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The link between covid-19 pandemic and air pollution in Algeria

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ABSTRACT
With a total of 96000 positive cases and 2678 deaths, Algeria is the second most affected nation in Africa by Covid-19 after the South Africa. The Algerian Ministry of Health confirmed the first coronavirus (COVID-19) case on February 25, 2020, when an Italian national tested positive in Ouargla region in the south of the country. Since then, coronavirus disease has not stopped expanding and has been reported in all provinces with large variations among the different regions (centre, south, east and west). Among the potential factors responsible for this geographic variability, we have focused on the atmospheric pollution. The objective of this study is to examine the relationship between the confirmed cases of Covid-19 and air quality in Algeria provinces. Actual data on Covid-19 pandemic in Algeria provinces were collected from the Ministry of Health database. The corresponding long-term air quality concentrations, were obtained from Sentinel-5 precursor satellite data. Our results show that northern Algeria has been exposed to high concentration of atmospheric pollutants. Moreover, provinces with high fatality due to coronavirus occurred in this part of the country: Alger (366 cases), Setif (225) and Blida (207 cases). Correlation analysis confirms the positive association between air quality and cases of Covid-19 and show that the long-term exposure to atmospheric pollutant may be one of the most significant contributors to COVID-19 virus fatalities in Algeria. Finally, air quality should be taken into account by governments as part of an integrated approach to sustainable development and infectious disease spread prevention.
Keywords: Air pollution, COVID-19, Mortality, Algeria.

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INTRODUCTION

The COVID-19 pandemic, also known as the coronavirus pandemic, was first identified in December 2019 in Wuhan, China. The World Health Organization declared the novel coronavirus a pandemic on March 2020 as it spreads in more than 110 countries around the world [1]. The COVID-19 virus has been the object of study of several disciplines over the last year (biological, ecological, political, economical, sociological, etc.). The growing number of studies is justified by the number of deaths due to the COVID-19. As of 30 November 2020, more than 63.2 million cases have been confirmed, with more than 1.47 million deaths attributed to COVID-19 [2]. Coronavirus is a highly infectious disease that will usually produce typical symptoms such as fever, dry cough and fatigue or myalgias, but less characteristic symptoms have been described, which makes the diagnostic process more difficult and may increase the risk of further virus transmission [3, 4].

Several researches suggest that the urban air pollution could cause adverse effect to human health. According to the World Health Organization [5], 7 million deaths were recorded in 2019 as a direct result of ambient air pollution. The majority of these deaths occur in countries with low and medium incomes, mostly in Asia and Africa, as well as in the Eastern Mediterranean region, Europe and the Americas. Air pollution can damage the cardio-respiratory and immune systems, by altering the host resistance to viral infections [6-13]. And it could increase the risk catching COVID-19, especially people who are very vulnerable.

Epidemiological studies suggest that environmental factors (e.g., air pollution) can influence the spread and infectivity of coronavirus disease [6]. [14] examined the association between exposure to nitrogen dioxide (NO2) and coronavirus fatality in European countries and found that the long-term exposure to this pollutant may be one of the most important contributors to fatality caused by the COVID-19 virus in these regions. [15] have found that particulate matter PM2.5 and PM10 concentrations can affect the case fatality rate of COVID-19 in Wuhan (China) suggesting a favorable context for the spread of the COVID-19 due to air pollution.

Like other countries around the world, Algeria has not escaped from this pandemic. At the time of writing this, over 96.000 people are infected by the virus and more than 2678 persons have died. On African continent, Algeria estimated to has highest import risk of COVID-19 from China and moderate-to-high vulnerability to epidemic emergency [16]. It is one of 13 countries World Health Organization has identified as a top priority for preparedness measures due to their direct links or high volume of travel to China [5]. However, the first case of coronavirus has been reported in Algeria came from Europe, in particular from Italy. The present study is the first attempt in Algeria to investigate the relation between air pollutant concentrations and reported COVID-19 cases for different provinces of Algeria. The purpose of this paper is to provide scientific evidence on the effect of air quality on COVID-19 spread in Algeria.

