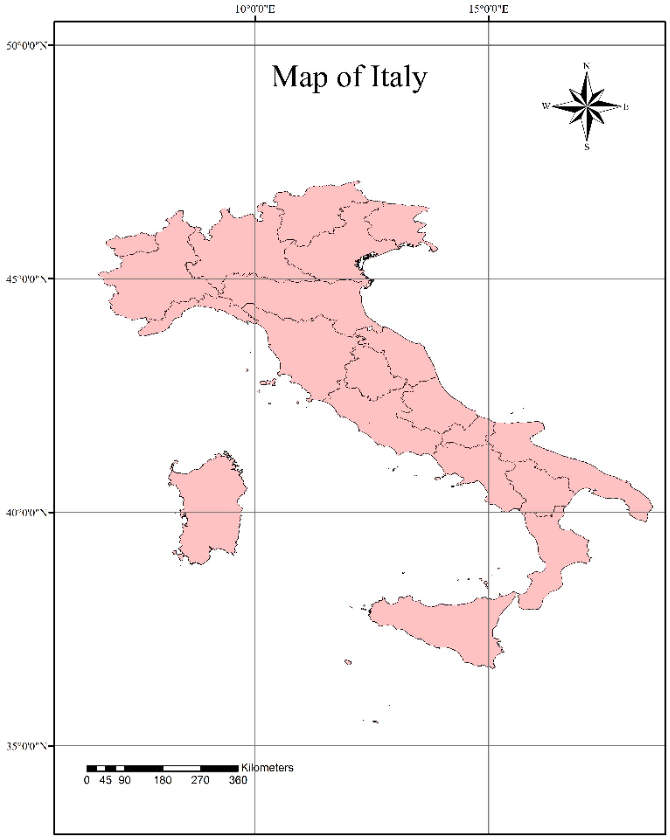

Figure 1: **Study Area**

Data Used

Satellite Sensor	**Resolution**	**Duration**
OMI (Ozone Monitoring Instrument)	0.25 degree	January to April 2019 and 2020

Ozone Monitoring Instrument (OMI) data are used for the study. The instrument is very efficient for distinguishing ozone and other atmospheric species. The sensor has a spectral region of 264 – 504nm, a spectral resolution of 0.42nm – 0.63nm and a resolution of 0.125 × 0.1250. The acquisition and measurement from tropospheric and stratospheric levels of the earth's atmosphere is the main objective of the instrument's mission. OMI is having a unique capability for measuring trace gases (O3 / SO2 / NO2/ HCHO / BrO and OCIO) with minimal footprint and daily global coverage. TOMS-like OMTO3e product has been used for the study of Ozone. For the study of the tropospheric column, NO2OMNO2d data product has been selected. Similarly, for the study of Aerosol Optical Depth (AOD), the OMAEROe product has been selected based on the multi-wavelength algorithm that uses up to 20 wavelength bands between 331 nm and 500 nm. Monthly averaged satellite data from the month of January to April are taken from NASA's Goddard Space Flight Center data repository and are used for the study from the years 2019 and 2020. Obtained data were processed and visualized using high level computing languages for better analysis. GIS tool has been used especially for mapping and for managing the geographical data information during the processing and interpretation of satellite data.

