Evaluation of the potential relationship between Particulate Matter (PM) pollution and COVID-19 infection spread in Italy

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INTRODUCTION

To date, several scientific studies focused on viruses diffusion among humans demonstrated that increased incidence of infection is related to airborne particulate matter (PM) concentration levels [1,2]. It is known that PM fractions (e.g., $PM_{2.5}$ and PM_{10}) serve as carrier for several chemical and biologic pollutants, viruses included. Viruses may be adsorbed through coagulation onto particulate matter composed by solid and/or liquid particles whose lifetime into the atmosphere is hours, days or weeks. Particles and adsorbed biologic pollutants may be subjected to diffusion into the atmosphere and transport, also at long distances (long-range transport). PM also represents a substrate allowing long term persistence of viruses into the atmosphere, hours or days. Viral inactivation depends on selected environmental parameters: if on the one hand both high temperature and solar radiation are able to speed up the inactivation rate, on the other hand high relative humidity may promote the diffusion rate [3]. Recently published scientific studies already highlighted the relationship between viruses diffusion among exposed population and particulate matter concentration levels into the atmosphere. According to Chen et al., 2010 ambient influenza and highly pathogenic avian influenza virus (H5N1) may be subjected to long-range transport due to saharian dust [4]. The authors demonstrated that the concentration of ambient influenza A virus was significantly higher during the Asian dust days than during the background days. Ye et al., in 2016 investigated whether Respiratory Syncytial Virus (RSV) infection in children in China was associated with ambient temperature and airborne pollutants [5]. RSV was demonstrated to cause pneumonia in children and its penetration in the deepest parts of respiratory apparatus promoted by particle-based transport. A positive correlation between the infection rate and the particulate matter $PM_{2.5}$ ($r = 0.446$, $P < 0.001$), PM_{10} ($r = 0.397$, $P < 0.001$) was shown. Chen et al., provided further evidence that virus incidence is associated with exposure to atmospheric high $PM_{2.5}$ concentration levels in China [6]. More specifically, data on daily numbers of measles cases and $PM_{2.5}$ concentrations were collected from 21 cities in China during October 2013 and December 2014. The authors highlighted that 10 $\mu g/m^3$ increase in $PM_{2.5}$ was significantly associated with increased measles incidence providing the final recommendation to apply PM abatement strategies in order to slow down the diffusion rate. Finally, the most recent study carried out by Peng et al., in 2020 demonstrated that PM concentration levels population was exposed to significantly affected the misleas spread in Lanzhou (China) [7]. As a result, the authors suggested to develop effective abatement strategies of PM concentration levels with the purpose to reduce potential risks for the population.

Given the brief introduction reported above, it is possible to conclude that particulate matter fractions $PM_{2.5}$ and PM_{10} represent an effective carrier for viruses transport and diffusion and proliferation of virus diseases as well.

COVID-19 DIFFUSION IN ITALY: DIFFUSION RATE AND PM_{10} DAILY LIMIT VALUE EXCEEDANCES

With the purpose to assess the relationship between PM concentration levels and COVID-19 diffusion rate, the following data were collected:

- PM_{10} daily concentration levels collected by environmental monitoring stations of Environmental Protection Agency (ARPA) network at National level. PM10 data by monitoring stations on Italian territory and publicly available on ARPA websites were collected. The number of PM_{10} daily limit value exceedances (50 $\mu g/m^3$) and the number of environmental monitoring stations for each selected Province were both taken into account (number of PM_{10} exceedances/number of stations for each Province).

- number of COVID-19 infected persons for each selected Province reported on Civil Protection website and updated with daily frequency.

Data matching allowed to highlight the association between the number of PM_{10} daily limit value exceedances, registered in the period 10th February-29th February, and the number of COVID-19 infected persons updated at 3th March. The analysis of PM10 levels-infected cases was carried out taking into account a delay time of 14 days, that is the estimated COVID-19 incubation period until symptoms manifestation and diagnosis. Correlation between the number of COVID-19 infected persons in each Province (reported on a logarithmic scale and classified in 5 different classes) and the average number of exceedances of PM_{10} daily limit value for each class is reported in Figure 1 (R^2=0,98). The average for each class was calculated dividing the average number of exceedances by the number of monitoring station for each Province.

