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Facemasks simple but powerful weapons to protect against COVID-19 spread: Can they have sides effects?

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ABSTRACT

In the last few months, the spread of COVID-19 among humans has caused serious damages around the globe letting many countries economically unstable. Results obtained from conducted research by epidemiologists and virologists showed that, COVID-19 is mainly spread from symptomatic individuals to others who are in close contact via respiratory droplets, mouth and nose, which are the primary mode of transmission. World health organization regulations to help stop the spread of this deadly virus, indicated that, it is compulsory to utilize respiratory protective devices such as facemasks in the public. Indeed, the use of these facemasks around the globe has helped reduce the spread of COVID-19. The primary aim of facemasks, is to avoid inhaling air that could contain droplets with COVID-19. We should note that, respiration process is the movement of oxygen from external atmosphere to the cells within tissue and the transport of carbon dioxide outside. However, the rebreathing of carbon dioxide using a facemask has not been taken into consideration. The hypercapnia (excess inhaled content of CO_2) has been recognized to be related to symptoms of fatigue, discomfort, muscular weakness, headaches as well as drowsiness. Rebreathing of CO_2 has been a key to concern regarding the use of a facemask. Rebreathing usually occur when an expired air that is rich in CO_2 stays long than normal in the breathing space of the respirator after a breath. The increase of the arterial CO_2 concentration leads to symptoms that are aforementioned. Studies have been conducted on facemask shortages and on the appropriate facemask required to reduce the spread of COVID-19; however no study has been conducted to assess the possible relationship between CO_2 inhalation due to facemask, to determine and recommend which mask is appropriate in the reduction of the spread of the coronavirus while simultaneously avoid CO_2 inhalation by the facemask users. In the current paper, we provided a literature review on the use of facemasks with the aim to determine which facemasks could be used to avoid re-inhaling rejected CO_2. Additionally, we presented mathematical models depicting the transport of COVID-19 spread through wind with high speed. We considered first mathematical models for which the effect air-heterogeneity is neglected, such that air flow follows Markovian process with a retardation factor, these models considered two different scenarios, the speed of wind is constant and time–space dependent. Secondly, we assumed that the wind movement could follow different processes, including the power law process, fading memory process and a two-stage processes, these lead us to use differential operators with power law, exponential decay and the generalized Mittag-Leffler function with the aim to capture these processes. A numerical technique based on the Lagrange polynomial interpolation was used to solve some of these models numerically. The numerical solutions were coded in MATLAB software for simulations. The results obtained from the mathematical simulation showed that a wind with speed of 100 km/h could transport droplets as far as 300 m. The results obtained from these simulations together with those presented by other researchers lead us to conclude that, the wind could have helped spread COVID-19 in some places around the world, especially in coastal areas. Therefore, appropriate facemasks that could help avoid re-inhaling enough CO_2 should be used every time one is in open air even when alone especially in windy environment.

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Introduction

The first outbreak of the pandemic with severe acute respiratory syndrome (SARS-COV-2) that resulted in COVID-19 was declared in late December 2019 in Wuhan, Hubei China. The symptoms of this novel disease were first published by a medical Chinese expert in a top scientific research journal named Lancet [1]. The major severe and common symptoms attributed to the coronavirus are dry cough, fever, fatigue, haemoptysis, diarrhoea, and headache [2]. On March 13, 2020, the disease had infected up to 80,000 humans in China. A total of 60% of this numbers were coming from the Wuhan City, while more than 80% were from the Hubei province; which are recorded to have originated locally from the Republic of China [3]. Worldwide Asia, America, Canada, Germany, Australia and 111 other countries have been infected with the disease in which most of the affected patients were locally outdoor of the united republic of China [4]. Due to the exponential spread of COVID-19 around the globe, and its fatal effects, the world health organization has recommended regulations, additionally to their measures, countries around the world have imposed their own regulations with the same aim to stop the transmission of COVID-19 among their citizens. These guidelines include wearing facemasks in community and social environment, proper hand hygiene and the use of appropriate personal protective equipment especially for health workers that are in practice in order to prevent SARS-CoV-2 transmission. Hygiene practices such as frequent handwashing, mouth and nose cover with tissue or elbow during sneezing and coughing are also included in the WHO measures to be adhered to [5]. From an economic point of view, China constitutes one of the major facemask producers in the world, whereby they produce approximately 50% of facemask distributed globally. The universal policy of wearing facemasks, created a high demand in the acquisition of facemasks globally, which in turn exerted a huge burden on the major suppliers including China. For instances, it has been recorded that about 20 million facemasks were produced daily; however, the production was reduced to 12 million during the Chinese New Year celebration [6]. Despite the necessity to ensure the adequate provision of facemasks to comply with WHO recommendations; the consequences of reduced intake of oxygen and forceful inhaling of exhaled carbon dioxide due to wearing facemask has not yet been considered. The COVID-19 infected people are already suffering from symptoms such as fatigue, headache or shortness of breath; how much more does the inhaling of CO_2 can influence the health of the general public? This is very crucial to inquire as multiple are wearing facemasks even though they have not yet been infected with coronavirus. Therefore, one could ask if it is possible that wearing an appropriate facemask for a long period while exercising social distancing can cause one to inhale so much CO_2 than oxygen? Can this therefore be associated to fainting?

