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IDENTIFICATION OF ROLE OF AIR POLLUTION PARTICULATE MATTER IN SPREAD AND INCREASE OF COVID-19 BY USING SOFT COMPUTING TECHNIQUES

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OBJECTIVE:

To understand the correlation between air pollution and covid -19.This document will help in understanding the role of particulate matter in spread and increase of covid-19‘s morbidity and mortality.

Covid-19 could have an air transmission and atmospheric particulate matter (PM) could create a suitable environment for transporting the virus at greater distances than those considered for close contact

INTRODUCTION

On 11 March 2020, the World Health Organization (WHO) declared the coronavirus pandemic: the Sars-cov-2 virus (Covid-19) is a threat to the population’s health. Air pollution is also one of the greatest challenges of our millennium, and some early studies have highlighted a positive correlation between air pollution and the spread of the virus. Therefore, it is crucial to define which role the atmospheric particulate plays in the spread, morbidity, and mortality of the virus. In this context, two hypotheses should be highlighted. First, Covid-19, similarly to other viruses, could also have an airborne transmission, and particulate matter (PM) could act as a carrier through the aerosol, conveying the virus and increasing its spread. Secondly, PM could instead have induced damage to the lung cells, increasing the inflammation state. This rise of inflammation may increase the mortality rate and the severity of expression of the disease in the most polluted areas.

Among the environmental parameters, some climate condition such as temperature, humidity, sunlight and wind revealed a reduction of the COVID-19 spread and air pollution seems to have a role in airborne transmission of SARS-CoV-2 and severity of COVID-19 Nevertheless, to better understand COVID-19's diffusion patterns, an interdisciplinary, multidimensional approach should be encourage in order to develop firm conclusions

Air pollution has been identified as the largest environmental cause of disease and premature death in the world. Ambient particulate matter (PM) induces its pro-inflammatory and thrombogenic effects through the generation of oxidative stress by its chemical compounds and metals. The recent identification of environmentally persistent free radicals (EPFRs) in the PM, resulting from a mixture of combustion sources, theorize its role in the increase of disease severity of lower respiratory tract infections (LRTI) . Scientific evidences support that short- and long-term exposures to ambient air pollutants are associated with a broad of adverse health outcomes, such as higher mortality rates, greater hospital admissions and increased outpatient visits

Various studies suggest that outdoor air pollution, resulting from a combination of factors such as meteorological data, level of industrialization as well as regional topography, could operate both as a carrier of the infection and as a worsening factor of the COVID-19 severity

PROBLEM DOMAIN

Exposure to air pollution is considered as the major environmental cause of several diseases and premature death around the globe. Study evidence indicates that both short- and long-term exposures to air pollutants are associated with a wide range of adverse health effects, such as higher fatality rates, increased hospital admissions and increased outpatient visits some reviews highlighted the links between air pollution and COVID-19. However, up to now a limited number of data-dependent studies have been conducted to investigate the association between air pollution and COVID-19 infection and mortality. The available studies that have demonstrated the effects of short-term (within 2 months of exposure) and long-term exposure (more than 2 months of exposure) to air pollution on COVID-19 infections

