

**The effects of social isolation and the COVID-19 pandemic on air quality  
around the world**

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## ABSTRACT

In December 2019, a new virus variant was discovered in China, belonging to the coronavirus family, whose associated respiratory syndrome became known as COVID-19. Due to the ease of transmission, lethality and lack of knowledge about this new disease, several countries chose to adopt measures of social distancing, in addition to restrictions on travel and the performance of activities considered non-essential. Thus, the present study aimed to carry out a bibliographic survey about the main effects of social isolation on air quality, in some regions around the world, through consultation of scientific articles, national and international research institutes, as well such as satellite imagery. The results showed that the effects of these measurements were observed on air quality in different parts of the world, with a reduction in the levels of some of the main air pollutants, such as NO<sub>2</sub>, CO<sub>2</sub>, CO and particulate matter. In contrast, some studies showed that the concentration of O<sub>3</sub> increased in certain regions. It was possible to conclude that the improvements observed were temporary, as they did not result from structural measures, but from transitory situations; and that the adoption of public policies to restrict the emission of pollutants is essential to reduce the incidence and aggravation of associated respiratory diseases, avoiding the overload of health systems, especially in the current pandemic scenario.

**KEYWORDS:** Atmospheric pollution. Social isolation. COVID-19.

## 1 INTRODUCTION

In December 2019, a new virus variant belonging to the coronavirus family was identified for the first time in the city of Wuhan, China, which includes other respiratory syndromes such as SARS-CoV (Severe Acute Respiratory Syndrome) and MERS-CoV (Middle East Respiratory Syndrome). This new variant was known as Coronavirus 2019 Disease (SARS-CoV-2), or simply COVID-19, and has been responsible for a serious health crisis, with global dimensions (LONE & AHMAD, 2020).

Due to the great ease of transmission, through droplets and contact, the virus was disseminated throughout China, reaching almost 2,000 confirmed cases in less than a month and, subsequently, to several countries in the Asian continent (BENVENUTO et al., 2020). The spread of this new virus quickly followed to Europe, which became the new epicenter of the disease, especially in Italy and Spain; North America, arriving in the United States; and then to other continents, leading the World Health Organization (WHO) to declare, in January 2020, an international public health emergency and, in March of the same year, a SARS-CoV-2, COVID-19 pandemic situation (SILVA et al., 2020; WHOa, 2020; WHOb, 2020).

In order to try to stop the rapid evolution of the pandemic and avoid a collapse in health systems, several countries adopted a series of structural measures, among which progressive measures of social distancing were highlighted, through the prohibition of large events, with agglomeration of people; closing schools and businesses considered non-essential; travel restrictions, with guidelines for reducing travel and the use of public transport; incentive to work at home (home office); in addition to raising the awareness of the population to remain at home, reducing the movement of people and means of transport (AQUINO et al., 2020; KUPFERSCHMIDT & COHEN, 2020).

In more extreme cases, several countries have adopted a community lockdown regime: the lockdown. This system was adopted when the previous ones proved to be insufficient to contain the spread of the virus. In this case, there is intervention by the authorities, which apply to an entire community, city or region, stricter restrictions measures regarding interpersonal interactions, as well as the functioning of the most diverse activities, such as commercial, industrial and transport; only those considered essential, such as the sale and purchase of basic

supplies and access to the health system, are allowed to function (WILDER-SMITH & FREEDMAN, 2020).

As a result of these containment measures, there was a drastic reduction in vehicle traffic; reduction in energy demand due to reduced production in factories; and consequent reduction in greenhouse gas (GHG) emissions, which are mostly released through the burning of fossil fuels, in automotive vehicles and through the most diverse industrial activities (COUTO et al., 2021; SPERANDIO & GOMES, 2020) .

Effects of these events on air quality, especially in large urban centers, could be observed in various parts of the world, with reports in various scientific researches, news released in different media, and records in satellite images, which served as sources to carry out this study.

## **2 GOALS**

The main objective of this study was to raise the most relevant impacts of the restriction and social distancing policies, implemented in several countries around the world in order to contain the spread of the COVID-19 virus, on the quality of the atmospheric air.

Secondary objectives are to carry out a brief review of the main atmospheric contaminants, their sources of origin and maximum tolerable levels; of the main air quality indicators and, finally; the effects on human health of the presence, in the atmosphere, of high concentrations of these contaminants, relating to the occurrence and worsening of respiratory diseases.