The National Institute of Health in the United State of America stated that inhaling high level of CO_2 may be life threatening if it exceeds tolerable intakes of CO_2 by people, since CO_2 is much likely to build up in the face mask [7]. Carbon dioxide is known as a natural colourless, odourless and non-flammable gas and a by-product of the body respiratory process. In normal room air, CO_2 percentages are very low around 0.04% [8]. Carbon dioxide at low concentration level has little toxicological effect; but it is known to be dangerous when it is greater than 10% in the atmosphere. At higher level (above 5%), it can cause hypercapnia resulted from respiratory acidosis. Therefore, CO_2 toxicity can cause headache, inability to concentrate and night blindness. However, severe rise in the respiratory acidosis increases the parasympathetic nervous system; which entails the removal of water from the acetylcholine by acetylcholinesterase through the process of hydrolysis, which severely cause the despair of both circulatory and respiratory systems [9]. It has further been observed that being exposed to CO_2 concentrations above 10% may lead to convulsion, coma and finally death [8,10]. Several researches have shown that there is a wide variability in the tolerance level of CO_2 in humans. The concentration of blood varied between (41.8–64.6 mmHg) pressure or 0.055–0.085 atm in the atmosphere between those with symptoms, that CO_2 exposure that are not harmful are not be considered by the rate value [11]. The severe exposure of CO_2 concentration lies between 14.1 and 26% [8,12]. However, it is resolved that the accepted CO_2 range decreases according to age ($p < 0.0001$) and that cigarette smokers might have high tolerance due to their familiarization with higher level of CO_2 intake from smoking cigarette [11,13]. There is recently a police report about a driver who was involved in a traffic accident on the 23rd of April 2020 in New Jersey, USA; as a result of extended wearing of his facemask. The driver blamed the wearing of the N95 facemask for too long for his collision, for having inhaled excess concentration of CO_2. These claims were accepted by the investigating police officers. [7] Moreover, following a survey conducted based on healthcare workers wearing N95 mask during the outbreak of SARS-CoV-2 in 2006, it was declared that workers under physiological stress had headaches due to the wearing of N95 for up to 12 h [14]. Another survey reported that 37.3% of health workers from a total of 212, had headaches due to the wearing of facemasks for a longer period of time [15]. It has been recorded that in the agricultural sector, farmers wear facemasks too for a long time when spraying pesticides, and the farmers experienced increased body heat stress due to high humidity and increased temperatures as a result of wearing facemasks [16].

Climatic factors including climate temperature, humidity, wind speed have played some crucial role in respect to the transition of the ongoing pandemic COVID-19, caused by the severe acute respiratory syndrome coronavirus2 (SARS-COV-2) and patient's recovery and the death rate across the globe. Various type of research indicating the spread of seasonal flu which has occurred four times in the ancient 1000 years: the Spanish flu (1918), Asian flu (1957), Hong kong flu (1968) and finally the Swine flu (2009) outbreak [17], such cases were also reported with colder climate conditioned which is similar to the recent outbreak, SARSCoV-2 virus [18]. Together, these viruses have caused many millions of illness cases, deaths as well as hospitalization, which has contributed a significant drain to the economy and the society. Martinez et al. (2020) have reported that seasonal changes occurred in cycle is a universal feature with respect to the global COVID-19 pandemic, as well as the respiratory viral disease influenza. The latter was observed every winter in temperate region for the influenza virus [19]. Following a study done by Shaman, a modelling scientist in the USA, it was observed that absolute humidity can be the pretentious by seasonality of influenza virus [20].