eferences	Study region	Study design	Period of study	Outcome
hang et al. (24)	219 prefecture cities in China	Retrospective	January 24 to February 29, 2020	A positive correlation was observed between air pollution indicators and new COVID-19 confirmed cases. The SARS-CoV-2 spreading was between 5 and 7% when the air quality index (AQI) was increased by 10 units.
hu et al. (25)	120 cities in China	Retrospective	January 23 to February 29, 2020	A significant positive association was found for $PM_{2.5}$, PM_{10}, NO_2, and C with newly COVID-19 confirmed cases. A 10-$\mu g/m^3$ increase (lag0–14) i $PM_{2.5}$, PM_{10}, NO_2, and O_3 was associated with a 2.24, 1.76, 6.94, and 4.76% increase in the daily counts of COVID-19 cases, respectively.
et al. (7)	Wuhan and XiaoGan in China	Retrospective	January 26 to February 29, 2020.	A significant correlation was observed between COVID-19 incidence and AQI in both cities ($p < 0.01$). The incidence of COVID-19 was highly correlated with $PM_{2.5}$ and NO_2 in both cities.
in et al. (26)	29 Provinces in China	Retrospective	January 21 to April 3, 2020	Higher ambient CO concentration was a risk factor for the increased spreading of SARS-CoV-2, while higher temperatures, efficient ventilation and air pressure reduced its transmissibility.
ao et al. (27)	Whuan in China	Retrospective	January 19 to March 15, 2020	After adjusting to temperature and relative humidity, SO_2, NO_2, CO, and O_3, the case fatality rate (CFR) was positively associated with $PM_{2.5}$ and PM_{10}.
ang and Xu (28)	Whuan in China	Retrospective	January 25 to April 7, 2020	A significant positive correlation ($p < 0.01$) was observed between AQI especially $PM_{2.5}$ and the daily COVID-19 deaths.
ansini and Fornacca (14)	China, France, Germany, Iran, Italy, Spain, UK and the USA	Retrospective	NA	Increased SARS-CoV-2 infections were observed in the regions where high levels of $PM_{2.5}$ and NO_2 were present. A significant correlation was found between the levels of air quality with COVID-19 spread and mortality in six countries except for Spain and Germany.
avaglio et al. (29)	England	Retrospective	As of April 10, 2020	The markers of poor air quality, such as NO and SO_2 were associated with an increased rate of COVID-19 related deaths across England, after adjustment of population density.
onstantinoudis et al. (30)	England	Retrospective	As of June 30, 2020	An increase of 0.5% and 1.4% in COVID-19 mortality rate was observed for every 1 $\mu g/m3$ increase in NO_2 and $PM_{2.5}$, respectively.
agazzino et al. (31)	3 cities in France	Retrospective	NA	This study showed a direct relationship between air pollutants ($PM_{2.5}$ and PM_{10}) and COVID-19 fatality.
gen (32)	France, Germany, Italy, Spain	Retrospective	January to February 2020	About 78% of deaths occurred in just five regions of northern Italy and central Spain, where NO_2 were present at the highest concentrations combined with downward air pressure.
ele and Magazzino (33)	25 cities in India	Retrospective	January 29 to May 18, 2020	In machine learning (ML) analysis with Causal Direction from Dependency (D2C) algorithm, a direct relationship was found between the concentration of $PM_{2.5}$ and COVID-19 mortality.
oran et al. (34)	Milan, Italy	Retrospective	January 1 to April 30, 2020	COVID-19 infections showed a positive correlation with ground level O_3. However, ground level NO_2 was inversely correlated with COVID-19 infections. Outdoor airborne aerosols might be the possible carriers of COVID-19 transmission.
oran et al. (35)	Milan, Italy	Retrospective	January 1 to April 30, 2020	Daily new cases of COVID-19 were positively related to PM and AQI. Dry air supports SARS-CoV-2 transmission. Warm-season may not have a role in spreading viral infection.
ttorini and Regoli (36)	Italy	Retrospective	As of April 27, 2020	Long-term air-quality data showed a significant correlation with COVID-1 cases in 71 provinces in Italy, provided further evidence that chronic exposure to air pollution may influence the viral spreads.
etti et al. (37)	110 Provinces in Italy	Retrospective	February 24 to March 13, 2020	A significant association has been observed between the geographical distribution of daily PM_{10} exceedances and the initial spreading of COVID-19 in the Italian provinces.
oker et al. (38)	Northern Italy	Retrospective	January 1 to April 30, 2020	A positive association was observed between ambient $PM_{2.5}$ concentration and excess COVID-19 related mortality. A one-unit increas in $PM_{2.5}$ concentration ($\mu g/m3$) was associated with a 9% increase in th COVID-19 related fatality.
ontera et al. (39)	Italy	Retrospective	As of March 31, 2020	A high number of COVID-19 cases were found in the most polluted regions and the affected patients required ICU admission. The mortality was two-fold higher in these polluted regions than the other regions.
occia (40)	Northern Italy	Retrospective	As of March 17, to April 2020	An association was observed between accelerating and vast diffusion of COVID-19 and air pollution. This study demonstrated that contaminated air accelerates the transmission of the SARS-CoV-2 to humans other tha the transmission from human to human.
asquez-Apestegui et al. 1)	20 districts in Lima (Peru)	Retrospective	As of June 12, 2020	The higher rates of spread of COVID-19 in Lima were associated with the previous long-term $PM_{2.5}$ exposure.
ndree BPJ (42)	355 municipalities in the Netherlands	Retrospective	As of March 31, 2020	$PM_{2.5}$ was a highly significant predictor of COVID-19 cases and the related hospital admissions. It was also observed that COVID-19 cases were increased by almost 100% when pollutant concentrations were increased by 20%.
endryx and Luo (43)	USA	Retrospective	As of May 31, 2020	In regression analyses, COVID-19 prevalence and mortality rates were significantly associated with greater diesel particulate matter (DPM).
u et al. (44)	3000 counties in the U.S.A.	Cross-sectional	As of April 04, 2020	An increase of only 1 $\mu g/m^3$ in long-term $PM_{2.5}$ exposure is associated with an 8% increase in the COVID-19 fatality rate.
dhikari and Yin (45)	New York, USA	Retrospective	March 1 to April 20, 2020	Short-term exposures to ozone and other meteorological factors could b associated with COVID-19 transmission and initiation of the disease, but disease aggravation and fatality depend on other factors.
ashir et al. (46)	California, USA	Retrospective	March 4 to April 24, 2020	Air pollutants such as PM_{10}, $PM_{2.5}$, SO_2, NO_2, and CO showed a significant correlation with the COVID-19 epidemic.