## **3 METHOD**

The applied methodology was to carry out a bibliographical research, in scientific articles, added to information made available by several national and international research institutes and agencies, of great credibility. At first, 50 studies were selected and read, more than half of which were used in the composition of this study, related to the topic of the COVID-19 pandemic and its consequences for the environment, focusing mainly on air pollution and its relationship with the adoption of restrictive measures around the world.

Then, a consultation of satellite images, made available by the National Aeronautics and Space Administration (NASA) and by the European Space Agency (ESA), was carried out in order to detect variations in the concentration of various atmospheric contaminants in different parts of the world. The images that were more interesting and showed more significant changes were used to compose this study, in order to present their interpretation and critical analysis.

## **4 RESULTS**

### **4.1 MAIN URBAN ATMOSPHERIC CONTAMINANTS**

#### **4.1.1 PARTICULATE MATTER (MP<sub>2,5</sub> E MP<sub>10</sub>)**

Particulate matter is the name given to the set of pollutants made up of dust and smoke, and any mixture of solid or liquid particles that are suspended in the atmosphere, due to their small size. They are usually divided into two main groups: the MP<sub>2,5</sub>, which consist of particles

with a very small diameter (less than 2.5 mm) and have greater acidity; and the MP<sub>10</sub>, particles whose size varies between 2.5 mm and 10 mm (BRAGA & SALDIVA, 2001).

Due to their small size, the MP<sub>2,5</sub> are more likely to reach the respiratory tract and carry pollutants to the pulmonary alveoli, impairing gas exchange and increasing the incidence of various respiratory diseases. They consist of primary particles, generated mainly by fuel burning processes in mobile and stationary sources, such as automotive, industrial and thermoelectric vehicles; and secondary particles from the formation of particles in the atmosphere from gases (QUEIROZ *et al.*, 2007; BRAGA & SALDIVA, 2001).

The MP<sub>10</sub> are considered inhalable particles, commonly found in the vicinity of regions with high industrial concentrations, and which can reach the airways, carrying gases adsorbed on their surface to the airways, aggravating diseases such as asthma (BRAGA & SALDIVA, 2001).

The Resolution of the National Council for the Environment (CONAMA) No. 491 of November 19, 2018, which provides for air quality standards, establishes that the concentrations of MP<sub>2,5</sub> must not exceed 60 mg/m<sup>3</sup> in Intermediate Period 1 (PI1) and 25 mg/m<sup>3</sup> in the Final Period (PF). For MP<sub>10</sub>, in PI1 these concentrations must not exceed 120 mg/m<sup>3</sup> and for PF, 50 mg/m<sup>3</sup> (BRASIL, 2018).

### 4.1.2 CARBON MONOXIDE (CO)

Carbon Monoxide (CO) is an extremely harmful gas. Due to its great affinity with the hemoglobin present in red blood cells, a small amount of CO can lead to the saturation of a large amount of hemoglobin molecules, decreasing the blood's capacity to transport oxygen (BRAGA & SALDIVA, 2001).

The main source of CO contamination is the means of transport, being a product of the incomplete combustion of fossil fuels, found mainly in coal-fired thermal power plants and used in explosion-engine vehicles (automotive vehicles) (FERNANDES *et al.*, 2018).

According to CONAMA Resolution No. 491 of 2018, the air quality standard for this contaminant is up to 9 ppm, for a sampling time of 8 hours (BRASIL, 2018).

### 4.1.3 NITROGEN OXIDES (NO AND NO<sub>2</sub>)

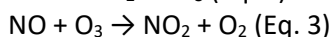
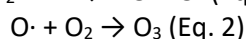
Nitrogen oxides (NO<sub>x</sub>) are gases that have an oxidizing effect, being extremely toxic to the human body when inhaled. Nitrogen gas (N<sub>2</sub>) and molecular oxygen (O<sub>2</sub>) react to form nitric oxide (NO), nitrogen dioxide (NO<sub>2</sub>) and other NO<sub>x</sub>. The main sources of atmospheric contamination by these compounds are fuel combustion in the car engine or in industrial ovens, under high temperature (BRAGA & SALDIVA, 2001). In the atmosphere, NO quickly reacts with oxygen and ozone to form NO<sub>2</sub>. On the other hand, in the lower layers of the atmosphere, NO<sub>2</sub>, through photochemical reactions (in the presence of sunlight) with hydrocarbons and oxygen, forms ozone (O<sub>3</sub>), another important atmospheric contaminant (SICARD *et al.*, 2020).

