Carbon monoxide (CO) levels after COVID-19 pandemic in Ecuador

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Abstract

Due to the high contagion and mortality caused by COVID-19, the government of Ecuador and the rest of the world adopted measures to combat the pandemic, causing unexpected consequences in air quality, due to the restrictions implemented. The objective of this study was to evaluate variations in tropospheric carbon monoxide (CO) concentrations in the cantons of Ecuador, before (2019) and during (2020) the COVID-19 pandemic. Atmospheric data were obtained from the European Space Agency's Sentinel 5-P TROPOMI. It was observed that carbon monoxide concentrations in the first days of quarantine decreased by about 13%, however, these levels were momentary, for the rest of the year 2020 carbon monoxide (CO) concentrations were higher by 5% compared to 2019.

KeyWords: COVID-19, Carbon monoxide, Sentinel 5-P, Pandemic.

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Introduction

SARS-CoV-2 is the causative agent of the new epidemic called COVID-19, which originated in Wuhan, Hubei province of the People's Republic of China (Guerrero, 2020). On January 30, 2020, the World Health Organization (WHO) Emergency Committee listed this outbreak as a global health emergency based on increasing rates of case reporting in China and other countries (Velavan & Meyer, 2020). In Ecuador, on February 14, 2020, a 71-year-old woman arrived from Madrid and subsequently presented symptoms associated with this disease. On February 29, 2020, the first case of COVID-19 was reported in the city of Babahoyo, making Ecuador the third country in the region with infected persons within its territory (Ogonaga & Chiriboga, 2020).

Given the high contagiousness among people, different prevention measures were taken (Figure 1). The policies implemented during the quarantine had a direct impact on economic activity in Ecuador. In March and April 2020, many industries stopped their services. Likewise, all public transportation was paralyzed, while private transportation was restricted, allowing transit once a week according to the final license plate number at a specific time (from 05:00 to 14:00). In general, only activities related to health and food were approved (Zambrano-Monserrate & Ruano, 2020).

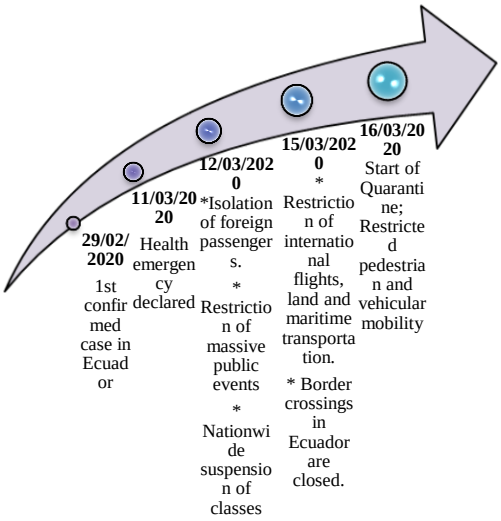

Figure 1. Chronology of sanitary measures due to COVID-19 outbreak in Ecuador. Source: Own elaboration based on Scifo (2020)

Despite the negative effects caused to human health by the COVID-19 outbreak, this crisis has brought positive and unexpected consequences for air quality and the environment; in the city of Quito, in the first month of confinement, carbon monoxide (CO) concentrations decreased by 38% (Zalakeviciute et al., 2020). Atmospheric pollutants such as carbon monoxide (CO) represent one of the major pollutants in the Earth's atmosphere. Its main producing sources responsible for approximately 80% of emissions are motor vehicles that use gasoline or diesel as fuel and industrial processes that use carbon compounds (Téllez et al., 2006; Ubilla & Yohannessen, 2017).

The European Space Agency (ESA) published several images that were captured by the Sentinel-5 Precursor, a satellite that monitors various atmospheric gases including carbon monoxide (CO), and nitrogen dioxide (NO2), among others, showing significant changes in the air quality of major cities in Madrid, Spain and Milan, Italy, following the COVID-19 pandemic as a consequence of blockades and restrictions (ESA, 2020; Suhaimi et al., 2020). The National Aeronautics and Space Administration (NASA) released several satellite images, showing changes in major U.S. cities (Holcombe & O'key, 2020).