MATERIAL AND METHODS

In this study, long-term status of air pollutant concentrations and their spatial distribution were derived using the European Space Agency's (ESA) Sentinel-5 precursor satellite data (spatial resolution of 5.5 km) available through TROPOspheric Monitoring Instrument (TROPOMI). TROPOMI is able to measure a wider range of atmospheric trace gases such as nitrogen dioxide (NO2), ozone (O3), sulphur dioxide (SO2), Sulfate (SO4), methane (CH4), and carbon monoxide (CO) [17]. Subsequently, for each province, the mean concentration of air pollutants was calculated based on the period (2017-2019).

The data of daily COVID-19 cases and death rates were collected from the official website of the Ministry of Health of Algeria from February 25 to November 30, 2020 (http://www.insp.dz/ index.php/news/ coronavirus.html).

Pearson correlation test was used to determine correlation between atmospheric pollutants variables and COVID-19 infections and fatalities. The analyses were performed with XLSTAT software version 2015.5.01.

RESULT

Temporal evolution of the COVID-19 pandemic

Figure 1 illustrates COVID-19 data within a 279 days period, in Algeria, including total confirmed cases, total deaths, and recoveries. As of November 30, 2020, there were 83199 confirmed cases of coronavirus (COVID-19) across the whole of Algeria since the first confirmed case on February 25.

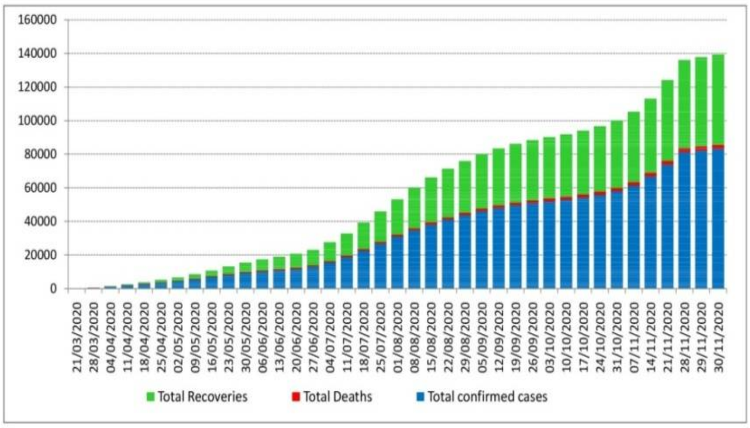

Figure 1. The number of total confirmed cases, deaths, and recoveries in Algeria from February 25 to November 30, 2020

Regional distribution of Covid-19 pandemic in Algeria

The maps of the figure 2 highlight the spatial variation of the pandemic which exists between different administrative provinces of country.