Results and Discussion

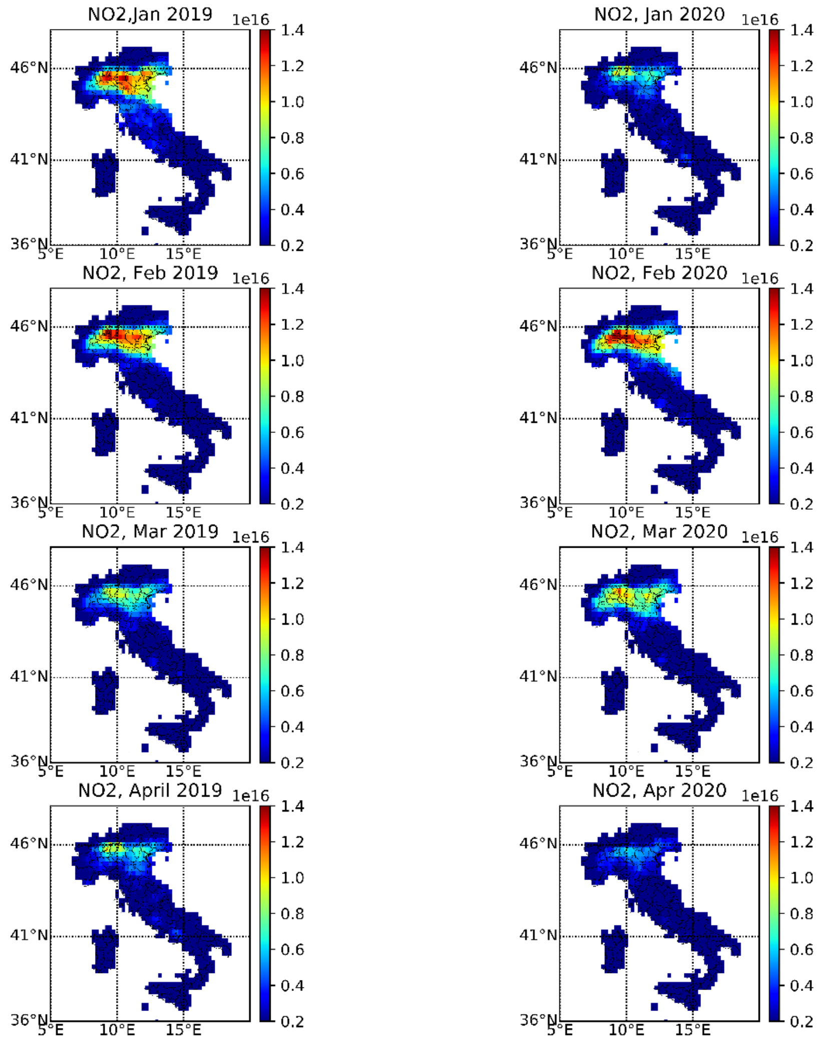

***Figure.2*:** **Comparison of concentrations of NO_2 from January to April in 2019 and 2020**

The concentration of NO_2 from January to April in both the years 2019 and 2020 goes on decreasing due to an increase in temperature. During the normal conditions, the southern part of Italy records not much variation in concentration of NO_2 due to relatively warmer conditions and value varies from 0.2 to 0.4 thus depicting quite lower concentrations of NO_2. The concentration of the pollutant in northern Italy has reported to be high due to colder conditions than the south and the value varies from 0.6 to 1.4. This year due to the pandemic COVID-19 partial lockdown was declared in the country which led to the decrease in the concentration of NO_2 in northern parts as well. Lockdown announcement in the country was done during February which reduced the NO_2 concentration in the country further in comparison to the previous year due to a reduction in the vehicular conditions. The concentration reduced so much that the value reached 0.6. The higher concentration of NO_2 in the country led to a higher number of cases of novel coronavirus infection as it is a respiratory disease and bad air quality deteriorated the condition of the respiratory system of people. The colder conditions in the country are also one of the major reasons for the higher number of cases. As a result of this, Italy became the second hotspot of the malady. The positive impact of the announcement of lockdown was the improvement in the air quality which is visible when we compare the concentration of the pollutants in April 2019 and April 2020.

