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Virus-Laden Particles and Particulate Matter (Air Pollutants) with Viruses Attached: Terminology Matters — Short Report. How Rumors that Air Pollutants Spread SARS-CoV-2 Are Born

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HIGHLIGHTS

1) The lack of suitable terminology regarding airborne virus transmission is an important problem.
2) The claim that SARS-CoV-2 creates clusters with outdoor PM10 in air is unsubstantiated
3) Virus-laden particles are not equivalent to air pollution particulate matter (PM).
4) Evidence of SARS-CoV-2spread by air pollutants does not exist.

Ishmatov, A., Virus-Laden Particles and Particulate Matter (Air Pollutants) with Viruses Attached: Terminology Matters — Short Report. How Rumors that Air Pollutants Spread SARS-CoV-2 Are Born (October 1, 2020). Available at SSRN: https://ssrn.com/abstract=3703004 or http://dx.doi.org/10.2139/ssrn.3703004

Virus-Laden Particles and Particulate Matter (Air Pollutants) with Viruses Attached: Terminology Matters — Short Report. How Rumors that Air Pollutants Spread SARS-CoV-2 Are Born

Introduction /

Do they suppress the spread of coronavirus or additionally pollute the air and expose our respiratory system to additional negative stress (allergies and irritation)?

▲ Italy uses snow cannon to disinfect alpine villages – video

https://www.theguardian.com/environment/2020/apr/24/coronavirus-detected-particles-air-pollution

Introduction /

Is there a direct scientific basis for this procedure to combat covid-19?

▲ Italy uses snow cannon to disinfect alpine villages - video

https://www.theguardian.com/environment/2020/apr/24/coronavirus-detected-particles-air-pollution

Perhaps this is the @BASIS@?!:

Prof. Setti said tiny droplets with SARS-CoV-2 between 0.1 and 1 micron may travel further when coalesced with pollution particles up to 10 microns than on their own. This is because the combined particle is larger and less dense than the droplet and can remain buoyed by the air for longer.

> "The pollution particle is like a micro-airplane and the passengers are the droplets," said Prof. Setti.

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“Firs Evidence” ????

The “Environmental Research” has published an original paper by Setti et al (2020a), which served as a source of multiple citations of an unproven fact (or the “first evidence”) that virus-bearing aerosols produced from human atomization likely undergo transformation in air, including coagulation with ambient preexisting PM (PM10; PM2.5) and that air pollutants (PM10, PM2.5) spread the COVID-19.

The study (Setti et al., 2020a) and other available studies (see review in (http://dx.doi.org/10.2139/ssrn.3703004)) do not provide a sufficient basis for the conclusions that SARS-CoV-2 creates clusters with outdoor PM (PM10) in the air and that the pollution particles are similar to the “micro-airplanes” with the respiratory droplets being the “passengers”, and/or air pollutants (PM10, PM2.5) spread the COVID-19.

The aim of this report is not to prove or disprove the statement related to SARS-CoV-2 transmission by air pollutants but to show that these assertions are only a scientific hypothesis with no direct or indirect evidences and that relaying this hypothesis to the media and citing this in the literature as a proven fact (or as the “first evidence”) are premature. The current report shows that such citations can lead to born of the erroneous impression and the rumors that SARS-CoV-2 is transported by air pollutants, and this can create problems in society in the era of the COVID-19 pandemic.

Why respiratory droplets should be "carried" by other particles in air?

Typical droplets generated by a cough, a sneeze, or speech (e.g., d < 20 μm) can be airborne and remain airborne for a long time (Vuorinen et al. (2020): "...on initially 20 μm droplets was provided, which can linger in still air for 20 min – 1 h").

As virus-laden droplet nuclei (e.g., d < 10–20 μm) can be airborne, they can be collected in PM10 samples; however, this fact does not indicate that virus-laden particles create clusters (coagulate) with outdoor PM (PM10 and PM2.5) in the air. Although such an "event" is possible, no direct evidence of such an event is provided by all sources cited in the current paper.

@Small dropletsare released during respiration and speeches and these could evaporate (partly or totally leaving more or less dried residue) and they are sufficiently small to be suspended in atmosphere and transported/dispersed like the other particles. So the question is why they should be "carried" by other particles in air? They will also be transported by themselves like any other particle.@ (Daniele Contini)

Is there any direct evidence that the coronavirus spread over long distances by air? — is it really important?

or

Can air desinfection (by aerosolisation of chemicals components) in the cities help us?