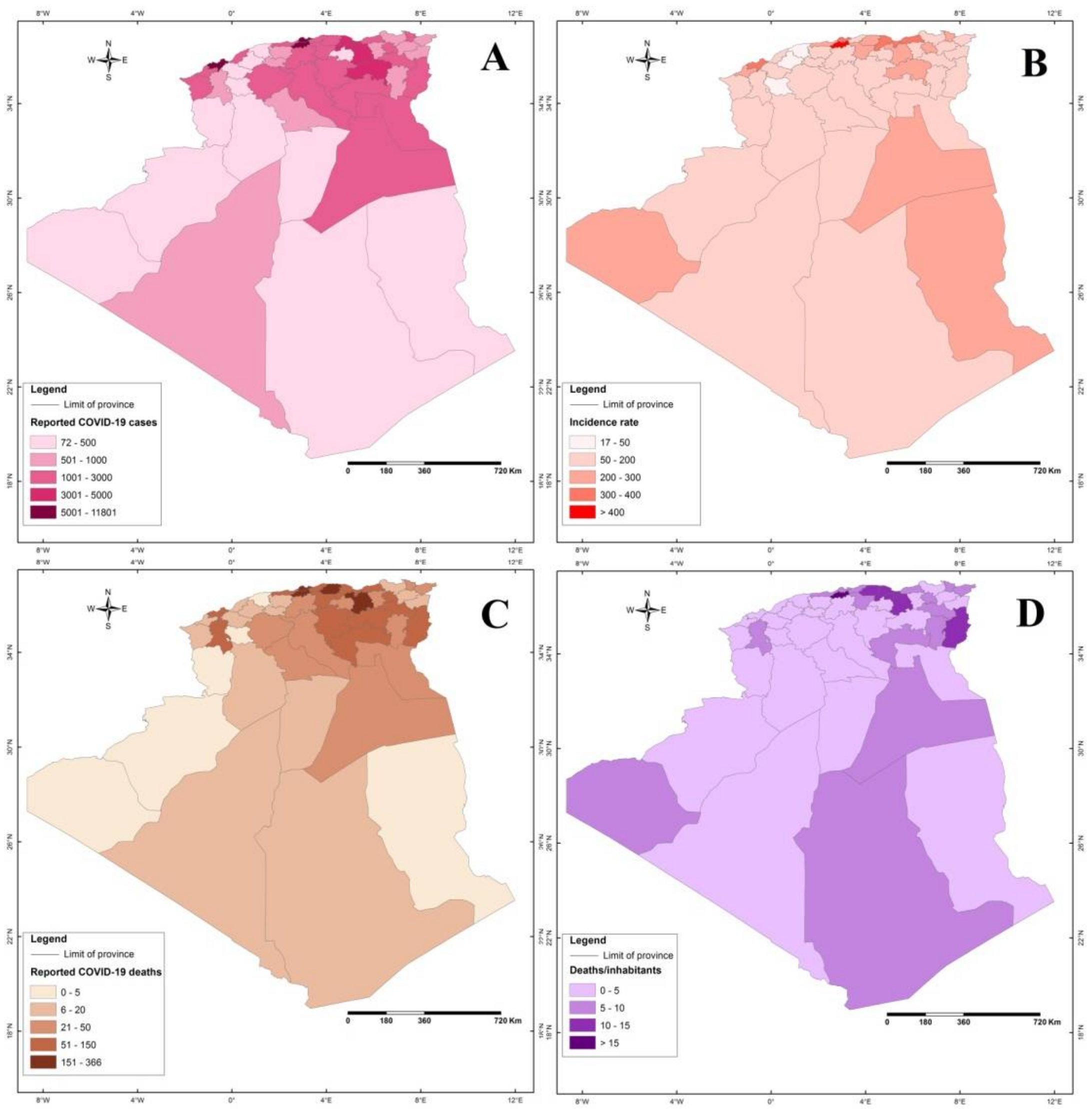

Figure 2. Provincial distribution of Covid-19 pandemic in Algeria (from February 25 to November 30, 2020). A) number of cumulative cases of COVID-19; B) incidence rate C) cumulative deaths; D) mortality rate

Mapping the atmospheric pollutants reveals a major area of high concentration in the northern part of Algeria. Six provinces of the North exceeded 3000 cases, e.g. 10049 at Alger, 6316 at Oran, 5957 at Blida, 4331 at Setif, 3561 at Bejaia, 3213 at Batna (Fig. 2A).

Blida has the highest incidence of coronavirus cases among its population in Algeria at 436 per 100000 people (Fig. 2B), compared to the national average of 178. It is followed by a rate of 346 in Bejaia. Oran has recorded the third highest rate of cases in Algeria at 342 cases per 100000 people.

There have been 2294 recorded coronavirus deaths in Algeria since the beginning of the pandemic. The Alger province has the highest number of deaths recorded in this country at 360 (Fig. 2C). However, Blida has the highest death rate from the virus with approximately 15 deaths per 100000 as of November 30, followed by Setif and Tizi Ouzou with 13 deaths per 100000 population (Fig. 2D). These figures indicate a much greater prevalence of this pandemic in northern Algeria, both in terms of the number of infections and the severity of cases which may vary according to the different population.

