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Novel Coronavirus (SARS-CoV-2) and Airborne Microplastics

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Abstract

Of current concern to global health is the emergence of a novel human coronavirus (SARS-CoV-2) causing severe respiratory tract infections in humans. Person to person and surface contact have been fingered as the major transmission route of SARS-CoV-2. The ability of virus to survive in the environment is a critical factor in viral transmission. Recent researches have shown that the virus can survive on surface of plastics up to 5 days under room temperature and in aerosol for up to 3 hours. Therefore this research opinion proposes that SARS-CoV-2 can be accommodated in formed viral biofilms on microplastics surfaces and can thus be deposited over longer distances, than is currently being thought to be, since microplastics are airborne over long distances (> 100 km). This pathway should be studied by scientist as it may provide insight on why some region experienced the outbreak with no trace/history of visit or contact by an infected person. As there are currently no specific therapies for SARS-CoV-2, we therefore proposed that total lockdown (which have also reduced global anthropogenic activities) is perhaps in the best interest of mankind

1. Introduction

In late 2019 in Wuhan, China, the new human coronavirus named Severe Acute Respiratory Syndrome (SARS-CoV-2 or COVID-19, formerly HCoV19) emerged and now declared a pandemic by World Health Organization [1] in March 2020, due to its global widespread. In the last twenty years, the highly pathogenic human coronavirus have emerged three times with other respiratory syndrome coronaviruses i.e Middle East Respiratory Syndrome (MERS; in 2012, 2015, 2018) and Severe Acute Respiratory Syndrome (SARS; in 2002-2004) [2-3].

Recent data (as at March 25th, 2020) have shown that there are four hundred and twenty-two thousand, six hundred and fourteen (422,614) cases of SARS-CoV-2 infection in 196 countries with death of eighteen thousand, eight hundred and ninety-two death (18,892) (death rate 4.5 %) [4]. This trend is on continuous increase daily as more cases are recorded, despite the global efforts to stop the outbreak. This therefore, is responsible for the global lockdown or movement restriction and thus affecting the global economy [5]. Other efforts to stop the spread involves encouraging proper hygiene including hand washing, social distancing and not touching once face (also the eyes, nose and mouth).

Two possible routes i.e direct or indirect can occur for transmission of virus from an infected person to uninfected person or a new host. One of the major routes of transmission of coronavirus is person-to-person, which has been described both in hospital and family settings [6]. It is therefore important to prevent the transmission of this virus in the public and healthcare systems. This will prevent the further spread of the virus. Indirect viral transmission involves an uninfected person coming in contact either by hand with contaminated surfaces or from inhaling contaminated air. The potential transmission of coronaviruses from contaminated dry surfaces has been demonstrated and reviewed [3,7-8].

The stability of SARS-CoV-2 in aerosol (solid or liquid particles that hang in the air, including fog, dust, and gas) and surfaces has also been recently demonstrated [9]. Several factors such as excreted (via various body fluids) quantity of viral particles by an infected person or organism, environmental factors (physical, chemical and biological), proximity of an uninfected person, and individual/host organism susceptibility influences this kind of transmission [10]. Particularly, the higher the quantity of virus excreted, the higher the virus chances to survive and reach a new host organism [11]. Therefore, the ability of virus to survive in the environment is a critical factor in viral transmission [10,12]. These emphasizes the need to understand in detail the persistence of SARS-CoV-2 on inanimate surfaces [3,13], and also suspended in air (transported in aerosol) with other inaminate surfaces such as microplastics. In addition, in light of the recent scientific studies [14] which proved that apart from nasal and respiratory secretions, SARS-CoV-2 can be actively shed in the stools of an infected person or patients for as long as five weeks after the patient might have recovered from the diseases, thus revealing the likelihood of bioaerosols being released in air during flushing of the toilet.

The aim of this review was therefore to discuss the potential of small size plastics (airborne microplastics) transporting/transmitting SARS-CoV-2 in air, as potential source of exposure to the virus.

2. Methodology

Materials such as statistical bulletins, blogs, journals articles and conference/workshop/seminar papers that were published online were used for sourcing information. Web of Science, Pubmed and Google Scholar were three major scientific databases used to search for related articles and at least one of the following keywords needed to sample appear in article's title or abstract: "SARS-CoV-2", "Microplastics", "nCOV-19", "COVID-19", "2019-nCoV", "Coronavirus", "Aerosol", "Plastic", "Viruses" and "Airborne microplastics" (conducted in March and April, 2020). One or more of the aforementioned keywords must be present in an article for the article to be included in the present review. All searches were restricted to articles written in English.