The NO<sub>2</sub> concentrations considered acceptable, for a reference period of 1 hour, should not exceed the value of 260 mg/m<sup>3</sup> in PI1 and 200 mg/m<sup>3</sup> in PF (BRASIL, 2018).

### 4.1.4 OZONE (O<sub>3</sub>)

Ozone is a gas that, despite having a natural origin in the upper layers of the atmosphere, is very harmful in its lower layers. It is a secondary pollutant, formed from photochemical reactions between NO<sub>x</sub> and volatile organic compounds (VOCs). Despite having great importance in controlling the entry of ultraviolet radiation on Earth, in lower layers (troposphere), high concentrations of this gas represent risks to the environment and human health, being linked to the occurrence and worsening of various respiratory diseases (ALVES et al., 2020).

The following equations show the main route of ozone formation.



Following Eq.1, it appears that NO<sub>2</sub> is dissociated by the incidence of sunlight (photochemical reaction), giving rise, therefore, to NO and atomic oxygen with free radical to react. In this sense, in Eq.2 the atomic oxygen reacts with molecular oxygen, giving rise to ozone (O<sub>3</sub>). In Eq.3, where ozone is dissociated in the reaction with NO, forming NO<sub>2</sub>, the cyclic way in which the reactions tend to take place in the atmosphere is depicted. (ALVES et al., 2020).

The concentrations of O<sub>3</sub> considered acceptable, for a reference period of 8 hours, should not exceed the value of 140 mg/m<sup>3</sup> in PI1 and 100 mg/m<sup>3</sup> in PF (BRASIL, 2018).

#### **4.1.5 SULFUR DIOXIDE (SO<sub>2</sub>)**

Sulfur dioxide (SO<sub>2</sub>) is a characteristic pollutant of industrial agglomerates. It comes mainly from the combustion of diesel, coal and oil. When burned, these fuels release the sulfur they contain, which combines with the air to form SO<sub>2</sub>. As it is a highly soluble gas in the upper air tract mucosa, it can cause acute respiratory diseases in humans, in addition to aggravating heart and lung diseases (CAMILLO et al., 2020).

The SO<sub>2</sub> concentrations considered acceptable, for a reference period of 24 hours, should not exceed the value of 125 mg/m<sup>3</sup> in PI1 and 20 mg/m<sup>3</sup> in PF (BRASIL, 2018).

#### **4.2 GLOBAL AIR QUALITY AND THE COVID-19 PANDEMIC**

As mentioned earlier, the COVID-19 pandemic situation has placed the world in an entirely different dynamic, unprecedented in recent history. The confinement of a large part of the world's population, as well as the restrictions imposed on various activities of daily life, especially in large urban centers, with the highest population concentrations, made the world as we know it to change drastically. There was a slowdown in several sectors, which resulted in big changes in the levels of atmospheric emissions in the year 2020, noticeable in different parts of the globe.

According to a survey carried out by Le Quéré et al. (2020) the restrictive measures adopted in early 2020 have already represented the equivalent of a daily reduction of 17% in global CO<sub>2</sub> emissions. According to the International Energy Agency (IEA), in the first months of 2020, the world stopped emitting about one million tons of CO<sub>2</sub> per day, mainly due to the reduction in the consumption of coal and oil (IEA, 2020; SAN MARTIN & SAN MARTIN, 2020). In

addition, decreases in the concentrations of some atmospheric pollutants, such as ozone, particulate matter and nitrogen dioxide, were observed, which represented a reduction of approximately 20% in pollution levels in 27 countries (VENTER et al., 2020).

However, some authors point out that the result was a consequence of a change in habits over a period of time, and that emission reductions during the rest of the year would depend on the duration and extent of the containment measures, as well as the time it would take for countries to resume their normal activities. For these authors, it is very possible that such changes are not permanent, since they were not the result of changes in the economy, politics or transport and energy systems; rather, it is the result of contingency measures imposed by the pandemic situation, without major structural changes (LE QUÉRÉ et al., 2020).

The fact is that, permanent or not, the changes existed and made us reflect on the planet's capacity for resilience; on the implementation of more structural measures, which allow establishing more harmonious relationships with the environment; in addition to adopting more conscious and even healthier consumption and life habits. According to Agrawala et al. (2020) the speed with which emissions were reduced showed how it is possible to improve the quality of the environment we live in and the air we breathe. The authors noted that these changes were already expected, as something similar occurred in 2008, due to the air cleaning policies adopted for the Olympic Games in Beijing, China.

