Association of particulate matter pollution PM_{10} and $PM_{2.5}$ and COVID-19 pandemic in Quito-Ecuador

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Abstract— **This study aimed to investigate the associations between particulate matter (PM) concentrations and the confirmed cases, new cases and deaths by Covid-19 in Quito-Ecuador. Covid-19 data were extracted from Ecuador's National Risk Management Service, while the average daily values of PM$_{10}$ and PM$_{2.5}$ were obtained from the data reported by the Quito Environment Secretariat. The analysis of the data was performed using Kendall and Spearman's ranks correlation tests since the data did not present a normal distribution. A strong significant correlation was found between PM$_{10}$ and confirmed cases and deaths, while between PM$_{2.5}$ and confirmed cases, new cases and deaths, the correlation was weak, in both Kendall and Spearman tests. These results are consistent with the growing trends of PM$_{10}$ due to ash emissions from Sangay and Reventador volcanoes, which are a natural source of PM. As a result, this study supports the possibility that the PM$_{10}$ could act as a vehicle in the transmission of Covid-19. Our results will help the World Health Organization and the National Risk and Emergency Management Service in Ecuador take effective action to combat Covid-19.**

Index Terms— **Covid-19, Particulate matter pollution, Ecuador, Volcanic Ash, Quito, Coronavirus.**

I. INTRODUCTION

In December 2019, a new type of Severe Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) was reported in Wuhan City, Hubei Province, China [1]. On February 11, Covid-19 was coined by the World Health Organization [2]. As of March 11, there were already 118,000 cases in 114 countries with 4,291 dead, leading WHO to decree Covid-19 as a pandemic [3]. To date, 21,756,357 confirmed cases have been reported and 771,635 deaths have been reported, of which 11,607,196 confirmed cases have occurred in America [4]. As a result of this pandemic scenario, the global scientific community is called upon to study and generate relevant and timely knowledge in the fight against Covid-19. This can be evidenced in the Scopus database reporting more than 29,000 scientific papers to date. Among the different approaches that must be addressed in the study of the transmission of Covid-19, environmental pollution is one of them since this could serve as a vehicle in its transmission.

The adverse effects of environmental pollution and respiratory diseases are a well-documented fact [5], therefore it is natural to study the possible correlation between Covid-19 and polluting particles. In this sense, Bashir et al. [6] found a significant association between environmental pollutants such as PM_{10}, PM$_{2.5}$, SO$_2$, NO$_2$ and CO and Covid-19 in California. Applying a generalized additive model, Zhu et al. [7], investigated the association of six contaminants (PM$_{2.5}$, PM_{10}, SO$_2$, CO, NO$_2$ and O$_3$) with confirmed Covid-19 cases in China. Their results indicated that there is a significant correlation between environmental pollutants and Covid-19 infection. Recently, a correlation between climate indicators and Covid-19 was studied by Bashir et al. [8] in New York City, showing that average temperature, minimum temperature, and air quality are significantly associated with the Covid-19 pandemic. The assessment of the correlation between ground-level ozone levels (O$_3$) and nitrogen dioxide (NO$_2$) with Covid-19 in Milan, Italy, was studied by Zoran et al. [9]. They found the possibility that O$_3$ can act as an incubator of the Covid-19 virus.

Currently, decision-making in the face of the global spread of Covid-19 is framed in a scenario of great uncertainty. Strategies to fight against Covid-19, usually adopted by many governments, are social estrangement, mobility restriction, and lockdown. However, while the pandemic is developing, the construction of knowledge that lessen uncertainty is required. To this day, Ecuador is the second country in the Americas, after the United States, with the most deaths per million inhabitants, with a total of 92,586 confirmed cases and 6,070 deaths. Therefore, in order to reduce uncertainty in the strategies assumed to combat Covid-19, and motivated by the following sentence "We believe that epidemiological and experimental researches are urgently required to estimate the impact of PM$_{2.5}$, incidence on the exposed population in almost every country [10]", in this work we studied the association between environmental pollutants PM$_{2.5}$ and PM_{10} and Covid-19 in the city of Quito-Ecuador following the approaches taken in [6], [8], [9].

