Case Report

Journal of Future Medicine and Healthcare Innovation

The Air Quality Before-and-After COVID-19 in Tunisia: A Case Study of the Month of May Between 2018 and 2023

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Submitted: 2023, Nov 17; **Accepted:** 2023, Dec 12; **Published:** 2023, Dec 22

Citation: Arif, A. (2023). The Air Quality Before-and-After COVID-19 in Tunisia: A Case Study of the Month of May Between 2018 and 2023. *J Future Med Healthcare Innovation, 1*(1), 15-19.

Abstract
The global coronavirus 2019 pandemic (COVID-19) reduced air pollution despite the economic, social and health disruptions that it caused on a global scale. We aimed to study the sulfur dioxide (SO2) and nitrogen dioxide (NO2) variability, which are the main air pollutants. We used the data from the Copernicus Sentinel-5P satellite to analyze the atmospheric concentrations of these pollutants in three Tunisian regions: the North, the Centre, and the South, before and after the onset of this global pandemic; we compared them with the results from other countries. We examined also the relationship between meteorological variables and these pollutants; the results showed a return to normal levels from May 2022, indicating a decline in COVID-19 cases and deaths worldwide. A multivariate linear regression analysis was performed to identify the meteorological variables that affect these air pollutants.

Keywords: COVID-19, Pandemic, Activities, Coronavirus, Meteorological, Tunisia, Pollution, Air, Health, Pollutant

1. Introduction

Air pollution is one of the major problems in this time. According to a report from the European Environment Agency (EEA) in 2020, air pollution caused more than 400,000 premature deaths in Europe, accounting for almost 12.5% of the total death rate [1]. Indeed, Sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) are the main air pollutants that they contribute to acid rain, smog, respiratory diseases, and climate change. For instance, the coal-fired power plants SO_2 emissions in China have caused severe acidification of soils and waters, threatening biodiversity and food security [2]. NO_2 emissions from vehicle exhausts in urban areas have increased the risk of asthma, bronchitis, and lung cancer among the population [3, 4]. Therefore, the Copernicus Sentinel-5P satellite data play an important role in monitoring air quality, particularly the sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) concentrations. The air quality and the pollutant concentrations monitoring can help policy makers, scientists and citizens make informed decisions and actions to reduce air pollution and its harmful effects.

2. Data Analysis

Satellite data have been used in Tunisia to track fluctuations in air quality in response to COVID-19. The Copernicus Sentinel-5P satellite – one of the elements of the European Copernicus program – has provided permanent mapping of variations in atmospheric pollution since its launch in 2017. We identified the link between COVID-19 and the air pollution response in Tunisia using satellite data from ground-based Sentinel-5P. Using the daily data from the SENTINEL-5P satellites in Tunisia domain for May, 2018 to 2023 years, the graphs below show the mean concentrations of nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) over three Tunisian areas: The North, the Centre, and the South. The North includes regions between 35 degree and 38 degree latitudes; the Centre regions between 33 degree and 35 degree latitudes; and the South includes regions between 30 degree and 33 degree latitudes.

The results indicated that the surface air concentration generally improved for all pollutants in 2020; however, changes in 2021 have been reversed; this may be due to the reduction of some countries' restrictions. Although the air quality is improved temporary, it is an important outcome for planning the control of environmental pollutants. The broken curves reflect the years 2018 and 2019 for the month of May. The broken curves reflect the years 2018 and 2019 for the month of May: The solid red curve is that of the years between 2020 and 2023 (Figure 1). The concentration trends of sulfur dioxide (SO_2) for the period 2020-2023 compared to the previous year, i.e. 2019, represent a decrease between 79% and 86% for the North of Tunisia, between 40% and 60% for the Centre and between 9% and 47% for the South. Also, the interrupted concentration curves of nitrogen dioxide (NO_2) reflect the years 2018 and 2019 for the month of May (Figure 2). The continuous red curve is that of the years 2020-2023. The concentration trends for the period 2020-2023 compared to the 2019 year represent a decrease between 57% and 77% for the North of Tunisia, between 3% and 48% for the Centre and an increase between 7% and 26% for the South. This last result for the south of Tunisia is the cause of the industrial absence zones and the minimal road traffic in these regions. These data show that the strongest reductions were observed after the first period of confinement, which lasted from the end of March-beginning of April 2020, in the North and Centre of Tunisia. This was observed in particular during the month of May (Figures 1 and 2). For June and July 2020 respectively, SO_2 data indicates that concentrations are still lower than pre-COVID-19 values for the following regions: 83% for the North, between 88% and 89% for the Centre, and between 10% and 40% for the South. The NO_2 data shows concentrations lower than pre-COVID-19 values for these regions: between 67% and 69% for the North, between 54% and 57% for the Centre, and higher than 4% or the same for the South. Therefore, a spectacular fall in Sulphur dioxide (SO_2) and Nitrogen dioxide (NO_2) produced mainly by human activities was observed after the first period of confinement in several Tunisian regions, especially in the North and the Centre.