#### **4.2.1 ASIAN CONTINENT**

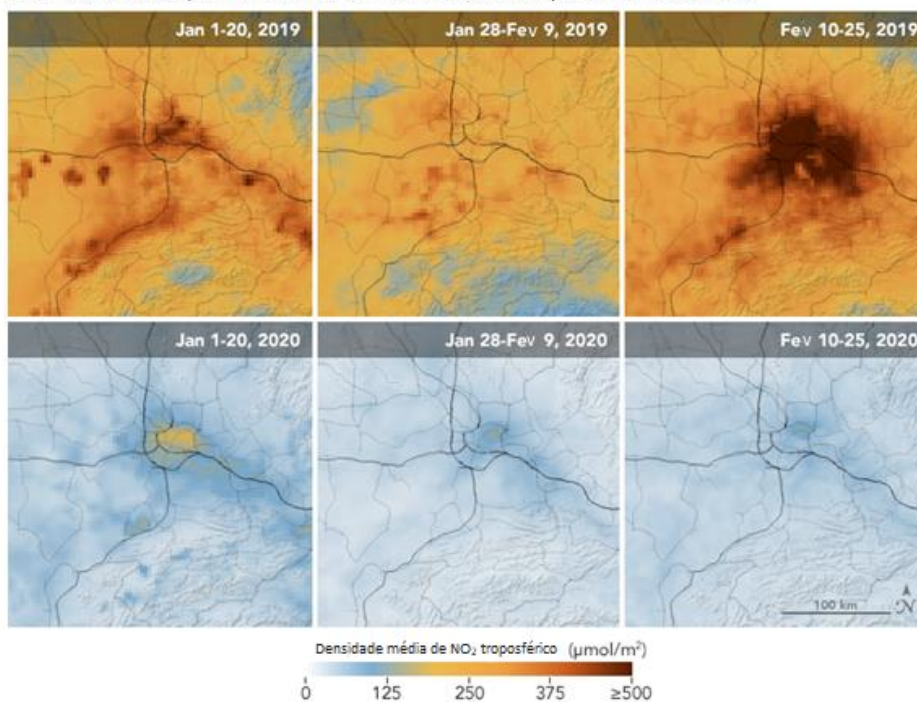
China was one of the first countries to adopt stricter isolation measures and, consequently, one of the first to contemplate the results. Studies carried out in the city of Wuhan, considered the “cradle” of the pandemic, found a decay of 22.8  $\mu\text{g}/\text{m}^3$  of nitrogen dioxide, due to the quarantine established between February 10 and 14, 2020. In other 367 Chinese cities, for the same period, a decrease of 12.9  $\mu\text{g}/\text{m}^3$  of  $\text{NO}_2$  was found (CHEN et al., 2020).

Figure 1 consists of satellite images provided by the National Aeronautics and Space Administration (NASA), and shows the concentrations of  $\text{CO}_2$  in the city of Wuhan between 2019 and 2020, indicating a reduction in the emission of this pollutant by up to 30%. Although the drop coincided with the Chinese Lunar New Year celebrations, where factories and companies close to celebrate the festivities, contrary to what was observed in previous years, in 2020 air pollution remained low, even after this period. NASA researchers associate this phenomenon with the COVID-19 pandemic, and the quarantine imposed on millions of people (NASA, 2020).