II. GEOGRAPHICAL POSITION OF QUITO

Ecuador is located in South America and is surrounded by Peru and Colombia and crossed by the Andes mountain range from north to south. In addition, it is located in the Pacific "Ring of Fire" which is an alignment of land and submarine volcanoes and ocean faults with about 40,000 miles in its circumference. Quito is the capital of Ecuador and Pichincha Province. It is the oldest capital of South America and the most densely populated city in Ecuador, with 2 million inhabitants in its metropolitan area. It is located in the Guayllabamba basin, on the western slope of the active Stratovolcano Pichincha, in the eastern part of the Andes and its altitude is 2850 m.s.n.m. As shown in Fig. 1, Quito is located in a volcanic region, some of these volcanoes are active, others are classified as potentially active, passive, or at rest and/or erupting.

III. RESEARCH METODOLOGY

The data set for Covid-19 was acquired from report No. 56 issued by the National Risk and Emergency Management Service (REMS) of the Republic of Ecuador. This report includes information on the temporal evolution of Covid-19 from 13

Fig. 1. Geographical position of Quito: Quito is located in a volcanic area. Geometric figures in colors indicate volcanic areas. The Sangay volcano and Reventador have recently expelled ash.

March 2020 to 13 August 2020 [11], which is the time interval considered in this investigation.

The data on the polluting particles $PM_{2.5}$ and PM_{10} was taken from the website supported by the Quito Environment Secretariat. The Shapiro–Wilk test was used to analyze datasets, and it was found that the datasets did not exhibit a normal distribution Therefore, Kendall and Spearman rank correlation tests were chosen for data analysis. The statistical analysis was conducted using the software [12].

IV. RESULTS AND DISCUSSION

Fig. 2 shows the trend of Covid-19 data in Quito. The temporary evolution of confirmed cases, new cases (per day), and the number of deaths were traced from 13 March 2020 onwards

(13 August 2020). A growing trend in the number of confirmed cases is observed. The same can be seem is observed in the number of deaths, with the particularity that there is a upward trend after May 13. Regarding the number of new cases per day, the range remained between 0 and 400.

Fig. 3 shows the temporal evolution of the daily average values of the polluting particulate matter, $PM_{2.5}$, and PM_{10}, from March 13 of 2020 onwards. A linear adjustment was made to observe the trend of the data. It is observed that the trend line of $PM_{2.5}$ undergoes a slight inclination, although the data are kept in a
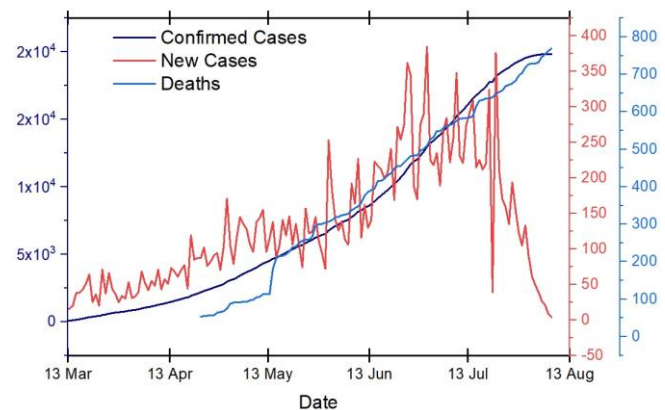

Fig. 2. Temporary evolution of Covid-19 in Quito, from March 13, 2020 to August 13, 2020.

range between 20 and 70 during the study period (March 13 to August 13, 2020). In contrast, the values of PM_{10} experience a tendency to grow stronger in the same study period.