In general, knowing that the COVID-19, caused by the SARS is a novel global pandemic, minor evidence is known by its effect on temperature and relative humidity on daily new infected cases and death. SARS CoV/SARSCoV-2 that occurred Mid-November last year 2019 in China, a study based on the various provinces; Hong Kong, Beijing, Guangzhou, Taiyuan designated that the outbreak was related via the changes in temperature [21]. Epidemiological data as well as developing laboratory have proposed that the global pandemic virus maybe affected by environmental conditions [22].

From literature researcher have shown that SARS-CoV-2 causes severe respiratory tract and gastroenteritis diseases [23]. The virus dye-off around 56 °C [24]. SARS-CoV-2 can be very stable at 4 °C and at time temperature, the virus is very sensitive to heat temperature. The time required for the virus to survive have been reduced to less than/equal to 5 mins, meanwhile the time for incubation temperature has risen to 70 °C. Doremalen et al. [25] observed between the temperature range 21–23 °C, the SARS-CoV-2 virus can survive for about 72 h on hard surface. Similar results were obtained by another researcher stating that the virus is mostly active when higher temperature decreases between 9 and 24 °C range [26]. However, looking at a study done on the effect of temperature on COVID-19 in different region in South Africa, they observed that climate temperature does not hinder the spread of the virus as well as the death rate but very substantial influence on the rate of recovery [27]. Also, no correlation was observed between the infected cases and the death rate of individuals with COVID-19 virus. According to Xie and Zhu, [28] when reporting on the daily confirmed cases of COVID-19 virus, they conveyed that a 1% increase of individuals were infected was associated to 4.861%, as the average temperature between lag (0–14 °C) fall beneath 3 °C. Furthermore, another report on the daily death rate and temperature of COVID-19 confirmed cases, results show positive suggested correlation amongst these variables whereas negative suggestions were related to the absolute humidity. More so, the study of Peng et al. [29] on the effect of climate temperature and humidity of COVID patient located in 31 provinces, central region of China showed the that as the climate temperature and humidity rise, there was a fall in the transmission rate of COVID patient spotted. Similar results were observed in a recent investigating on the impact of temperature and humidity in 166 countries across the world excluding china, and another on the mortality rate of COVID patients in Wuhan china. Researchers observed a decline in the transition rate of COVID patient that resulted to an increase in climate e temperature and humidity. For some days it was also observed that the death rate was lowered when the temperature and humidity as the temperature and humidity increases. They also realised that on days that the temperature is extensive very high or low, high death rate were detected [30]. Some other researcher reported no correlation between temperature and humidity variables and their variations [31].

Another important regulation is the social distancing with a spacing of 1.5 to 2 m, however, with the results and simulations obtained recently, where researchers proved that the virus due to its weight could be transported by wind as droplets as far as 1.83 m indoor [25], and another researcher simulated that the droplets could be transported as far as 11 m from the initial released point when the average wind speed is 2 km/h outdoor, this makes the regulation of 1.5 m questionable either indoor or outdoor [32]. Indeed, an adequate publication of list of regulations to be taken against the spread of COVID-19 among humans will first requires, a proper understanding of the virus transmission pathways. Thus, a set of scientific results could be done to finding efficient measures to help reduce the spread of the virus and to reliably protect healthcare workers, education stuffs, essential workers and the civilians across the globe. With no initial consistent scientific investigation, it was believed that contact infection were assumed to be the principal transmission route of COVID-19, but today, with all results obtained by epidemiologists, virologists and even mathematicians, today, hygiene measures and avoidance of hands shaking may not be enough to stop the spread of the virus. Droplet infection is nowadays proven to be one of the main transmission routes over a short distance see (Wang et al. [2]). We should recall that the regulation of social distance is not new as this was assumed to be efficient as the route of transmission is also airborne [33]. Interestingly, it was reported recently that COVID-19 can remain infectious in aerosols for a period of 3 to 8 h, at least under laboratory conditions at high humidity [25]. It can be imagined that, the infections can happen under specific scenarios over a long distance, this was already indicated by Guerrero et al.[32]. Where the authors performed simulation of wind with speed of 2 km/h transporting droplet released by a single sneeze as far as 11 m outdoor. Johnson and his co-authors showed that an important proportion of the aerosol exhaled by humans has a radius of <5 μm [34]. This could occur when, exhaling, speaking, singing and coughing. Additionally, to this, it was reported that, the size and evidently the numbers of droplets with the volume of voice [35]. Additionally, the upper respirational tract diseases expand the production of vaporizer particles [36]. It was reported that water droplets of small size can evaporate within few seconds at normal moisture conditions [37]. However, it was reported that droplets with radius of 5 μm for example were evaporated just after 1 s at 50% relative humidity in contrast of large droplets that sunk immediately to the ground due to gravity but later evaporate [38]. With all these results in hand, there is a clear evidence that the wind could be a carrier of droplets containing concentration of COVID-19, while some case studied have been done for indoor and outdoor exposure with a wind speed of 2 km/h, no mathematical model has been suggested to see in general how far such droplets could be transported. In the current paper, we will also provide some mathematical models that could be used to predict how far droplets could be transported by wind with high speed.