**Figura 1 – Comparison between NO<sub>2</sub> emissions in the city of Wuhan (China) in the years 2019 and 2020.**

Manchas de poluição em Wuhan

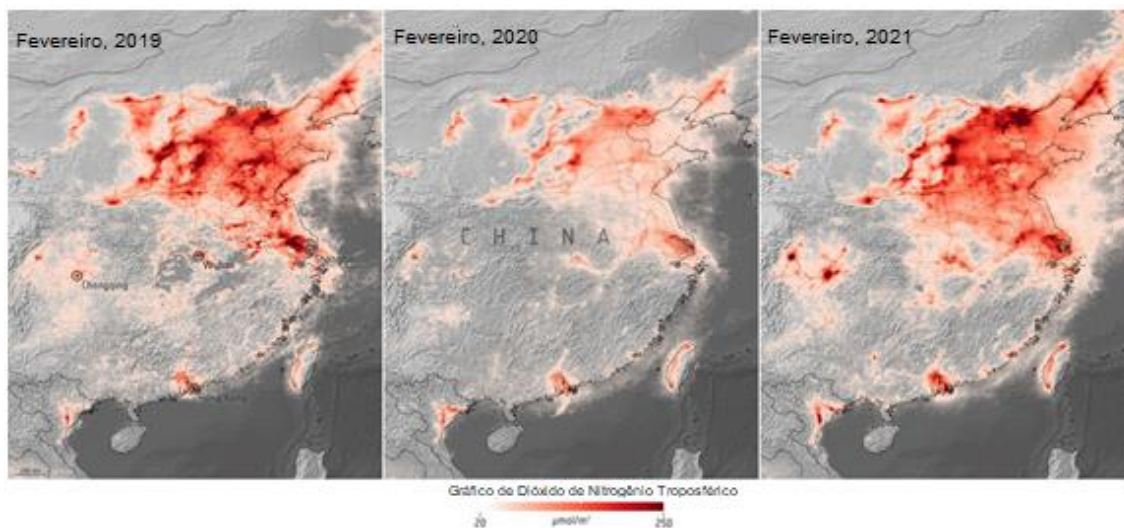
Ao contrário de 2019, os níveis de NO<sub>2</sub> em 2021 não subiram após o ano novo chinês.



Source: Adapted from NASA, 2020a.

On the other hand, images recently released by the European Space Agency (ESA) show that air pollution in China has been returning to pre-pandemic levels, as restrictions have been eased and activities in the country resume regularity. Figure 2 clearly shows the comparison between the years 2019, 2020 and 2021, for the month of February, with regard to NO<sub>2</sub> emissions. As you can see through the images, the part in red indicates the concentration of nitrogen dioxide present over the country, and the hue gets stronger as the concentration of this pollutant increases (ESA, 2021).

**Figure 2 – Comparison between NO<sub>2</sub> concentrations in China, in the pre, during and post-COVID-19 periods.**

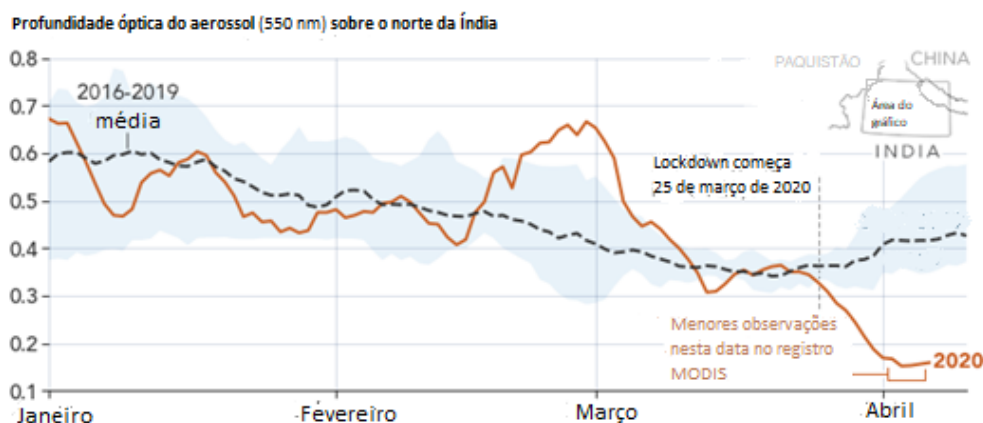


Source: Adapted from ESA, 2021.

In 2019, in a pre-pandemic scenario, concentrations were quite high, approaching 250  $\mu\text{mol}/\text{m}^2$  in the vicinity of centers such as Beijing, Wuhan and Shanghai. In February 2020, during the quarantine period, NO<sub>2</sub> concentrations had a sharp drop, clearly seen in the image, where the red tones are much lighter. In the recent scenario, it is possible to observe that the levels of air pollution are very close to those observed in 2019, with the very dark red spot in the vicinity of Beijing being highlighted.

In India, in March 2020, the government placed its more than 1.3 billion people on lockdown in order to contain the spread of the pandemic. In just a week of reduction in industrial activities and vehicle circulation, it was already possible to see, through images provided by NASA, a sharp drop in aerosol concentrations in northern India (NASA, 2020b), as can be seen in the graph of Figure 3.

Figure 3 – Aerosol concentration in northern India.