The objective of this study was to evaluate variations in tropospheric carbon monoxide (CO) concentrations in the cantons of Ecuador, before (2019) and during (2020) the COVID-19 pandemic.

Materials and methods

Location of the study área

Located on the equator between Colombia and Peru, Ecuador is the smallest Andean country, with 256,370 km2, according to the Military Geographic Institute (IGM). It is made up of four geographic regions that offer an exceptional variety of ecosystems and biological diversity; the transportation sector is the largest source of air pollution, ahead of the residential and industrial sectors (Fontaine et al., 2008).

Atmospheric and spatial data

Atmospheric data were obtained from the Copernicus Open Access Center platform, taking as reference the Sentinel 5-P satellite of the European Space Agency (ESA, 2020). Sentinel-5P is the first Copernicus mission to monitor the atmosphere, aiming to reduce the data gap between Envisat satellites (Veefkind et al., 2012). Sentinel 5-P carries the most advanced TROPOMI instrument to measure ultraviolet-visible (270-500 nm), near-infrared (675-775 nm) and shortwave infrared spectral bands (2305-2385 nm), which means it can image various air pollutants such as NO2, O3, CH2O, SO2, CH4 and CO with higher accuracy (Galli et al., 2012; Zheng et al., 2019), with a resolution of 5.5 km and daily temporality (Ogen, 2020).

Satellite data were collected with the help of the Google Earth Engine platform which has powerful tools linking the potential of massive data and the efficiency of cloud processing (Perilla & Mas, 2020), modified a programming algorithm in Phyton (Zhang et al., 2020), thus establishing the temporality ranges for carbon monoxide in the study area. The raster was obtained with a Geotiff format extension and georeferenced to the World Geodetic System (WGS-1984). Then, extraction was performed based on a mask to delimit the study area, then the spatial distribution and temporal changes of carbon monoxide (CO) levels were analyzed. This spatial analysis was carried out based on the 221 cantons of Ecuador, generating descriptive statistics with the help of ArGis 10.8 software and the "Zonal Statistics as Table" tool, using as a basis the shape file of Ecuador obtained by the Military Geographic Institute and the raster of the concentrations of carbon monoxide (CO).

Statistical analysis

Atmospheric data obtained from the Sentinel 5-P satellite were processed to obtain the mean and maximum carbon monoxide concentrations (mean ± standard deviation) in the established periods, expressed in units of mol/m2. The ten cantons with the highest carbon monoxide concentrations were selected by analyzing the variation rate, which represents the difference between carbon monoxide concentrations corresponding to a period before the COVID-19 pandemic (the reference year 2019) and during the pandemic (the reference year 2020), expressed as a percentage.

Results and discussion

Carbon monoxide (CO) concentrations at the tropospheric level in Ecuador, including the 221 cantons, were based on the first month of COVID-19 containment (March 16 to April 16, 2020) and the same period before the pandemic (March 16 to April 16, 2019), as shown in Figure 2. The 2019 map (a) reveals that carbon monoxide concentrations range from 0.0237 to 0.0579 mol/m2. The 2020 map (b) reveals that carbon monoxide concentrations range from 0.0183 to 0.0538 mol/m2, evidencing a significant decrease in carbon monoxide concentrations (7%) compared to the same period in 2019 as a consequence of COVID-19 confinement.

These results were expected because carbon monoxide emissions are directly linked to anthropogenic activities, and vehicle circulation in Latin American countries such as Brazil, Ecuador, Mexico and Peru decreased between 72% and 90% during the months of April and the first weeks of May 2020, when the most stringent confinement measures were implemented (Parra, 2020). This result is consistent in comparison with other research conducted in Ecuador (Zalakeviciute et al., 2020) and other countries such as China, Germany, France, Italy, Spain and the United States (Muhammad et al., 2020; Ogen, 2020; Omrani et al., 2020). According to Pacheco et al., (2020). NO2 levels at the tropospheric level in Ecuador also decreased considerably (13%) in the first fifteen days of COVID-19 confinement compared to 2019.