3. Results and discussion

Coronavirus and environmental factors

Studies found concerning the survival of coronavirus on plastic surface and in aerosol at different conditions were summarized in Tables 1 and 2. Overall, the virus could survive up to five days on plastic surface at relative humidity of 40 – 50 % and at controlled temperature range of 21 to 25 ^{o}C as well as at room temperature which may vary. Neeltje et. al., [9] used the SARS-CoV-2 nCoV-WA1-2020 (MN985325.1) and SARS-CoV-1 Tor2 (AY274119.3) strains in their study and compared their stability in aerosols (< 5 µm). Using a three-jet nebulizer, the aerosol was filled with viruses with 50% tissue-culture infectious dose; $TCID_{50}$/mL of $10^{5.25}$ and $10^{6.75\text{-}7.00}$ for SARS-CoV-2 and SARS-CoV-1 respectively. So the decay rate of the coronaviruses was determined to measure stability. Results showed SARS-CoV-2 was more stable and remained throughout the period of study (three hours). Overall, the survival ability of SARS coronavirus in environments seems to be relatively strong. The long transportation (> 2 m) of the virus in air in hospital settings was recently studied [18]. They collected air samples in intensive care units and general wards and results from the study showed that 35 % and 12.5 % of the air samples were contaminated respectively, indicating that the virus can travel in air with the maximum transmission of ~ 4 meters from the source.

Table 1. Persistence of coronavirus on plastic at different conditions

Surface	Strain/ isolate	Inoculum (Viral Titer in $TCID_{50}$ per mL)	Temperature (ºC)	RH (%)	Persistence	Reference
Plastic	Strain HKU 39849	10^5	1. 22 to 25 2. RT	40–50	1. > 5 days 2. 2-3 weeks in liquid environment	[15]
	Strain P9	10^5	RT	N/A	4 days	[16]
	Strain FFM1	10^7	RT	N/A	6 – 9 days	[17]
	SARS-CoV-2 nCoV-WA1-2020 (MN985325.1)	$10^{5.25}$	21 to 23	40	≤ 5 days	[9]
	SARS-CoV-1 Tor2 (AY274119.3)	$10^{6.75\text{-}7.00}$	21 to 23	40	≤ 5 days	[9]

RH: Relative Humidity; RT: Room temperature; N/A: Not available.

Table 2. Persistence of coronavirus in aerosol at different conditions

Medium	Strain/ isolate	Inoculum (Viral Titer in $TCID_{50}$ per mL)	Temperature (ºC)	RH (%)	Persistence	Reference
Aerosol	SARS-CoV-2 nCoV-WA1-2020 (MN985325.1)	$10^{5.25}$	21 to 23	40	3 hours	[9]
	SARS-CoV-1 Tor2 (AY274119.3)	$10^{6.75\text{-}7.00}$	21 to 23	40	3 hours	[9]

RH: Relative Humidity; RT: Room temperature; N/A: Not available.

Microplastics as a potential carrier of SARS-CoV-2

It is well established that SARS-CoV-2 can be contracted from contact with contaminated surfaces and hands [3] and so hand washing with soap or sanitizer has been greatly encouraged to stop the spread from person to person and use of masks to prevent excreting droplets/fluids from the mouth or nose. One route yet to be looked into is the potentiality of contracting the virus from contact with contaminated micro size surfaces such as microplastics (MPs) that are airborne. This may provide insight on why some region experienced the outbreak with no trace/history of an infected person visiting the region. For example, in the United States of America, the Center for Disease Control on February 26, 2020 confirmed a case of an infected with "no known exposure to the virus through travel or close contact with a known infected individual" [19].

Studies (summarized in Tables 1 and 2) have shown that SARS-CoV-2 can survive on plastic surfaces (also in aerosol) for up to 5 days under room temperature longer than other tested surfaces e.g copper (4 hours), stainless steel (2 to 3 days), wood and glass (4 days), and cardboard (24 hours). Further, because the virus is detectable in the faeces just like the previous coronaviruses [20], and also in human faeces is microplastics [21]. Therefore aerosolization of virus in contaminated faeces was believed to be the mode of transmission of this outbreak [22-23] while the likelihood of microplastics contributing in this transmission have not been studied but cannot be ruled out.

In ecosystems, MPs are ubiquitous pollutants in size range of 0.1 µm to < 5mm, formed from the fragmentation of macroplastics either from sunlight (ultraviolet) effect or mechanically from tire wears, clothing etc. while maintaining the same properties as the large plastics. MP is an emerging environmental pollutant and the problems they pose to ecosystems are of current concern to environmental scientist globally [24]. One major ecological risk of MPs is based on the ability of air to transport MPs to new areas and contaminating the area by re-concentrating. Recent studies, have explained the dynamics of their sources, pathways, and reservoirs as well as their distribution and deposition in the environment [25]. SARS-CoV-2 can survive and can be transported in aerosol [9], although mainly concentrated at downstream up to 13 feet from the source while smaller quantities were found up to 8 feet upstream [18, 26]. This is similar to airborne MPs, which have shown to be present in all level of the atmosphere [24-25, 27-29]. So, SARS-CoV-2 (with diameter around 120 nm [30]) can be transported with MPs, with potential attachment on MPs surfaces through formed biofilms (Figure 2). The surface area-to-volume of MPs is very large, thus making them a good sorbent for contaminant adsorption.