Source: Adapted from NASA, 2020b.

The graph shows an average of aerosol concentrations in northern India between January and April 2020 (red line), compared to the average observed for the years 2016 to 2019 (dashed black line). Importantly, the peak observed at the end of February 2020 coincided with the occurrence of fires that affected India and Pakistan (NASA, 2020b).

Still in India, Dasgupta & Srikanth (2020) carried out a study in which the atmospheric consequences resulting from the 27-day lockdown were evaluated in 8 cities, comparing the pollution data with those from the same period of the previous year, and with national standards of air quality (NAAQS). The authors then concluded that there really was an improvement in air quality, for most parameters and cities analyzed, when comparing the same period of the years 2019 and 2020. The big exception in this study was ozone, which did not vary much within of the period evaluated, showing even a slight increase at times.

In the city of Ghaziabad, considered one of the most polluted in all of India, a decrease in the levels of some air pollutants was also observed, such as PM<sub>2.5</sub>, which presented a reduction of almost 85% in its concentration (LOKHANDWALA & GAUTAM, 2020).



**4.2.2 AFRICAN CONTINENT**

In Morocco, the lockdown was decreed on March 20, 2020, and all activities considered non-essential were banned. A study carried out in the country evaluated the air quality, in order to compare the rates before and during the confinement period, for two cities: Casablanca and Marrakesh. The period between February 16th and March 19th, 2020 was established as pre lockdown; and as during the lockdown, from March 20th to April 20th, 2020. This study showed that in Casablanca there was a reduction in the levels of NO<sub>2</sub> (-12 µg/m<sup>3</sup>), MP<sub>2.5</sub> (-18 µg/m<sup>3</sup>) and CO (- 0.04 mg/m<sup>3</sup>). Similarly, improvements in air quality were observed in Marrakesh, with reductions in NO<sub>2</sub> (-7 µg/m<sup>3</sup>), PM<sub>2.5</sub> (-14 µg/m<sup>3</sup>) and CO (- 0.12 mg/m<sup>3</sup>) (KHOMSI et al., 2020).