On the interaction of respiratory droplets with air pollutants

To demonstrate that virus-laden particles coagulate (create clusters) with outdoor PM (PM10, PM2.5), microscopic examination of the collected samples is required, which would show virus-laden particles clustering with outdoor PM. Microscopic examination of samples is a time-consuming and difficult task, and special measures are required when collecting samples (to exclude particle interaction post collection).

well-known fact//
The coagulation for large particles (d>1 μm) in urban air is negligible because of their relatively small Brownian diffusivities.
The coagulation rates are greater for ultrafine particles (d< 0.1 μm) and those particles coagulate preferentially with fine particles of diameters ranging from about 0.05 to 0.5 μm (Seigneur, 2019).

Again, if we consider the smallest possible sizes of respiratory droplet nuclei with the virus attached (d>0.2 μm) (Liu et al., 2020), then the question of coagulation and formation of clusters of virus-laden particles/droplets in air with other coarse pollutant particles with a size greater than 1 μm becomes more confusing.

CONCLUsION

The definitions of essential concepts related to the relationship between air pollution and coronavirus are highly ambiguous, including the concepts of “air pollution as a factor for health risk” (see related reviews in (Ishmatov, 2020a, b)) and “SARS-CoV-2 spread by particulate air pollution”, and the constituents “virus-laden particles”, “droplet nuclei”, “virus-bearing aerosols produced from human atomization”, and “particulate matter (air pollutants) with viruses attached” remain controversial. This ambiguity has resulted in deep misunderstandings between researchers and the spread of misinformation.

Although the presence of airborne viral fragments of coronavirus (RNA traces of SARS-CoV-2) in environmental samples is an important finding and its detection in such samples may serve as an early warning sign and indicate the scale of an outbreak, readers, researchers, and the media should be skeptical of the claims that SARS-CoV-2 can create clusters (coagulate) with outdoor PM (PM10) in air and that viable SARS-CoV-2 can spread by particulate air pollution as these are currently merely hypotheses without direct or indirect supporting evidence and may ultimately mean nothing to the actual spread of viable SARS-CoV-2 by air pollutants.

"Speculations and citations"

Unfounded speculations and conclusions related to SARS-CoV-2 transmission by air pollutants are increasingly appearing in newspapers and research articles; examples are as follows:

- 1) Setti et al. (2020a): "This is the first evidence that SARS-CoV-2 RNA can be present on outdoor particulate matter, thus suggesting that, in conditions of atmospheric stability and high concentrations of PM, SARS-CoV-2 could create clusters with outdoor PM and – by reducing their diffusion coefficient – enhance the persistence of the virus in the atmosphere."

- 2) Inapressrelease (http://w ww.s i mao n lus. it /wps i ma /wp - co nte nt/ up loads/2020 /03/C O V ID_19_pos it i on-paper_ENG.pdf), Setti et al. states "... it is possible to conclude that particulate matter fractions PM2.5 and PM10 represent an effective carrier for viruses transport and diffusion and proliferation of virus diseases as well."

- 3) Setti et al (2020b): "... seems to confirm (at least in case of atmospheric stability and high PM concentrations, as it usually occurs in Northern Italy) that the virus [means SARS-CoV-2] can create clusters with the particles and be carried and detected on PM10."

- 4) In a popular article on The Guardian site (which has since been cited and replicated by other media worldwide): (https://w ww. t he guard ia n.co m/e nviro nme nt/2020 /apr /24/co ro na vir us - detected-par ticles-air-pollution): "The pollution particle is like a micro-airplane and the passengers are the droplets," or "Setti said tiny droplets between 0.1 and 1 micron may travel further when coalesced with pollution particles up to 10 microns than on their own. This is because the combined particle is larger and less dense than the droplet and can remain buoyed by the air for longer." It is important to note that in the article on The Guardian site, this statement was subject to doubt and criticism by other researchers.

"Speculations"

Unfounded speculations and conclusions related to SARS-CoV-2 transmission by air pollutants are increasingly appearing in newspapers and research articles; examples are as follows:

- 5) Sanità di Toppi et al. (2020), citing the study by Setti et al. (2020a): "The hypothesis that the novel coronavirus might exploit the "highways" made up of atmospheric particulates is a challenging point that, in our opinion, deserves further, immediate, and in-depth experimental investigations."
  The above conclusion of Sanità di Toppi et al. (2020) was then mentioned by Domingo and Rovira (2020) without citation of the original studies by Setti et al. (2020a,b,c): "...Sanità di Toppi et al. (2020) have hypothesized that the SARS-CoV-19 might be using a species of "highways", which would be made up of atmospheric particulates, increasing its indirect transmission."