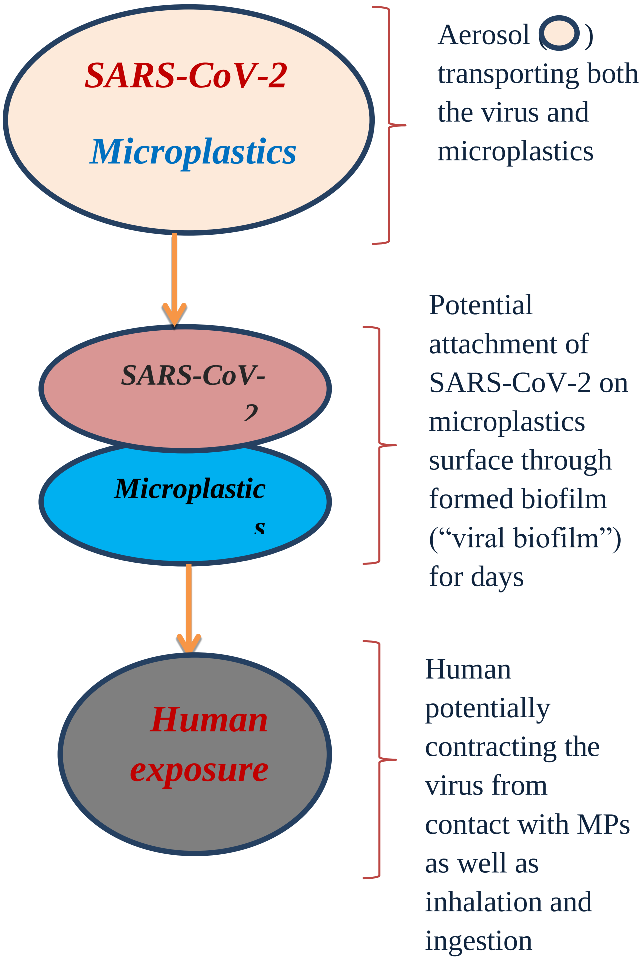
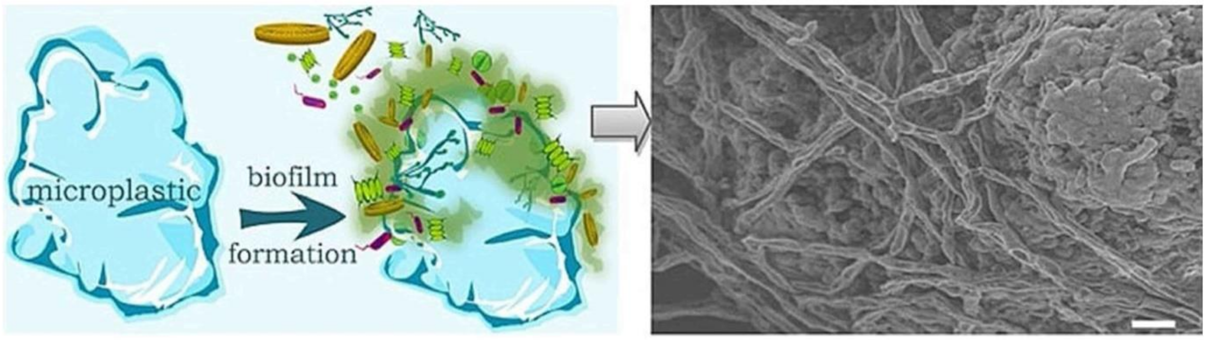


Figure 1. Plausible mechanism of transport and human exposure to novel coronavirus with airborne MPs

Biofilms are known to form on MPs surfaces within seconds of exposure to ambient environment [29,31]. Studies have isolated harmful human pathogens such as strains of Vibrio spp. in formed biofilm on MPs surfaces [32]. Further, scientist have shown that one efficient way by which some pathogenic viruses can spread from cell to cell is through the process of biofilm formation (Figure 2) considered as “viral biofilm” [33-34]. Therefore, understanding how biofilms form (especially on solid surfaces) is crucial for controlling microbial infections.