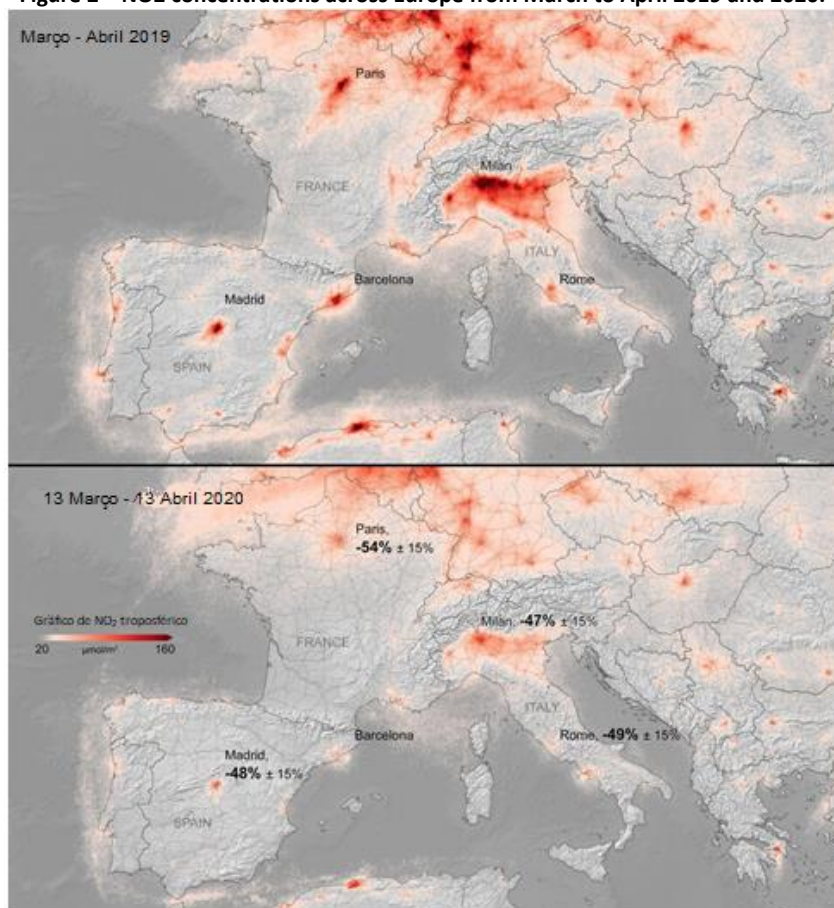
**4.2.3 EUROPEAN CONTINENT**

On March 18, 2020, the President of Portugal declared a state of emergency throughout the country, in order to control the rapid spread of the virus. As a result, various industrial activities and mass transportation were banned. With the continuing advance of the disease, and the explosion of cases across Europe, mandatory confinement ended up extending to six weeks. To assess the impact of confinement on air quality in the region between Douro and Minho (Portugal), Reis (2020) carried out a study in which data were collected from six air quality measurement stations, distributed among five Portuguese cities. Parameters NO<sub>2</sub>, MP<sub>10</sub> and O<sub>3</sub> were evaluated. As a result, the author noticed a significant drop in NO<sub>2</sub> concentrations, mainly associated with the reduction in vehicular traffic. In contrast, the stations showed a significant increase in ozone concentrations, probably associated with the lower concentration of oxygen monoxide present in the atmosphere, which can be explained through the ozone formation reactions, seen in Equations 1, 2 and 3 (ALVES et al., 2020; REIS, 2020).

A study carried out in several Italian cities revealed a drop in atmospheric pollution rates, especially in the concentration of particulate matter and nitrogen dioxide, which resulted in a reduction in cases of respiratory diseases associated with these contaminants (COCCIA, 2020). Another study gathered information which indicated that, in the period between February 23 and April 5, 2020, there was a reduction of approximately 90% in mobility in several European countries, such as Spain, Italy and France. This study also shows that, as a consequence, air pollution in these epicenters reduced by up to 30% in the period (MUHAMMAD et al., 2020).

Figure 4 shows a comparison between the months of March and April 2019 and 2020, with regard to NO<sub>2</sub> concentrations in the European continent. It is possible to observe that there is a drop in nitrogen dioxide levels across Europe, coinciding with the period in which the lockdown measures were adopted. Satellite images show that, in some locations, concentrations have dropped by 45 to 50% compared to the same period last year (ESA, 2020). Noteworthy are the falls observed in the Italian cities of Milan (-47%) and Rome (-49%); Madrid (-48%), in Spain; and a very sharp drop in Paris (-54%), in France.

**Figure 2 – NO<sub>2</sub> concentrations across Europe from March to April 2019 and 2020.**



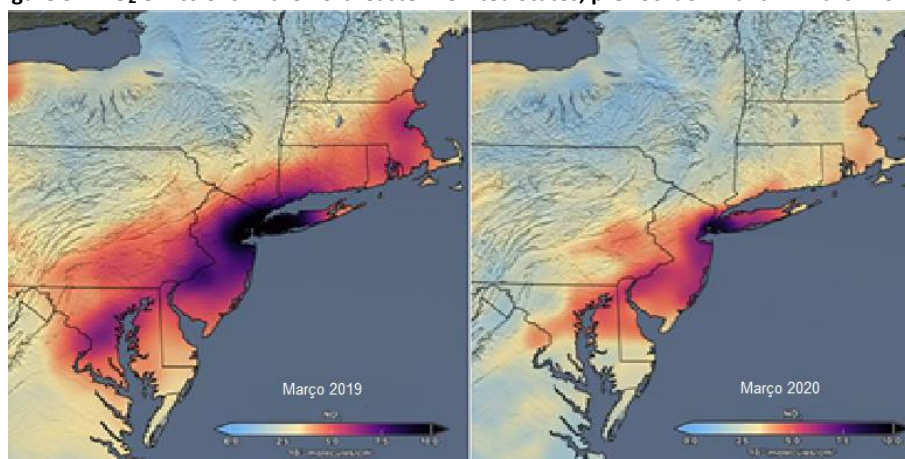
Source: Adapted from ESA, 2020.

#### 4.2.4 AMERICAN CONTINENT

In the United States, a study by Son et al. (2020) in urban areas of 10 states and the District of Columbia analyzed the observed changes in PM<sub>2.5</sub> concentrations during the period of restrictions caused by the COVID-19 pandemic. The authors observed that for most states (except in 3 of them) there was a great reduction in the concentration of this pollutant. Reductions ranged from 0.25 µg/m<sup>3</sup> (4.3%) in Maryland to 4.20 µg/m<sup>3</sup> (45.1%) in California. On average, PM<sub>2.5</sub> levels in 7 of the states, and in the capital, were reduced by almost 13% (SON et al., 2020).