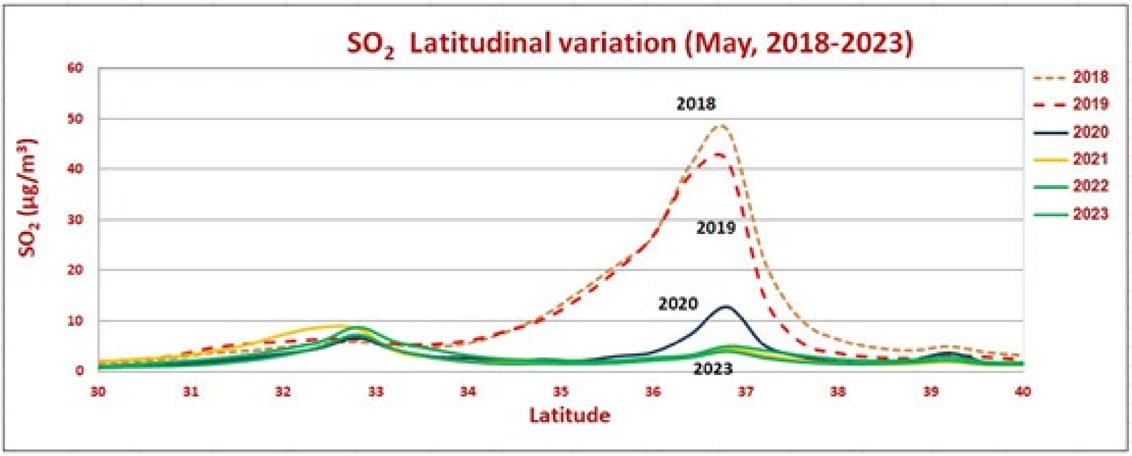


Figure 1: Latitudinal Variation of the Surface Sulfur Dioxide Concentration (SO_2, µg/m^3) in Tunisia for May, 2018-2023 Period