and mortality are summarized below:

Short-Term Exposure to Air Pollution and COVID-19

A recent study has examined the geographical properties of the COVID-19 infection and associated it with various annual satellite and ground level of air quality index in eight countries including Italy, Spain, Germany, France, UK, USA, Iran and China and found more viral infections in the regions where high levels of $PM_{2.5}$ and NO_2 were present .The study observed a significant correlation between the levels of air quality and COVID-19 spread and mortality in six countries except for Spain and Germany. Of these countries, Italy showed the strongest correlations in terms of both for infection and mortality, while population size and density did not correlate with COVID-19 incidence. In another study, after adjusting to temperature and relative humidity, SO_2, NO_2, CO, and O_3, the case fatality rate (CFR) showed a positive association with $PM_{2.5}$ and PM_{10} in China. A significant positive correlation ($p < 0.01$) was also observed between AQI especially $PM_{2.5}$ and the daily COVID-19 deaths in Wuhan, China. In three cities in France, a direct relationship was found between air pollutants ($PM_{2.5}$ and PM_{10}) and COVID-19 fatality. It is also plausible that SARS-CoV-2 transmission by fomites and aerosol, and the viral particle can remain infectious and viable in aerosol for several hours and on surfaces for several days.

A study collecting data from 110 Italian cities, reported a significant association between the geographical distribution of daily PM_{10} exceedances and the initial spreading of COVID-19 . It has been suggested that particulate matter (PM_{10}) may serve as a carrier for droplet nuclei, increasing the spread of SARS-CoV-2. This result was supported by another study that showed an association between accelerate and vast diffusion of COVID-19 and air pollution. Moreover, this study demonstrated that contaminated air accelerates the transmission of the SARS-CoV-2 to humans other than the transmission from human to human. Another study in Italy found a high number of COVID-19 cases were in the most polluted regions and the affected patients required ICU admission and the mortality was two-fold higher in these polluted regions than the other regions. In the USA, two retrospective studies also determined the effects of air pollutants on COVID-19. Adhikari and Yin demonstrated that short-term exposures to ozone and other meteorological factors could be associated with COVID-19 transmission and initiation of the disease, but disease aggravation and fatality depend on other factors. In other study air pollutants such as PM_{10}, $PM_{2.5}$, SO_2, NO_2, and CO showed a significant correlation with the COVID-19 epidemic.

Long-Term Exposure to Air Pollution and COVID-19

A new study looked at COVID-19 mortalities in four countries in Europe that have been most affected by the novel virus-Spain, Italy, France, and Germany . It was found that about 78% of deaths occurred in just five regions of northern Italy and central Spain, where NO_2 were present at the highest concentrations combined with downward air pressure, which prevented the dispersion of air pollutants. The author demonstrated that prolonged exposure to NO_2 may contribute to mortality caused by the COVID-19 infection in these areas. Another study used the data from US Environmental Protection Agency Environmental Justice Screen (EPAEJS) and prevalence and fatality rates as of 31 may 2020 demonstrated that, after adjusting for covariates, COVID-19 incidence and mortality rates were significantly correlated with greater diesel particulate matter (DPM) . In Italy, a recent study also reported a correlation between COVID-19 mortality in northern Italy where the high levels of pollutants were present. Long-term air-quality data showed a significant correlation with COVID-19 cases in 71 provinces in Italy, providing further indication that chronic exposure to air pollution may influence the viral spreads.