Berman and Ebisu (2020) analyzed, in addition to PM<sub>2.5</sub>, NO<sub>2</sub> concentrations in the continental United States during the lockdown period (13 March to 21 April) and in the period before that. The authors observed a significant reduction in NO<sub>2</sub> concentrations compared to historical data (2017 to 2019), reaching more than 25%, or a decay of 4.8 ppb.

According to NASA (2020c), during the lockdown period, NO<sub>2</sub> concentrations in the northeastern United States were reduced by up to 30% when comparing March 2020 with the average observed between March 2015 to 2019, as can be seen in Figure 5.

Figure 5 – NO<sub>2</sub> emissions in the northeastern United States, pre-lockdown and in March 2020.

Source: Adapted from NASA, 2020c.

Another important measure taken during the COVID-19 pandemic in the United States, which represented great environmental and atmospheric gains, was the suspension of fires. In normal years, during spring, fire is used to manage the pine forests in the southeast of the country. However, in 2020, the US Forest Service temporarily suspended these activities, for public health reasons, in order to contain the spread of the virus and reduce the population's exposure to smoke (NASA, 2020d).

Brazil was the first country in Latin America to report a confirmed case of COVID-19, on February 26, 2020, followed by Argentina a few days later. In both cases, the infected people had just returned from a trip from Italy (SILVA et al., 2020).

According to the State Institute for the Environment (INEA), as a result of State Decrees Nos. 46.970/2020, 46.973/2020 and 46.980/2020, which restricted industrial activities, vehicle circulation and provided guidance on social isolation measures in the State in Rio de Janeiro, there was a significant drop in NO<sub>2</sub> concentrations in some regions of the state, reaching a reduction of 91%, according to a reading carried out at the Santa Cruz station (INEA, 2020). The concentrations of CO also showed reductions, reaching 75% lower than in the pre-isolation period, in the Copacabana station. With regard to PM<sub>10</sub> particulate matter, two of the three stations analyzed indicated an average reduction of 26% and 16% in the concentration of this pollutant (INEA, 2020).

In the Brazilian city of São Paulo, where the highest numbers of confirmed cases and deaths from COVID-19 are recorded, restrictive measures of circulation resulted in a 50% drop in air pollutant rates, in just one week of lockdown (DE ALBUQUERQUE et al., 2020; DE SOUSA OLIVEIRA et al., 2021). According to the Environmental Company of the State of São Paulo (CETESB), in March 2020, when the city was in quarantine, all 29 air quality monitoring stations presented quality classified as GOOD for the primary pollutants, which are those coming directly from polluting sources, such as vehicles and chimneys (CETESB, 2020). Also, in March 2020, CO levels, which are important indicators of pollutants emitted by light vehicles, were among the lowest in the region, reaching a maximum concentration of 1.0 ppm (average of 8 hours), in contrast to a standard of 9.0 ppm (CETESB, 2020).

## 5 CONCLUSION

The data presented in this study reveal how human interventions are directly reflected in the environment, to a greater or lesser extent. It was possible to notice that the measures taken in different parts of the world, in order to contain the new coronavirus pandemic (COVID-19) resulted in significant reductions in the emission of several atmospheric pollutants, mainly NO<sub>2</sub>, CO<sub>2</sub>, CO and particulate matter. On the other hand, in some countries, increases in O<sub>3</sub> concentrations were observed, probably due to chemical interactions in the formation of this gas, caused by the reduction in the emission of NO<sub>x</sub> and particulate matter.

Despite the improvements observed during the lockdown period, in some countries, such as China, as economic activities are returning to normal, a gradual return of pollution levels to pre-pandemic concentrations is being observed, which proves that the observed changes in 2020 they were temporary, as they did not result from the application of effective structural measures to control pollution, such as the adoption of environmental laws that restrict the emission of pollutants, according to the meteorological characteristics of the region; and yes of a transitory situation.

Finally, it is important to highlight the effects of air pollution on human health, since environments with higher concentrations of pollutants are associated with a higher incidence of respiratory diseases, as well as a higher number of hospitalizations associated with these diseases. In a pandemic scenario, where a large part of hospital beds is being occupied by COVID-19 patients, structural measures need to be applied more rigorously, in order to avoid overloading the health systems and preventing people from being served, when seeking medical treatment.

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