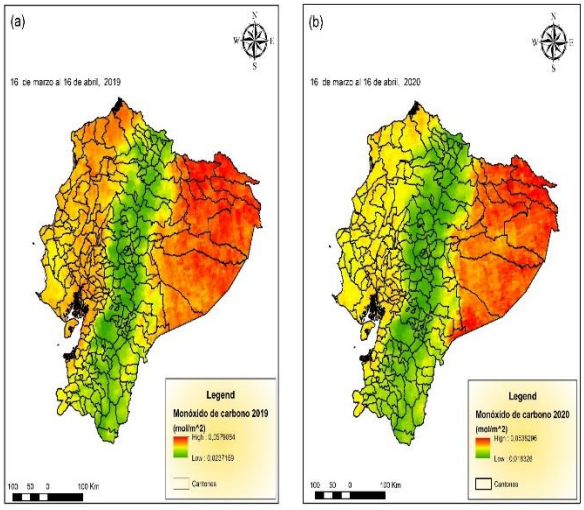

Figure 2. CO concentrations in Ecuador before (March 16 to April 16, 2019) and during (March 16 to April 16, 2020) COVID-19 confinement.

However, the patterns of decrease in carbon monoxide concentrations due to the COVID-19 pandemic were momentary, as demonstrated in Figure 3, for the remainder of 2019 (c) carbon monoxide concentrations range from 0.0179 to 0.0362 mol/m2. The 2020 map (d) during the pandemic reveals that carbon monoxide concentrations range from 0.0183 to 0.0381 mol/m2, evidencing a significant growth in carbon monoxide concentrations (5%) compared to the same period of 2019.

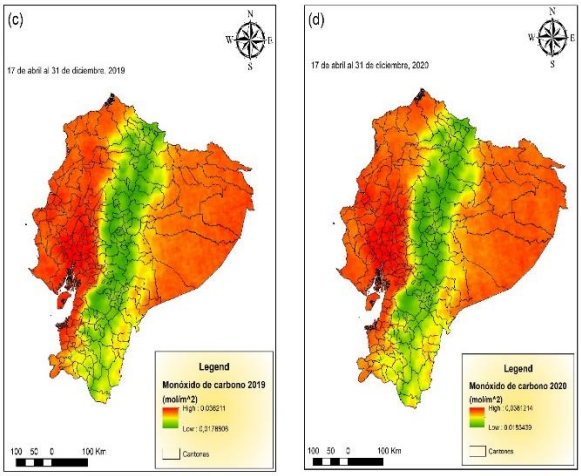

Figure 3. CO concentrations in Ecuador before (April 17 to December 31, 2019) and during (April 17 to December 31, 2020) the COVID-19 pandemic.

Of the 221 cantons analyzed, those with the highest average carbon monoxide concentrations are shown in Table 1, the first places belong to the province of Guayas, it was to be expected as it is the most industrialized in the country, the concentrations of carbon monoxide (CO) for 2020 (0, 03674±0.00026 mol/m2) (April 17 to December 31, 2020) in all cantons were higher compared to 2019 (0.03491±0.00021 mol/m2) (April 17 to December 31, 2019), showing significant growth of 5% during the pandemic year.

Carbon monoxide concentrations for both periods represent alarm levels in air quality, as they exceed the limits established in Executive Decree 3516, Book VI on ambient air quality standards (30000 µg/m3).

Table 1. Cantons with the highest CO concentrations before April 17 to December 31, 2019 and during the pandemic (April 17 to December 31, 2020). CO concentrations are expressed as mean ± standard deviation. The increase in concentrations is shown as a percentage (%).