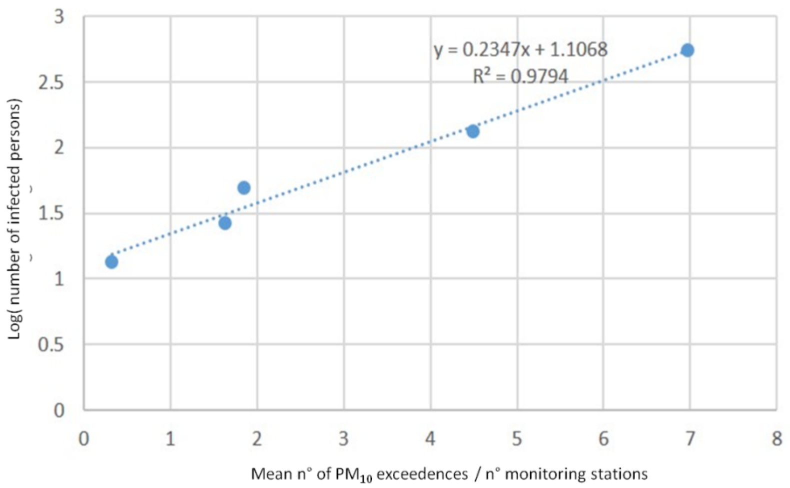

Figure 1: Correlation infected persons - PM_{10} exceedances.

This evidence leads the authors to the hypothesis of a direct relationship between the number of persons infected by COVID-19 and the PM_{10} concentration levels in specific areas of Italian territory, confirming previous findings of recently published studies regarding environmental factors involved in viral infection spread. The hypothesis of a direct relationship between COVID-19 cases and PM_{10} levels is strengthened by the evidence that concentration of COVID-19 outbreaks notified in Pianura Padana was higher than in other parts of Italy (Figure 2).

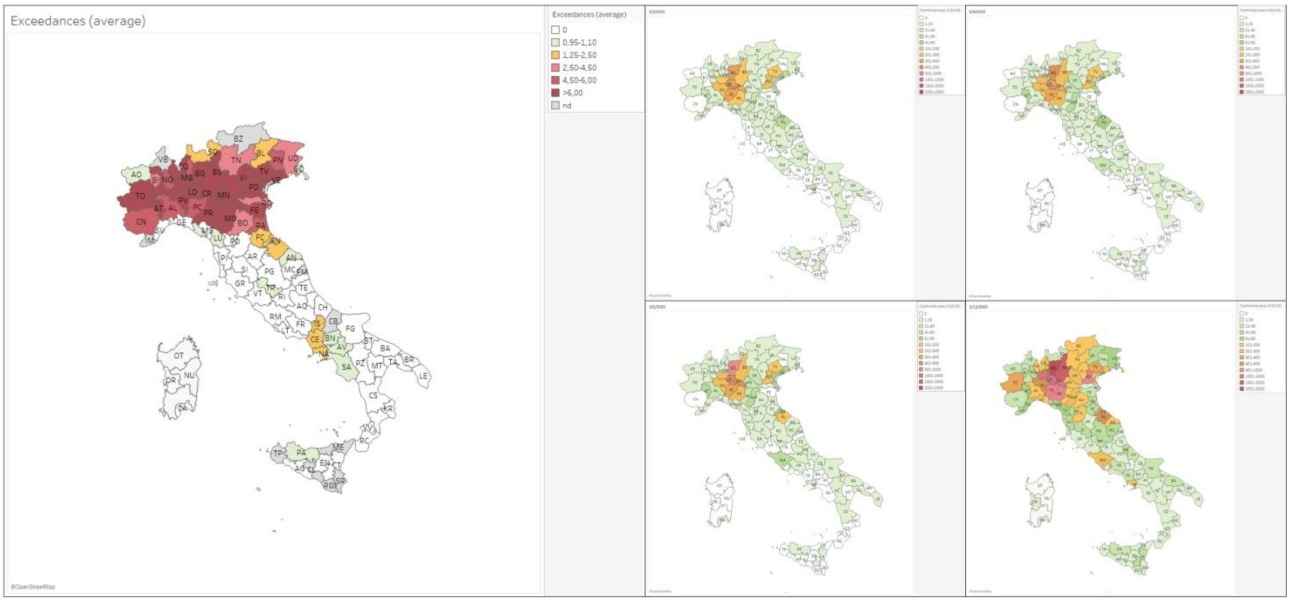

Figure 2: Mean of PM_{10} exceedances/number of monitoring stations in selected Italian Provinces in the period 10th-29th February 2020.

Moreover, taking into account that COVID-19 incubation period (time elapsed between the human exposure and the manifestation of symptoms until the diagnosis) was estimated to be on average 14 days and considering the monitored period (starting from 24th February to 15th March), it can be assumed that the virulent stage occurred between 6th February and 25th February. Infection spread trends for Southern regions are in agreement with epidemic models based on the typical transmission mode 'person-to-person contact' whilst anomalies in COVID-19 infection spread across Northen regions in Pianura Padana are observed suggesting that the diffusion was promoted by a carrier agent (Figure 3).