- 6) Borak (2020), citing Setti et al. (2020a): "Further complexity is added by observations that COVID infections may also be spread by particulate air pollut io n. "

- 7) Copat et al. (2020), citing Setti et al. (2020a): "...first preliminary evidence that SARS-CoV-2 RNA can be absorbed on outdoor particulate matter giving a suggestion that, ... SARS-CoV-2 could create clusters with outdoor PM and enhance the persistence of the virus in the atmosphere...".

- 8) The claim that SARS-CoV-2 can spread via outdoor PM was accepted as fact in a discussion raised by Francesca Costabile in the project of Journal Atmosphere: Section Air Quality and Human Health (https://www.researchgate.net/post/Any_association_betwee n_air_quality_and_vi rus_spread).

- 9) Xu et al. (2020): "... viral agents attached on the PM..." and "the air pollutant concentration, such as PM2.5 and PM10 concentrations, may affect the aerosol transmission of SARS-CoV-2. Fine particles with viruses attached can..." Xu et al. (2020) made these statements without citing the original study ofSetti et al. (2020); perhaps they were inspired by the article in The Guardian (https://w ww. t he guard ia n.co m/e nviro nme nt/2020 /apr /24/co ro na vir us - detected- par ticles- air- po llut io n).

"Speculations"

Unfounded speculations and conclusions related to SARS-CoV-2 transmission by air pollutants are increasingly appearing in newspapers and research articles; examples are as follows:

- 10) Zhang et al. (June 2020), citing Setti et al. (2020a): "In addition, nascent virus-bearing aerosols produced from human atomization likely undergo transformation in air, including coagulation with ambient preexisting PM and/or growth on a time scale of a few hours in typical urban air (27–29) [Zhang et al.(2020) proposed this assumption/speculation and cited three studies on the transformation of nanosized particles in the air]. Such transformation, as recently documented in coarse PM in Italy (21) [this assumption/speculation on transformation of nanosized particles in the air has become a proven fact for coarse PM due to citing Setti et al. (2020a)], may mitigate virus inactivation (9, 12), by providing a medium to preserve its biological properties and elongating its lifetimes [a logical chain based on an unproven assumption/speculation with citation of studies on virus survival led to a new assumption/speculation]."

- 11) Martelletti and Martelletti (2020), citing Setti et al. (2020c): "... the atmospheric particulate matter exercises a carrier (or boost) action along with the virus. The PM10 (particulate matter) is composed of solid and liquid particles which allow to float in the airflow longer and to be widespread over larger distances. Atmospheric PM has a sub-layer that facilitates the virus survival in airflows for hours or days." his conclusion of Martelletti and Martelletti (2020) was mentioned by Domingo and Rovira (2020) without citation of the original studies of Setti et al. (2020a,b,c): "These authors [means Martelletti and Martelletti] have suggested that the SARS-CoV-2 could find suitable transporters in air pollutant particles."

- Tung et al. (2020), citing Martelletti and Martelletti (2020) without citation of the original papers of Setti et al. (2020a,b,c): "Viruses may be adsorbed through coagulation onto PM and remain airborne for hours or days (Martelletti and Martelletti, 2020), thereby increasing inhaled concentrations of virus via PM in the lungs." Moreover, Tung et al. (2020) based on unproven facts (without direct or indirect supporting evidence) concluded: "In brief, PM2.5 may provide a good platform to "shade" and "carry" the SARS-CoV-2 during atmospheric transport. Thus, PM containing SARS-CoV-2 could be a direct transmission model in a highly polluted area."

"Speculations"

Unfounded speculations and conclusions related to SARS-CoV-2 transmission by air pollutants are increasingly appearing in newspapers and research articles; examples are as follows:

- 12) Coccia (April 2020a), based on statistical analysis: "... in polluting cities with low wind speed, the accelerated diffusion of viral infectivity is also due to a mechanism of air pollution-to-human transmission that may be stronger than human-to-human transmission" and "Overall, then, in the presence of polluting industrialization of cities and mechanisms of diffusion of viral infectivity also based on air pollution -to-human transmission (airborne viral infectivity diseases), this study must conclude that..."