Regional data on air quality levels

The last three years (from 2017 to 2019) of regional distribution of atmospheric pollutants is summarized in figure 3. By averaging all provinces, air pollutant mean concentrations differed among cities from 1st January to 31st December averaged over the time period 2017–2019 (Fig.3A–H). Across Algeria, two hotspots of nitrogen dioxide (NO_2) concentration were found in northern country, the Blida and Alger provinces (Fig. 3B). These two regions had values greater than 0.1 μg/m^3. The highest ozone (O3) mean concentration, reaching 140.3 μg/m^3, was observed in Skikda, while the lower mean concentration was recorded in Tamanrasset (121.4 μg/m^3) (Fig. 3A). The black carbon (BC) ranged from

0.07 µg/m^3 in Tamanrasset to 0.64 µg/m^3 in Tipaza (Fig. 3E). The particulate matter (PM2.5) mean concentrations were higher in southern provinces (up to 100 µg/m^3 in Adrar province) than in the northern cities (Fig. 3F). The highest methane (CH4) mean concentrations were observed in Mila (1.25 µg/m3), followed by Guelma, Souk Ahras, Skikda, Oum El Bouaghi and Constantine and while the lowest mean concentrations (1.19 µg/m3) were recorded in El Oued (Fig. 3D).

Carbon monoxide (CO) concentration is very high in Guelma province (0.17 µg/m^3) (Fig. 3C). Sulfate (SO_4) is also highest in all coastal provinces of Algeria with extremely high concentrations reaching (2.12 µg/m^3) (Fig. 3H). According to satellite data for the monitoring of air pollution over a 36 month period (2017 to 2019) in Algeria, the north provinces had the highest amounts of sulphur dioxide (SO_2) with values varied between 0.13 µg/m^3 to 4.10 µg/m^3, while the southern provinces had values less than 1 µg/m^3 (Fig. 3G).