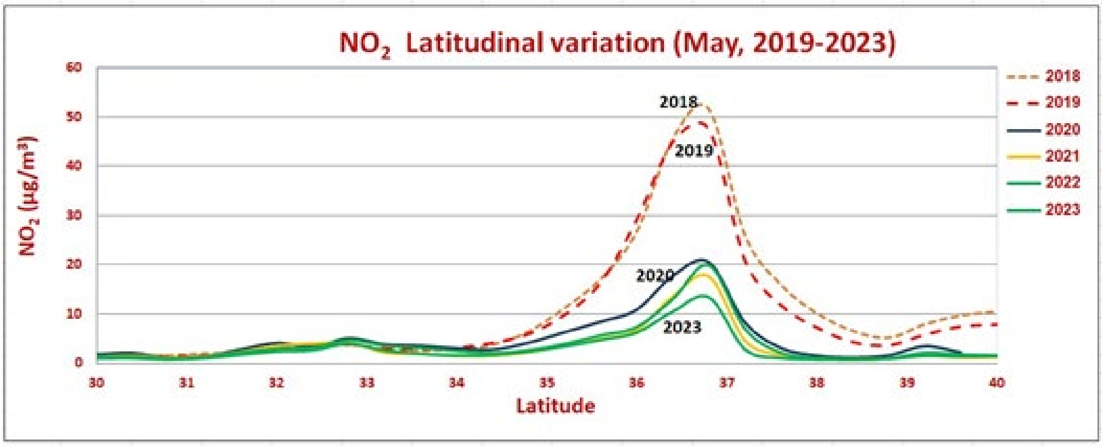
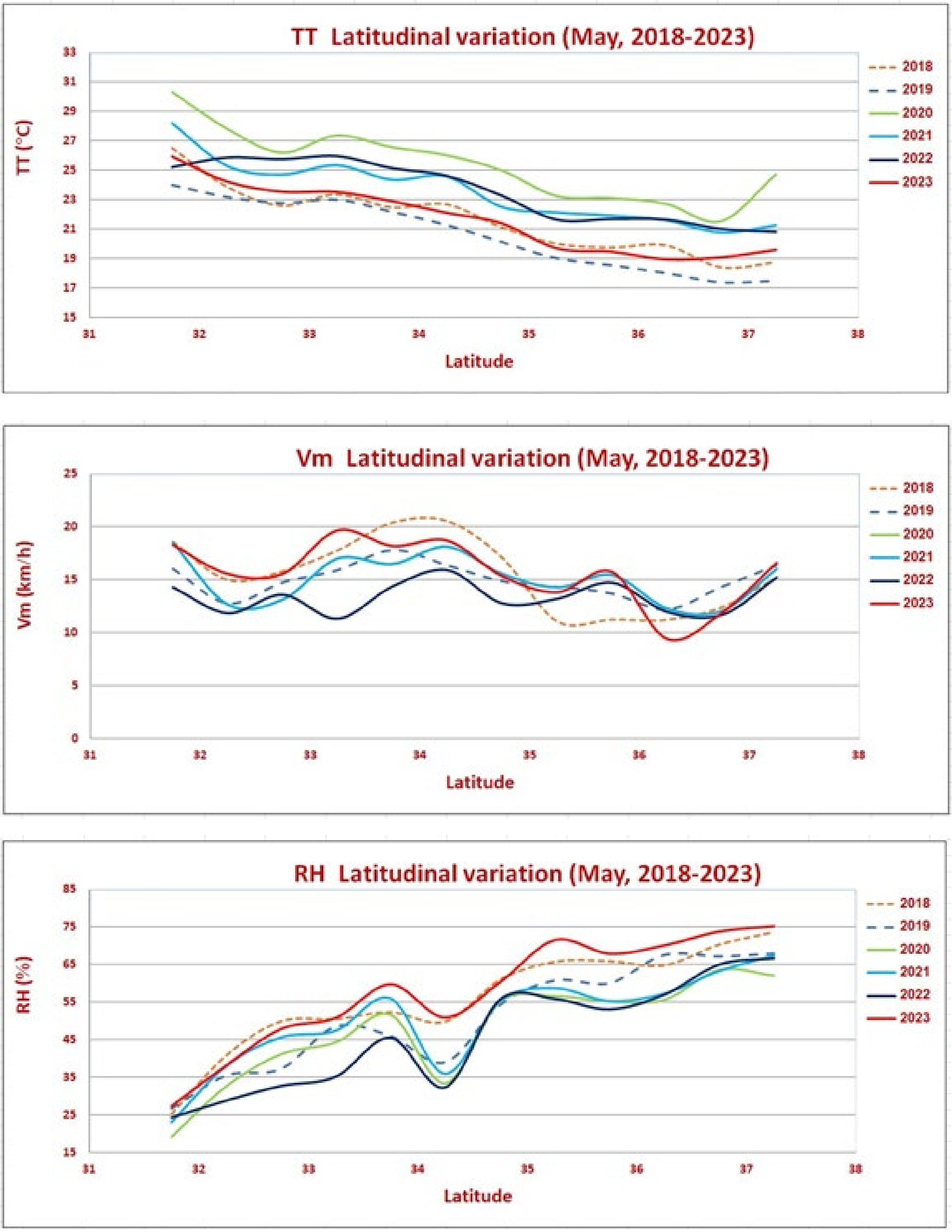


Figure 2: Latitudinal Variation of the surface Nitrogen Dioxide Concentration (NO_2, µg/m^3) in Tunisia for May, 2018-2023 Period

The reduction of these pollutants appeared in the majority of countries in the world [5-6]. Also, Northern Italy and France saw a reduction of nearly 50% of their NO_2 emissions during this period. In central China, NO_2 emissions have been reduced by almost 25% [7]. SO2 emissions have fallen by over 60% in Northern Tunisia, Mumbai, New York and Los Angeles nearly 33%, Madrid 50%, Seoul 50% and Wuhan 42% [8, 9]. Air pollution is responsible for many deaths and an increased of respiratory incidence illnesses; according to the World Health Organization (WHO), nearly 4.6 million people die each year from diseases related to poor air quality, responsible for more deaths each year than motor vehicle accidents [3, 8-11]. Deaths associated with air pollution include (but are not limited to) aggravated asthma, bronchitis, emphysema, lung and heart disease, and respiratory allergies [12-13].

3. Results and Discussion

A spectacular fall in Sulfur dioxide (SO_2) and Nitrogen dioxide (NO_2) produced mainly by human activities was observed after the first period of confinement in several Tunisian regions, especially in the North and the Centre. The pollutant concentrations are mainly linked to many environmental and meteorological factors. Meteorological parameters influence directly the pollutant concentrations through several physical and dynamic processes; for example, at high temperature, a combination of oxygen gas and nitrogen can occur in the presence of excess oxygen; this form tropospheric ozone. The daily calculation of the mean temperature for the Tunisian domain presented in the North an increase between 12% and 27% for 2020–2023 period compared to the 2019 year in May, between 9% and 21% in the Centre, and between 11% and 20% in the South. However, for the mean wind speed, a decrease was observed in the North between 1% and 9% for 2020-2023 period compared to the 2019 year in May, between 11% and 16% in the Centre and an increase between 1% and 14% in the South. Thus, for the relative humidity, the Tunisian domain presented in the North a decrease between 7% and 11% for 2020–2023 period compared to the 2019 year in May; between 2% and 11% in the Centre and between 9% and 13% in the South. The broken curves in Figure 3 reflect the years before COVID-19 for May 2018 and 2019 years. The continuous red curve is that of the years 2020–2023.