N°	Cantons	CO 2019 (mol/m^2)	CO 2020 (mol/m^2)	Variation
1	DAULE	0,03534±0,00040	0,03704±0,00039	5%
2	SAMBORONDON	0,03521±0,00034	0,03704±0,00036	5%
3	SALITRE	0,03507±0,00039	0,03718±0,00042	6%
4	BABA	0,03484±0,00042	0,03665±0,00031	5%
5	LOMAS DE SARGENTILLO	0,03482±0,00023	0,03675±0,00024	6%
6	PUEBLOVIEJO	0,03481±0,00043	0,03646±0,00039	5%

7	NOBOL	0,03480±0,00045	0,03642±0,00049	5%
8	SANTA LUCIA	0,03480±0,00048	0,03682±0,00031	6%
9	PALESTINA	0,03473±0,00038	0,03639±0,00040	5%
10	ALFREDO BAQUERIZO MORENO	0,03471±0,00036	0,03670±0,00037	6%
Mean	…	0,03491±0,00021	0,03674±0,00026	5%

Similar to the reported means, the maximum carbon monoxide concentrations for the year 2020 (April 17 to December 31, 2020) were higher compared to the year 2019 (April 17 to December 31, 2019), as demonstrated in Figure 4.

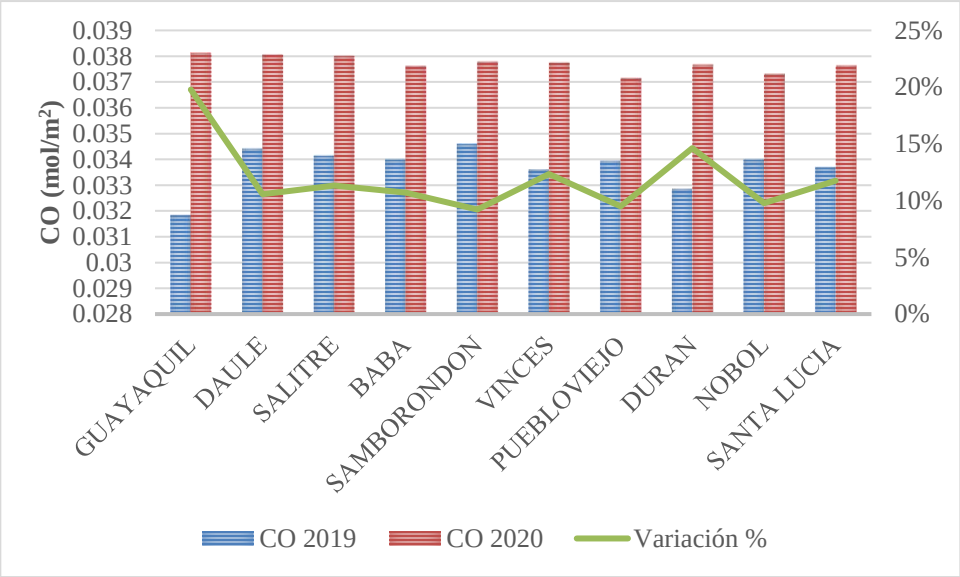

Figure 4. Maximum CO concentrations in Ecuador before April 17 to December 31, 2019, and during the COVID-19 pandemic (April 17 to December 31, 2020).

These results show that the decrease in carbon monoxide concentrations in Ecuador was momentary, nor the COVID-19 pandemic can curb the levels of carbon monoxide (CO) compared to other years. Similar behavior is observed in daily CO2 emissions worldwide, which decreased by 17% in the first days of April 2020 and then increased (Parra, 2020). These significant increases are linked to the measures adopted by several countries on insulation that became more flexible, causing an increase in vehicular traffic.

The United Nations stresses that the crisis generated by the COVID-19 pandemic has only triggered a short-term decrease in global emissions and will not make a significant contribution to reducing emissions by 2030 unless countries aim for an economic recovery that includes vigorous decarbonization (UN, 2020).

Conclusions

The present study revealed the improvement in air quality in the first days of the confinement; however, the COVID-19 pandemic does not have a positive aspect on carbon monoxide (CO) emissions in Ecuador, because the decreases found were momentary as a result of the economic slowdown of the country. For the year 2020, the concentrations were higher by 5% compared to 2019. Based on the results found, it is essential to promote circular economic development and the use of clean energies to improve air quality and to carry out more studies

that consider other gases that cause global warming and atmospheric pollution.

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