A recent study collecting data from 355 municipalities in the Netherlands showed $PM_{2.5}$ as a highly significant predictor of COVID-19 cases and hospital admissions . It also observed that COVID-19 cases were increased by almost 100% when pollutant concentrations were increased by 20%. A study in England reported an increase of 0.5 and 1.4% in the COVID-19 mortality rate for every 1 µg/m3 increase in NO_2 and $PM_{2\cdot5}$, respectively after adjusting of confounders . This study evidence of an effect

of long-term NO_2 exposure on COVID-19 mortality, while the effect of $PM_{2·5}$ remains unclear. Another recent study also provided evidence on the association of air pollution with SARS-CoV-2 lethality in England. The authors showed an association between fossil fuels released pollutants and vulnerability to viral infection. This finding suggests that people exposed to chronic greater levels of air pollution might be more vulnerable to viral infection. According to the UK's air quality and emissions news and information site, in France, where COVID-19 distribution maps depicted areas with a very large number of severely COVID-19 affected patients required hospitalization

VIRAL TRANSMISSION

Air is a vehicle through which microbial agents can move around the environment. Plants and cellular fragments, bacteria, fungi, viruses, parasites, and spores can be components of the bioaerosol [5]. Atmospheric PM would function as a carrier, or as a transport vector, for many viruses. Thus, PM may have increased the effectiveness of the virus spread in the aerosol as it creates a microenvironment suitable for its persistence [28]. PM10 and PM2.5 can be inhaled and, in addition to the polluting particles, the associated microorganisms are inhaled, too. Recent studies also indicate that microbial community composition and concentration are significantly affected by particle concentration and dimension [29]. The particles could also act as carriers, which have complex adsorption and toxicity effects on bacteria [30]. Certain particle components are also available as nutrition for bacteria and the toxic effect dominates in heavy pollution. The analysis of Franzetti et al. [31] of microbial community in PM10 and PM2.5 sampled in winter and summer in Milan (Italy) showed large seasonal variations in the microbial communities, with plant associated bacteria dominating in summer and spore forming bacteria in winter. The results obtained also indicate not only that the PM source can influence the presence of specific bacterial groups, but also that environmental factors and stresses can shape the bacterial community. In addition, inhalation transports the particles deep into the lungs, especially those smaller than 2.5 microns (PM2.5 and UFPs), and this allows the virus to develop within the respiratory tract and to cause infections

METHODOLOGY

Environmental Aspect	Methodology
Defining timelines of study comparison & activities register	Enlisting of aspect – impact register along with timeline of events for which the impact shall be studied and evaluated. For example, Initiation of slowdown and restrictions in movement• during 10th to 22nd March Followed by 23rd to 20th April as first phase of total• lockdown Then based on relaxations, if any time period between• 20th to 3rd May & so on till 31st of May 2020 Preferably activity wise listing for entire Maharashtra State underlining the activity related to regulation of the government to enlist essential activities such as pharmaceuticals in Chemical zone of MIDC's, thermal power plants in certain parts of industrial zones, etc. Similarly, parameters of evaluation were selected from within the most applicable & expected impactful parameters such as industrial units active during various phases, water consumption in industries & commercial applications, electricity use in residential, fuel use in vehicles Attempt were made to establish several surrogate analytical tools to understand behaviour as well as pattern of each source & expected impacts & also to generate baseline / COVID-19 activity data Most of the activity data are best guesstimates & every scientific / logical argument is presented to provide for best confidence in data gathered and analytical methods of interpretation used through transparent mechanisms.