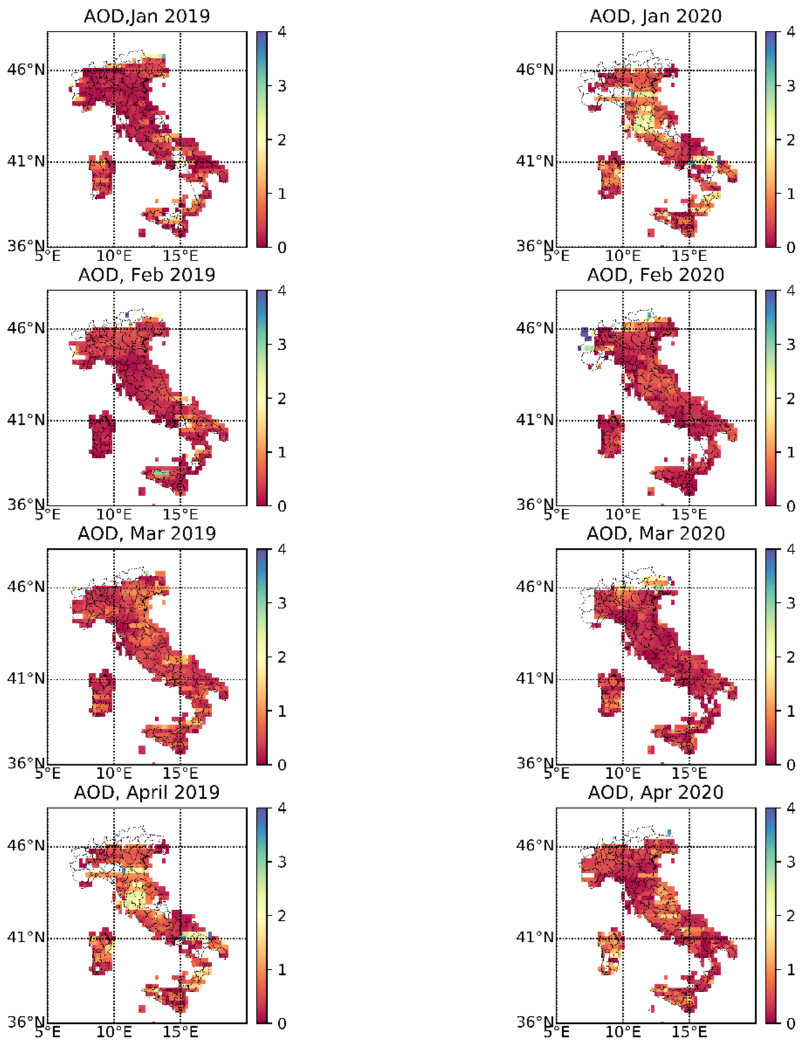

Figure.3: **Comparison of concentrations of AOD from January to April in 2019 and 2020**

The overall values of AOD concentration range from 0 to 3 thus depicting clear to slightly cloudy conditions. The concentration of AOD (aerosol optical depth) in 2019 and 2020 is quite similar. The month of January in 2019 observes the value ranging from 0 in maximum areas to 1 in some areas of the country. The conditions remain quite similar in February as well with values between 0 and 1 representing lower concentrations of aerosols. In March, the values in maximum regions reached 1 depicting an increase in the concentration. In April, the concentration of AOD raised and the value ranges from 0 to 2. In comparison to this, the concentration of AOD in the year 2020 is quite low. In January, in maximum parts of the country, the value ranges between 0 and 1 and some regions recorded the values between 2 and 4 representing higher concentration resulting in cloudy conditions due to blockage of sunlight. The month of February recorded the values majorly ranging from 0 to 1 depicting clear sky conditions. Some regions reported values ranging from 2 to indicating a very high concentration of aerosols and causing cloudy conditions. With the onset of March, the value ranges from 0 to 1 in maximum parts of the country but in a few regions, the value ranges from 2 to 4. The concentration in March 2020 remains lower than in March 2019 due to reduction in the number of vehicles as a result of lockdown. The month of April in 2020 observed quite lower concentrations of aerosols and value ranging between 0 and 1 in maximum regions of the country. In some regions, the concentration is reported to be slightly high and the value reached 2. The major reason for this is the imposing of lockdown due to the COVID-19 pandemic. Lockdown helped to improve the air quality conditions to a great extent.