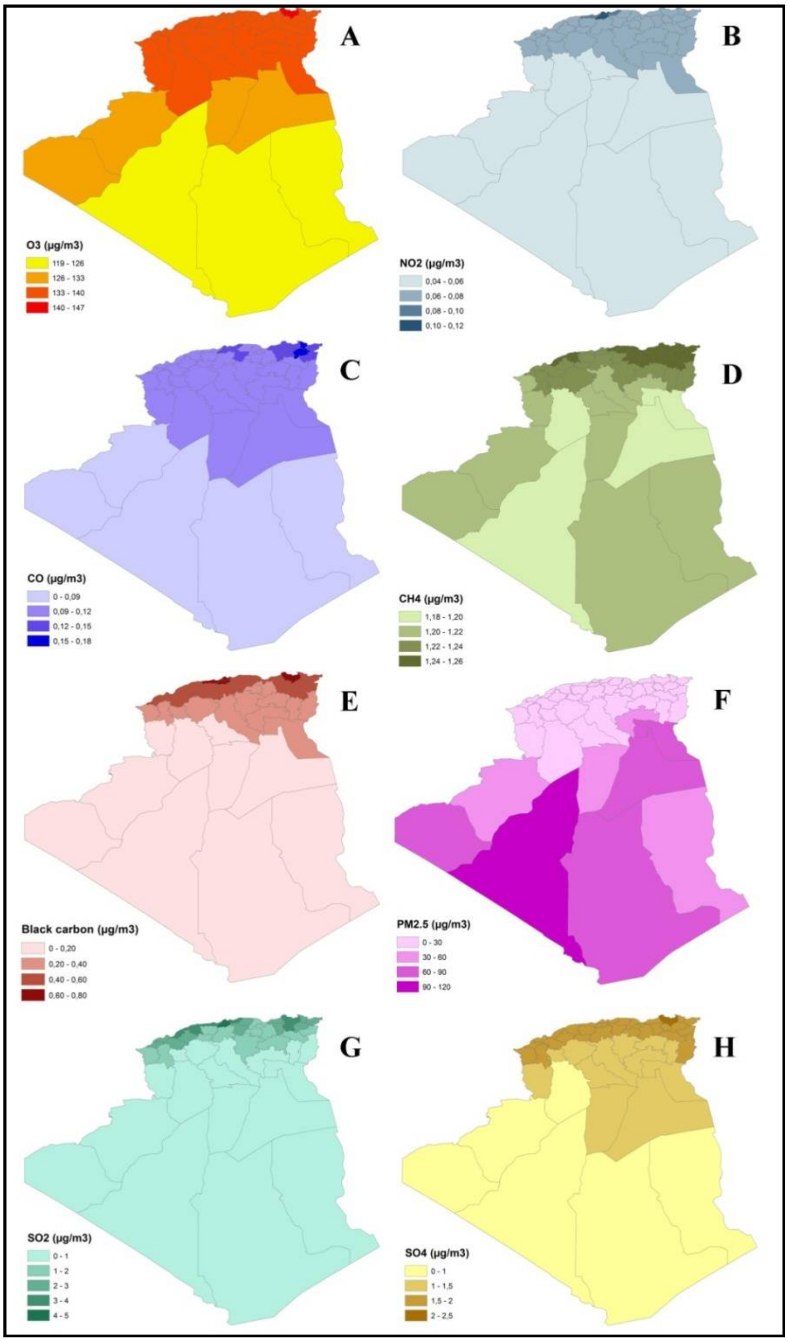

Figure 3. Regional data on air quality levels: A) ozone (O_3); B) nitrogen dioxide (NO_2); C) carbon monoxide (CO); D) methane (CH_4); E) black carbon (BC); F) particulate matter (PM2.5); G) sulphur dioxide (SO_2); H) Sulfate (SO_4) as average means of the last 3 years (2017 - 2019)

Links between regional atmospheric pollutants levels and COVID-19 cases in Algeria
Table 1 summarizes the Pearson's coefficients of correlation between COVID-19 Algeria cases and average air pollutant concentrations.

Table 1. Pearson correlation coefficients between COVID-19 Algeria cases and atmospheric pollutants concentrations (NS: not significant at p = 0.05; *, ** and *: significant at p < 0.05, 0.01 and 0.001, respectively)**

Parameters (in µg/m³)	Total cases	Incidence rate	Total deaths	Mortality rate
NO_2	0.70***	0.52***	0.66***	0.47**
Black Carbon	0,41**	0,34*	0,36*	0,29*
CH_4	0,31*	0,26 NS	0,31*	0,28*
CO	0,33*	0,32*	0,33*	0,32*
O_3	0,31*	0,20 NS	0,30*	0,24 NS
PM2.5	-0,23 NS	-0,11 NS	-0,21 NS	-0,14 NS
SO_2	0,48***	0,39**	0,40**	0,26 NS
SO_4	0,38**	0,34*	0,35*	0,31*

The correlation between all atmospheric pollutants concentrations is positive with all confirmed COVID-19 cases (total cases and total deaths) with the exception of the PM2.5 (Table 1). This positive correlation means that an increase in atmospheric pollutants concentrations is an indication of an increase in COVID-19 cases. The highest positive correlation was recorded between NO_2 and total cases ($r = 0.70$; p-value < 0.001). The lowest significantly positive correlation is observed between CH_4 and mortality rate ($r = 0.28$; p-value < 0.05). However, there are no significant correlations between O_3 and the rates COVID-19 (incidence rate, mortality rate) and between SO_2 and mortality rate. The significant correlations are evidence of the role that chronic exposure to atmospheric pollutants may have as a favourable factor for the spread the Covid19 especially in the regions characterized by a higher incidence of respiratory and cardiac affections.

DISCUSSION

Air pollution is among the environmental factor that can influence the COVID-19 transmission [6]. This study aimed to identify the associations between major air pollutants and COVID-19 cases and deaths in Algeria. Our regional analysis reveals that highly polluted provinces are located in the northern part of Algeria which characterized by an important industrial infrastructure based on the development of hydrocarbons and mineral resources, namely the oil and gas refining complexes, the steel industry, the chemical and petrochemical industries, the fertilizer manufacturing, the cement plants, and building materials production [18, 19]. These activities emit a large amount of air polluants, which has aggravated air pollution in Algeria and seriously affected people's life and health. For the present study, the SO4 concentration were higher in the Skikda province which located in the northern part of Algeria. This province is in contact with a petrochemical industrial complex, which raw materials and final products contaminate the surrounding areas via atmospheric pollution as well as effluents, which are dumped into seawaters [20]. According to [21], SO_4 is one of the main air pollutant closely correlated with the combustion of coal, petroleum and chemical fuels. In Algeria, the maximum value of SO_2 was recorded in the Blida province which has the highest death rate from the virus. SO_2 is the key precursor to the creation of new particles in the atmosphere by nucleation which may increased the risks of human exposure to ultrafine particles [22].