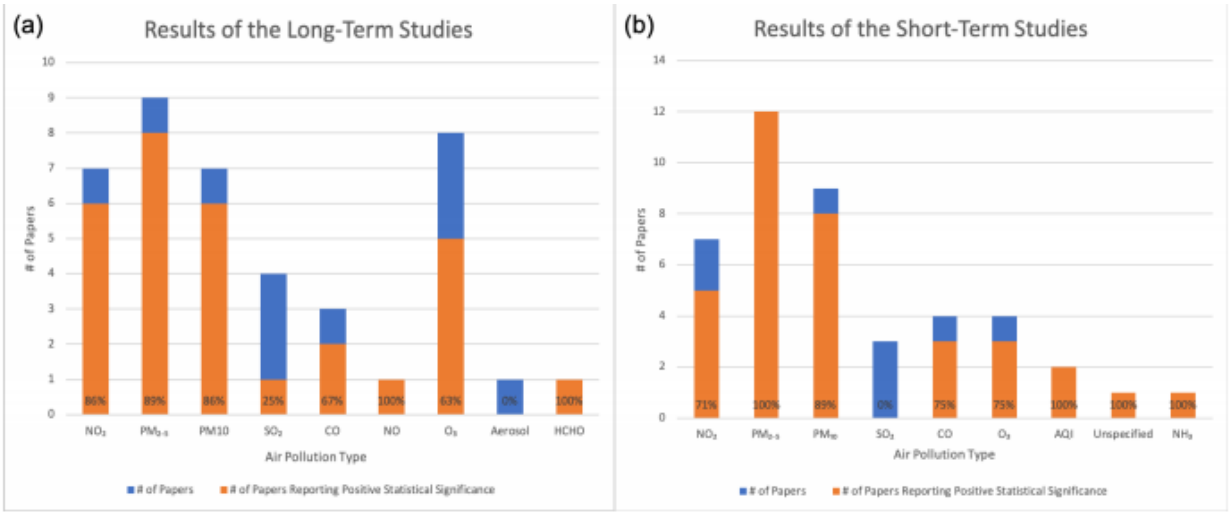
Air Quality	MPCB online monitoring data for criteria pollutants is used to compare trends through various timelines as defined in consultation with team from MPCB & based on the final objectives as delineated in the due course of this study Vehicle data from Maharashtra State statistics websites & published government references used as baseline whereas estimates of non-restricted essential services of transport shall be evaluated and correlated using Google Urban mobility Area source inventory created using specific activity data for hotels, bakeries, street vendors vis a vis government regulations from time to time & overall emissions pattern for State using secondary data as baseline using existing published records of MPCB Inventory of various sources such as construction, bakeries, hotels, street vendors using sample data sets published in National Sample surveys & other researches / studies in past and extrapolating to meet present study objectives
Water Quality	Resource consumption from local authorities for industries using online portal of MPCB for industrial details, irrigation department / ULB's & other government agencies. Analysis of consumption pattern changes in residential areas due to lockdown, restricted movement & migration data superimposed Use of surrogate analysis to understand organic load reductions affecting river water quality due to restrictions on industrial release of water River quality information from MPCB for both baseline & primary data collection attempt through Regional Officers under the SWMP & NWMP
Solid Waste	Changes in Municipal Waste generation / disposal & issues therein for both urban & rural populations in light of migration Reduction in Hazardous waste & effective changes in transportation / handling due to industry slowdown Difference in Biomedical waste generation & handling issues with health pandemic Correlating commercial related [aspects of consumerism] consumption patterns with MSW & others.
Health & Economic Assessment	Improved environmental conditions to be translated into economic benefits for the State in order to also present cost benefits analysis through greening of GDP. Though extremely limited to the scope of this study, attempt shall be made to refer effective published documents as a source of secondary data
Sustenance Options	Interpret & Analyze activity restrictions & equivalent changes in environmental quality to pose as an alternative equivalence

EXPERIMENTAL ANALYSIS

Concerning the effect of PM pollution and the spread of viruses in the population, several recent studies have analyzed whether the different areas of the world with a high and rapid increase in Covid-19's contagion were correlated to a greater level of air pollution. At present, there are three world areas where there has been a high number of people infected by Covid-19: China, where the pandemic started; Italy; and the USA, and the link between these countries is the very high level of air pollutants. This is the reason that recent studies have focused on these areas to find a possible correlation in air pollution and Covid-19's contagion. The investigation of this possible correlation should be analyzed at two levels: (a) the high level of air pollution over the last years, which has made the population more sensitive to Covid-19 (long-term exposition); or (b) the sensitivity to the virus, which is linked to the high level of air pollution in the period when the virus appeared (short-term exposition). It is known that chronic exposure to atmospheric PM contributes to increased hospitalizations and mortality, primarily

affecting cardiovascular and respiratory systems, causing various diseases and pathologies including cancer [37]. Premature deaths due to acute respiratory diseases from such pollutants are estimated to be over two million per year worldwide [38,39].

GRAPHICAL REPRESENTATION



CONCLUSION

Exposure to air pollution especially NO_2 and $PM_{2.5}$ may increase the susceptibility of infection and mortality from COVID-19. The available data also indicate that exposure to air pollution may influence COVID-19 transmission. Moreover, air pollution can cause adverse effects on the prognosis of patients affected by SARS-CoV-2 infection. The available research findings on this topic may help the epidemiologists to select a proper measure to prevent such an outbreak in the future. Attention should also be paid to the poor communities, who are susceptible to be exposed to indoor air pollution, contributing to a greater risk of becoming severely ill from COVID-19 infections. Air quality should be counted as an important part of an integrated approach toward public health protection and prevention to the spread of epidemics. Further research should be conducted focusing on additional confounders such as age and pre-existing medical conditions along with prolonged exposure to NO_2, $PM_{2.5}$, and other air pollutants to confirm their detrimental effects on mortalities from COVID-19.

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