(a) (b)

Figure 2. (a) Biofilm formation on the surface of MP (b) Scanning electron micrograph showing a biofilm attached to MP (Source: [29])

In line with the foregoing, there is every possibility that MP can accommodate SARS-CoV-2. However, the attachment of SARS-CoV-2 on MPs and transport are dependent on some varying environmental conditions (Figure 3), which also control it survival on surfaces [10, 12] [29,35-37]. These factors include physical conditions such as air flow and direction, humidity, ambient temperature, wind speed and gravity as well as landscape and densities of buildings.

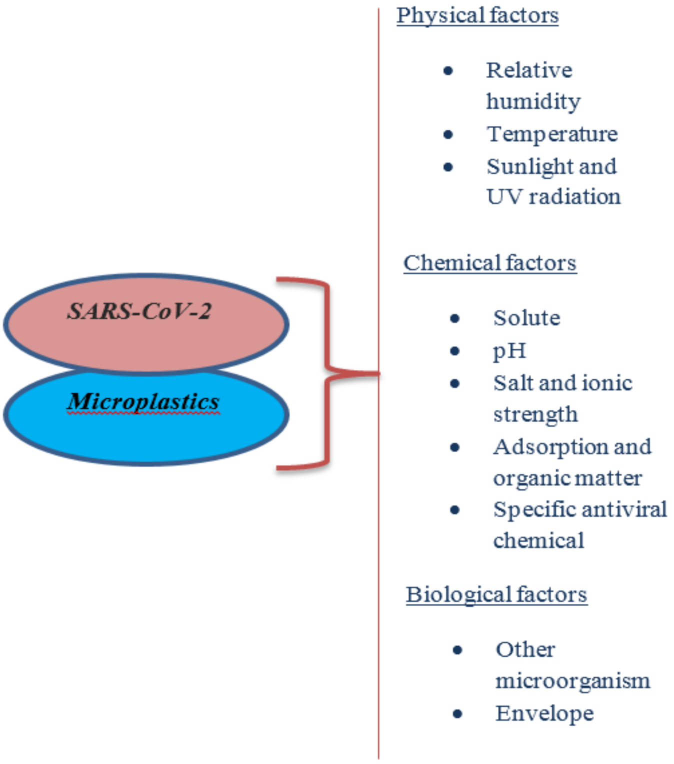


Figure 3. Factors affecting virus survival on surfaces (Modified from [10]).

Many studies on airborne MPs have demonstrated how these factors controls the transport of MPs in air over long distances (see [25]). Also, chemical factors such as solute, pH, salt and ionic strength, adsorption and organic matter and antiviral chemicals (mainly phytochemicals e.g quercetin, apigenin, catechin, hesperidin, and naringin etc) while also the presence of other microorganism (such as bacteria) will generally control the sorption or desorption of the virus from the surface of MP and toxicity. However, in current, there is no complete information on how these factors affect the survival and stability of SARS-CoV-2 in external conditions as well as its potential transportation with airborne MPs.

Implications of SARS-CoV-2 and Airborne MPs in tandem

The implications of this interaction (SARS-CoV-2 and airborne MPs in tandem) is that MPs can be consumed by humans unknowingly, who is regarded as the most exposed organism in all ecosystems, perhaps because they sit at the base of the food chain [24]. At the sizes at which these MPs occur in air, they can be easily inhaled and contacted from fallout or deposition. The first entry of inhaled MPs is in the upper airways (nasal cavity, pharynx, larynx) then further deposited to the respiratory zone (lower airways; trachea, primary bronchi, and deepest part of the lungs) [25, 38-40]. Inhaling MPs in the upper airways (also region of first attack by the virus) may convey human exposure to the virus. Gallagher [41] explained that the virus will first attack the throat by infecting the cells lining, airways and then lungs, which in turn transform them into "coronavirus factories" that forcibly eject and in a stream of new viruses that continue to infect yet more cells. Therefore, the potential risk and contribution of MPs to the outbreak of SARS-CoV-2 cannot be overlooked and should be studied in detail.

Conclusion

Based on current research, novel coronavirus (SARS-CoV-2) are stable in aerosol for up 3 hours and on plastic surface up to 5 days. This is enough for the virus to be picked up by airborne MPs (through biofilm formation) which are ubiquitous in the atmosphere. Also in feaces, the virus can be excreted with MPs, and they both can be aerosolized during flushing. MPs on the other hand can be transported for more than 100 km and thus potentially transporting with it the novel coronavirus (depending on environmental and climatic factors) and potentially exposing the new area and people to the virus. This pathway should be studied by scientist as it may provide insight on why some region experienced the outbreak with no trace of visit of an infected person. As no specific treatment currently available for SARS-CoV-2, early containment, contact tracing, effective wearing of masks and complete lockdown will be crucial to control and stop the ongoing outbreak of this novel infectious virus.

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Conflict of interest-The authors declare that there are no conflicts of interest

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