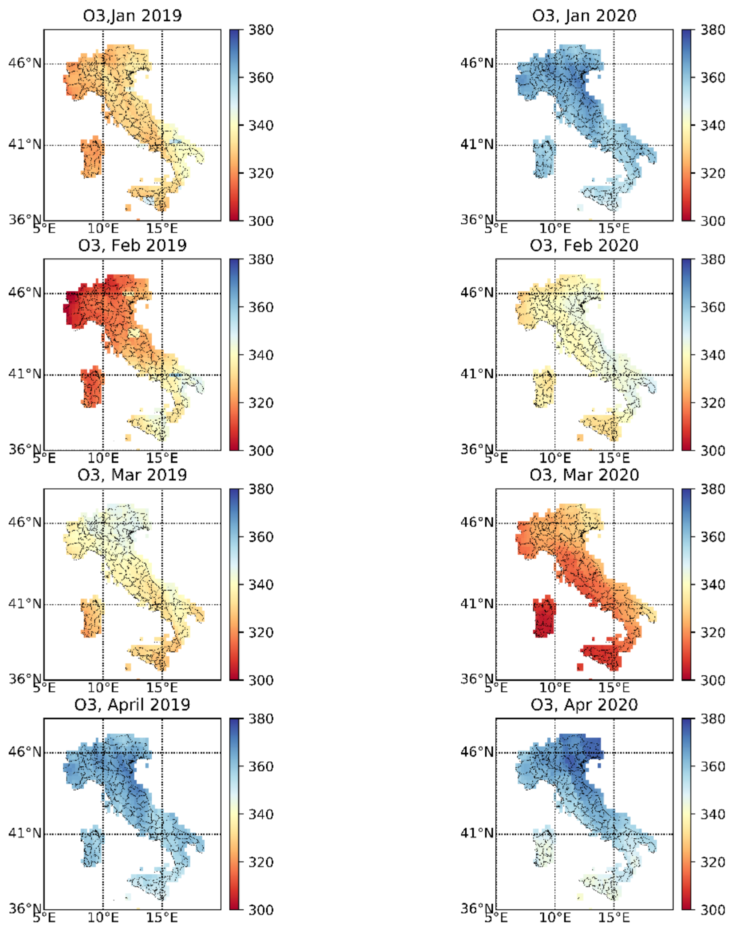

Figure.4: **Comparison of concentrations of O_3 from January to April in 2019 and 2020.**

The concentration of O_3 is quite low at the beginning of the year in 2019. The northern part of the country observes lower concentration of ozone than the southern part due to differences in temperature. In 2019, the value ranges from 320 in the northern region to 340 in the southern region in January. The values in February are observed as 300 in the north and 320-340 in south Italy. The month of March observes a slight increase in the concentration and the value ranges between 330 and 350 in the country due to an increase in the temperature. With the onset of April, as the summers arrive the country observes an increase in the concentration of pollutant and the value reaches 370 in the northern region and 350 in the southern region. The increase in the intensity of sunlight results in an increase in the concentration of O_3. The year of 2020 due to the outbreak of COVID-19, observed a significant increase in the concentration of ozone in February due to partial lockdown in the country and the value reached around 330-350 all over the country. The reduction in the number of vehicles due to lockdown reduced the concentration of NO_2 which eventually led to an increase in the concentration of pollutant. In March, the value reached around 300-330 across the country depicting a decrease in the concentration. With the onset of summers, the month of April observed a significant increase in the concentration of O_3. And the value reached 380 in the northern region and 350 in the southern part of the country. Due to the announcement of lockdown, the country was able to effectively improve the air quality which therefore helped in the reduction of the number of infected cases. The northern region of the country recorded a higher number of cases due to bad air quality and colder temperatures. The imposing of lockdown proved as an asset to the country in both cases whether it is air quality or the number of COVID-19 cases in the country.

Conclusion

The concentration of the pollutants NO_2, AOD and O_3 have been recorded to be lower in 2020 than in 2019. The major reason behind this is the announcement of partial lockdown in the country. Due to the cold climatic conditions the country records a higher concentration of NO_2, as a result of which the number of novel corona virus-infected cases in the country hiked. Since SARS-CoV-2 infection is a respiratory disease the regions with a higher concentration of pollutants reported more number of cases following a higher number of deaths due to damaged respiratory system. The people living in the colder and highly polluted areas have weaker immunity as a result of which they face a larger impact of the ailment. Most of the infected cases in the country are limited to the northern region. The presence of biogas plant and industries in the south led to increase in the concentration of the pollutants there as well which ultimately led to the weaker respiratory system of people and thus making more to catch the novel coronavirus infection. After the announcement of the lockdown, although it was partial, the level of pollutants in the atmosphere reduced to a considerable extent which helped in controlling the further transmission of SARS CoV-2 virus and also increased the recovery rate.

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