- An analysis of the data reveals that Coccia (April 2020) had no direct or indirect evidence to support the claim that COVID-19 may spread via air pollution-to-human transmission. As statisticians consistently emphasize: "correlation does not imply causation."

- Subsequently, Domingo and Rovira (2020) cited unpublished and unavailable data of Coccia, probably from the preprint available on medRxiv.com (Coccia, 2020b): "In this same line, Coccia (2020) has recently examined the mechanisms of transmission dynamics of COVID-19 in the environment for ... The results revealed that accelerated transmission dynamics of COVID-19 in specific environments was due to two mechanisms given by: air pollution-to-human transmission, and human-to-human transmission in a context of high density of population. "

- 13) Prather et al. (May 2020), without citing any sources: "Viruses [means SARS-CoV-2] can attach to other particles such as dust and pollution, which can modify the aerodynamic characteristics and increase dispersion."

- 14) He and Han (2020), citing Setti et al. (2020a): "Recently, Setti et al. (2020) found that SARS-CoV-2 present on particulate matter showed increased persistence by forming clusters".

- 15) Tang et al. (2020), citing Setti et al. (2020a): "SARS-CoV-2 could create clusters with outdoor PM and, by reducing their diffusion coefficient, enhance the persistence of the virus in the atmosphere".

HIGHLIGHTS

1 IT leads to a dramatic increase in the deposition of inhaled aerosols

2 IT lead to suppression of the defence mechanisms of the respiratory system

3 IT depends on weather conditions - and correlates with the seasonality of respiratory infections in the tropics and mid-latitudes

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Review article

Influence of weather and seasonal variations in temperature and humidity on supersaturation and enhanced deposition of submicron aerosols in the human respiratory tract

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HIGHLIGHTS

- Most studies do not consider the possibility of supersaturation in airways.
- Cold, rainy or wet weather can induce supersaturated conditions in airways.
- Supersaturation can lead to enhanced deposition of inhaled ambient aerosols.
- Increased respiratory symptoms correlate with supersaturation in airways.
- The role of supersaturation in respiratory symptoms is still to be researched.

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ABSTRACT

In this review, all available data on the effects of supersaturation in human airways were summarized and analysed, and the most critical parameters identified. The analysis shows the boundary conditions for increased supersaturation in airways: inhalation of cold air of $T < 22$ °C or cool saturated air of $T < 25$–27 °C. Thus, it was summarized for the first time that conditions during rainy weather or cold seasons in a temperate climate and rainy seasons in subtropical and tropical climates can induce supersaturated conditions in human airways. It was shown that under such conditions a total deposition of 300 nm particles may increase from −13% (when the supersaturation is not taken into account) to −90% due to enhanced condensational growth. It was found that such unusually high underestimation of deposition efficiency may be typical for most classical studies and approaches. An important observation was made for the first time: weather conditions which are favorable for enhanced deposition of submicron aerosols (and infectious aerosols) due to supersaturation in human airways may be connected with increased respiratory symptoms of asthma and chronic obstructive pulmonary disease (COPD) and two different patterns of seasonality of respiratory infections and influenza. This is one of the main aspects of this work that needs to be studied in the future. The primary implication of the results of this review is that weather patterns can play a significantly more important role in the deposition of ambient submicron aerosols in human airways than previously assumed.

1. Introduction

Air pollution with deposition of fine aerosols in human airways is associated with a number of detrimental health effects, it is a major health risk, leading to respiratory and cardiovascular mortality (Lelieveld et al., 2019). Submicron aerosols, which can come from variety of sources such as tobacco smoke (particle size 140–500 nm (Bernstein, 2004)), cooking emissions (Tigala et al., 2018; Stavroulas et al., 2019), diesel exhaust emissions (30–500 nm (Kittelson, 1998)), fossil fuel combustion (Chow and Watson, 2002; Watson et al., 2011), and biomass burning (see review in (Stavroulas et al., 2019)), can provoke local injury of the respiratory system and lead to cardiopulmonary health issues, including increased symptoms of asthma (Health Assembly of the American Thoracic Society. 1996), chronic obstructive pulmonary disease (COPD), and increased sensitivity to allergens (see review in (Weinmann et al., 2008; Hicks et al., 2018)). Moreover, recent studies (Fabian et al., 2008; Milton et al., 2013; Cowling et al., 2013; Lindsley et al., 2016; Yan et al., 2018) have linked the spread of respiratory

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