Particle matter air pollution is more complex, covering a large size range (the ultrafine particles PM0.1 with diameter < 0.1 µm; fine particles PM2.5 with diameter ≤ 2.5 µm; coarse particles PM10 with diameter > 2.5 µm and ≤10 µm [23]. Owing to their small size, fine particles (PM2.5), have a high alveolar penetration capacity, thereby triggering a local inflammatory process with circulatory repercussion [24]. The highest values of PM2.5 are recorded in the southern part of the country where dust storm events happen the most frequently. These latter are defined as natural events with high particulate matter concentrations, common in arid and semi-arid regions, or desert areas [25].

The second finding of this study was the significant association between air pollutants and reported cases of COVID-19. Our results were comparable to the previous studies in Italy, China, England and Malaysia [26-28]. [26] revealed that long-term air-quality data significantly correlated with cases of Covid-19 in 71 Italian provinces. In study conducted in China, [28] showed that PM10, PM2.5, NO_2 and CO are positively correlated with COVID-19 confirmed cases. The same results have been also reported by [29] in Malaysia.

A study in the England found a significant link between air pollution and coronavirus cases, so with the increase of 1 μg/m^3 of PM2.5, the COVID-19-related cases rises to 12%. Several studies have reported such relationship between the spread of some respiratory viruses and the higher concentrations of air pollutants [30, 31]. According to several researchers [26, 32, 33], chronic exposure to atmospheric pollutants may represent a risk factor in determining the severity and spread of Covid-19.
Thus, our results revealed a strong spatial correlation with NO_2 mean levels concentrations (2017–2019) (Pearson coefficient: $r = 0.70$, $p < 0.001$), confirming the Northern Algeria being a hotspot of NO2. Association between exposure to NO2 and Covid-19 infection has been described also by several researchers [28, 26, 14]. The nitrogen dioxide has mainly effect on the respiratory system, because an increase of the outdoor concentration of NO_2 may significantly increase the risk of respiratory tract infection [34].
The relationship of different air pollutants with the total cases and deaths in Algeria due to COVID-19 pandemic revealed that higher infected and mortality cases were reported in the most polluted areas in Algeria. It corroborates the fact that long-term exposure to air pollutants has weakened the immune system and also had profound effect on inflammation of the lungs. Although we found no significant correlation between PM2.5 and COVID-19 cases, [28], [35] and [26] found a positive correlation between this polluant and COVID-19 cases. [36] demonstrated that coronavirus can remain viable in aerosols for 3 hours. Researchers report that particulate matter such as PM2.5 and PM10 easily penetrate to the lower respiratory tract, and as a result, they can carry the coronavirus directly into the alveo and tracheobrochial region [37, 38]. Concerning SO_2, we found a positive correlation with COVID-19 cases, but [28] reported a contrasting finding of a negative correlation with daily COVID-19 cases.

CONCLUSION

In conclusions, the infectious diseases such as coronavirus disease (COVID-19) represent one of the key challenges for states in this century and especially for countries that do not have a strong health system. In this study, we investigate the correlation between the air pollution variables and COVID-19 infections and fatalities in 48 province of Algeria. The results put in evidence that nitrogen dioxide, black carbon, methane, carbon monoxide, ozone, sulfur dioxide and sulfate are positively correlated with the cases of Covid-19, whereas suspended Particulate Matter (PM2.5) shows a negative correlation but not statistically significant. In other words, poor air quality has proven to promote the spread of coronavirus significantly and especially in northern Algeria witch considerate the most polluted areas of the country. This work supports future research in studies documented to understand the potential of transmission and infection of COVID-19 disease and minimise the impact of future pandemics. Also, our findings may encourage more studies in other parts of the world to test other variables related to air pollution, e.g. nitrogen oxide (NO_x), particulate matter (PM10). Overall, this study demonstrates that air quality should be taken into account by decision-makers as part of an integrated approach to sustainable development and infectious disease spread prevention.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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