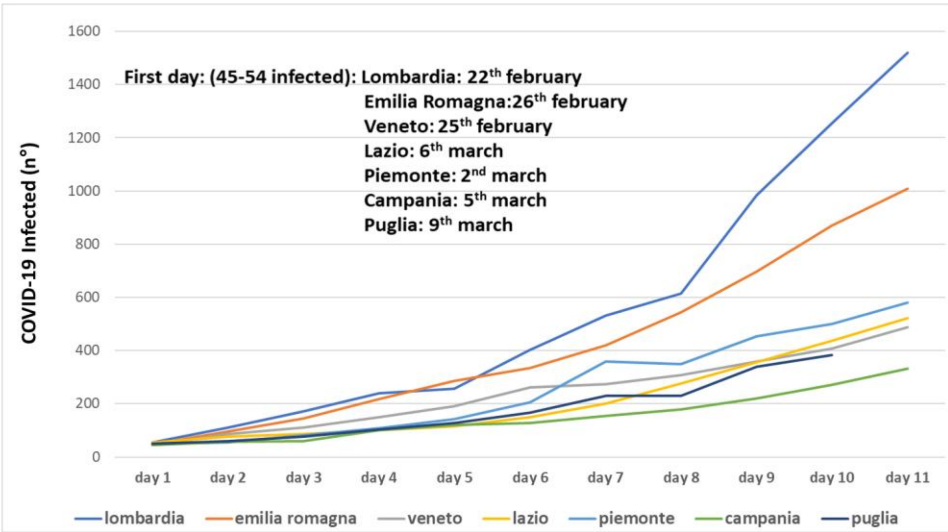

Figure 3: Infection spread trends in Northern and Southern regions in Italy.

The observed 'boost' process occurred when high PM_{10} concentration levels were registered. More specifically in Lombardia region, an oscillating trend of PM_{10} concentration level over the time was observed with three distinct periods characterized by a significant number of PM_{10} limit value exceedances (Figure 4, Province of Brescia).

-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
A	75	66	54	31	12	16	29	44	68	63	45	20	25	37	27	56	65	56	39	17	35	41	45	56	77	47	16	20	23
B	70	56	47	33	15	29	41	55	64	60	49	28	38	42	35	60	63	58	49	25	34	45	45	53	54	50	27	21	28
C	69	56	53	25	18	40	nd	nd	nd	58	25	21	44	33	33	63	50	39	43	27	45	54	59	72	76	34	66	nd	nd
D	88	58	56	13	18	39	68	69	82	68	34	38	80	50	40	71	73	61	54	22	74	51	49	67	84	35	28	24	35
E	nd	nd	nd	26	14	25	38	48	69	nd	nd	22	28	33	26	50	55	42	31	21	41	43	54	68	76	29	13	18	23

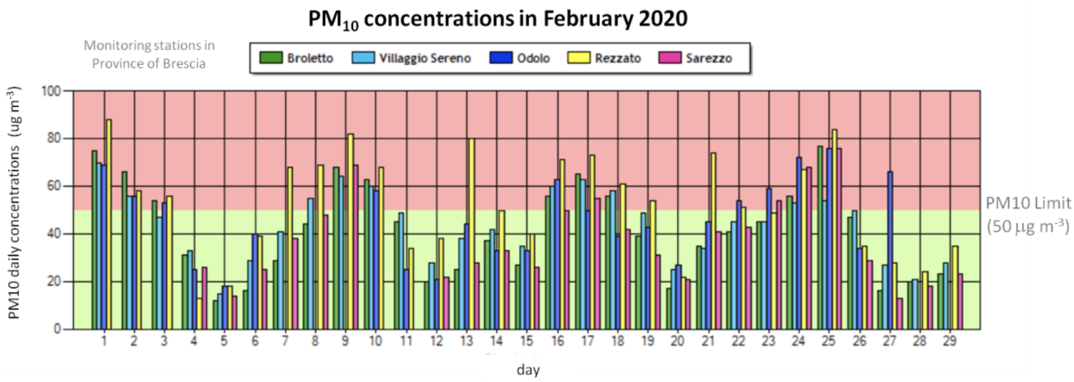

Figure 4: PM_{10} concentration levels and limit value exceedances in Province of Brescia in February 2020.

Therefore, on the basis of the collected data and observed relationships, it is reasonable to assume that, during the period 7th-29th February and in specific Northern Italian regions, PM_{10} concentration levels higher than the daily limit value resulted in a 'boost' process promoting the diffusion the COVID-19 among the exposed population, phenomenon not observed in other Italian regions that were affected by the contamination during the same period. At this regard, it's of concern the comparison with Rome where infected cases were notified simultaneously with the regions in Pianura Padana but where the infection spread was observed at lower extent. Finally, it is also important to point out that, besides airborne particles, environmental parameters such as temperature and relative humidity may represent key factors in activation and persistence of viruses in the atmosphere. The authors will pay attention on the aforementioned factors in the future in order to deepen the issue.

CONCLUSIONS AND SUGGESTIONS

In conclusion, the rapid COVID-19 infection spread observed in selected regions of Northen Italy is supposed be related to PM_{10} pollution due to airborne particles able to serve as carrier of pathogens. As already highlighted in previous studies, it is recommended to take into account PM_{10} contribution and make policymakers aware of the need to take direct actions for pollution control.

References

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