a)

b)

c)

Figure 3: Latitudinal Variation of the Mean Surface: a) Temperature (TT, °C), b) Wind (Vm, km/h) and c) Relative Humidity (RH, %) in Tunisia for May, 2018-2023 Period

Currently, additional research is being carried out as part of an ESA project called ICOVAC, studying the impact of COVID-19 containment measures on air quality and climate. At the beginning of 2020 and after the appearance of the COVID-19 pandemic, several countries launched a series of social-security and containment measures to try to limit this infection propagation. These measures caused a significant slowdown in economic activities, a drastic drop in road and air traffic and sharp reductions in industrial activities; these had remarkable reductions in emissions of air pollutants in particular. Trissevgeni Stavrakou, atmospheric scientist at the IASB (Institut d'Aéronomie Spatiale de Belgique) says that “the impact of meteorology on nitrogen dioxide (NO_2) observations could be significant and should therefore not be neglected” [14]. She adds that “for the comparison of mean monthly between 2019 and 2020, we estimate that there is uncertainty in the reduction caused by COVID-19 of the order of 15% to 20%.” By comparing, for different cities, the reductions indicated by satellite data with the data measured on the ground, we arrive at a satisfactory agreement, with differences which fall within the margin of uncertainty caused by meteorological variability. Claus Zehner, head of the Copernicus Sentinel-5P mission at ESA, emphasizes that “what is really remarkable is the very good agreement between the data provided by the Sentinel-5P satellite and the data collected on the ground.” He adds that “for the comparison of mean monthly between 2019 and 2020, we estimate that there is uncertainty in the reduction caused by COVID-19 of the order of 15% to 20%.” This demonstrates that monitoring air quality from space can contribute to regular reporting on air quality in European countries, something that has so far been done based solely on measurements on the ground.” The March-April 2020 confinement in Europe led to a considerable drop in nitrogen dioxide levels in industrial and densely populated regions in Europe. These decreases are explained by the notable contribution of road traffic and the industrial and energy sectors to nitrogen dioxide levels. Concentrations seem to return to almost normal levels in Tunisia after the month of August 2020; however, they return to a notable reduction from October until the end of the year with a reduction between 46%, and 62% in the North, and 9%, and 48% in the Centre.

Nitrogen dioxide is released into the atmosphere when fuel is burned by vehicles, electric or industrial stations. It can cause serious consequences for human health, including the likelihood of increasing the development of respiratory problems. Sentinel-5P carries on board the Tropomi instrument, a cutting-edge instrument that detects the unique signature of different atmospheric gases in order to map air pollutants more precisely, with spatial-resolution level.

4. Conclusion

Tunisia is not far from the consequences of COVID-19 impact on the air quality. The mean monthly processing of pollutant data showed remarkable changes mainly during the first confinement period 2020 and after, related to the decrease in emissions from road traffic and industries influenced by general atmospheric circulation on regional and global scales. Although this quality improvement was temporary, they are important results for environmental pollutant control planning. Concentrations of sulfur dioxide (SO_2) and nitrogen dioxide (NO_2), pollutants known for their deleterious effects on human health, saw remarkable decreases during and after the pandemic:

- A decrease in air pollution was observed, particularly in Europe, North America, and China.
- The monthly graphs show clearly the remarkable difference of pollutant concentrations in Tunisia for the months of May post-COVID-19 for the years 2020–2021, particularly in the North and Centre of Tunisia.
- Sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) observed significant decreases of more than 40%, particularly in the North and Centre of Tunisia during the confinement periods of 2020 and 2021 linked mainly to the reduction of road traffic and the slowdown of industry.

The considerable drop in the sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) concentrations in Northern Tunisia, characterized by the presence of industrial zones, is caused mainly by the regulations adopted by the government to limit the infection propagation following the outbreak of COVID-19. This study shows that the progressive limitation of industrial activity and automobile traffic in Tunisia caused by protective measures against the COVID-19 pandemic was accompanied by an apparent decrease in air pollution in the Tunisian regions; this was particularly evident in the North and Centre. Therefore, the consequences of this phenomenon brought us back to cleaner air.

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