Table 1 shows the empirical estimates of the contaminants $PM_{2.5}$ and PM_{10}. It is noted that the $PM_{2.5}$ is weakly correlated with the three scenarios: confirmed cases, new cases, and deaths, in both tests: Spearman and Kendall. Interesting behavior can be seen in PM_{10}. It is noted that the PM_{10} is strongly correlated with
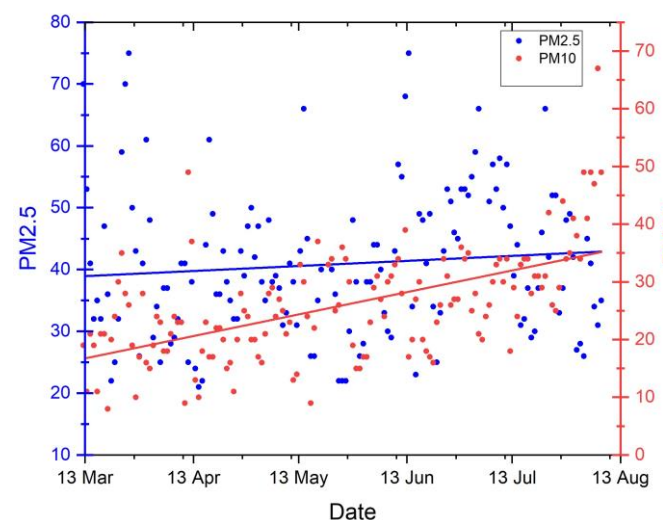

Fig. 3. Average daily variation of $PM_{2.5}$ and PM_{10} in Quito, from March 13, 2020 to August 13, 2020.

confirmed cases and deahts for the two tests used.

The results found in this work (Table 1) exhibit a strong correlation between PM_{10} and Covid-19, unlike the behavior of $PM_{2.5}$. A plausible, but not conclusive explanation, for these

TABLE I
EMPIRICAL RESULTS

	Pollutants	New Cases	Confirmed Cases	Mortality
Spearman Correlation Coefficient	PM_{10}	0.217**	0.569*	0.551*
	$PM_{2.5}$	0.248*	0.135	0.129
Kendall Correlation Coefficient	PM_{10}	0.155*	0.414*	0.401*
	$PM_{2.5}$	0.172*	0.094	0.080

**, * signifies shows significance at 5% and 1%, respectively.

results is that they could be associated with the growing trend of PM_{10} experienced in Quito during the study time interval, as seen in Fig. 3. As mentioned in the introduction, Quito is located in a region of high volcanic activity. Therefore, this growing trend of PM_{10} could be associated with ash emissions that occurred in the volcanoes Sangay [11] and Reventador during the study period (March 13 onwards), as a natural source of PM_{10} are the ashes emitted from volcanoes. Another important observation is that regardless of the strategies implemented by the REMS, such as social distancing, quartering, and mobility limitation, the number of confirmed cases and deaths continue to increase. Our results can help the World Health Organizations and local authorities take effective action in combating Covid-19 transmission. Finally, it might be recommended to use face masks that can filter particles such as PM_{10} and $PM_{2.5}$ in areas with volcanic activity such as Ecuador. To increase protection, it would not be advisable to use homemade face masks, because the porosity of homemade materials is much greater than the dimensions of the polluting particles PM_{10} and $PM_{2.5}$.

V. CONCLUSION

This paper has explored the association between polluting particulate material $PM_{2.5}$ and PM_{10} and Covid-19 through Kendall and Spearman's rank correlations. A strong correlation has been found between PM_{10} and Covid-19, in contrast to the weak correlation found for $PM_{2.5}$. This research is exploratory in nature, so it is recommended that more studies on particulate matter and Covid-19 are conducted in each country, especially in cities located in regions of high volcanic activity. With more information on possible Covid-19 transmission vehicles, better strategies can be adopted in combat against the Covid-19.

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