Data collection

An online literature review was done using worldwide electronic database search engines including Sci-finder, PubMed, Google scholar, science direct, world and local news sources between the period of 1st of June to 15th August 2020. PubMed search was the principal source area to identify the latest research articles that skilled the benefit of criteria search; while Google scholar search and others were used as other important database. During searching, the following keywords were used as criteria during the search; human studied having relation with breathing (inhaling and exhaling) difficulties, what happened during breathing, cellular respiration and reactions involved, carbon dioxide poisoning and biological health effects. Articles based on their medical and physiochemical effect on the intake of carbon dioxide were also included. Searches were also done on the ongoing pandemic regarding the WHO guidelines; the wearing of facemasks, varieties of basic cloth facemasks including their advantages and disadvantages, climate changes; effect on temperature, rainfall and wind speed. A total of around 70 articles were reviewed comprised of only peer-reviewed articles of original source files which included experimental and literature studies based on breathing, carbon dioxide poisoning and the ongoing threatening pandemic (COVID-19) and WHO guidelines. References of these articles were evaluated jointly with literature sources that were available. Valuable articles on COVID websites were also considered with appropriate cited references. The search was updated until the 1st week of August 2020.

Human breathing

It is well-known that the human body can withstand deprived of food, for some days without water, but nevertheless it can only survive in few minutes without air. This implies that breathing is very essential, efficient and necessary for the human body to function completely well. In general, the process of breathing also known as ventilation occur when there is movement of air into the lungs (inhalation) and out of the lungs (exhalation) (Fig. 1). This helps in the conservation of gas within the internal environment through the transportation of O_2 and CO_2 in and out of the lungs respectively. Breathing can occur through the nostril or mouth of the human body [39]. Breathing through the nostril is important for human health since it filters and cleans the air before it get inside the lungs. Whereas breathing through the mouth does not filter the air, and hence dangerously harm the body by causing inflammation which may increase the chance of harmful chronic diseases such as heart diseases to develop [40].

It is established that human beings cannot survive without air. Breathing serves a huge purpose of ensuring that adequate oxygen is supplied to the body organs and cells to produce energy and enable the crucial processes such as metabolism to take place. Additionally, the inhaled oxygen enables our cells to produce adenosine triphosphate (ATP) which is described as cellular energy. This is achieved by cells through the breakdown of sugar in the form of glucose, water and CO_2 which is exhaled through the lungs [41]. Furthermore, the absorption of oxygen to a cellular level helps to complete circular respiration (Schmidt-Rohr 2020); following four steps of the circular reaction pathway namely: 1. Glycolysis, 2. Synthesis of Acetyl CoA, 3. glycolysis, synthesis of Acetyl-CoA (Kreb cycle) and 4. The electron transport chain (kerb cycle) and the electron transport chain [42].

The first reaction is glycolysis, which means the splitting of sugar occurs in the cytoplasm of the cell. During this reaction, one glucose molecule is split into 2 molecules of pyruvic acid, which later results into 2 ATP for all glucose molecules formed [43]. Secondly, is the transition reaction, where pyruvic acid enters again into the mitochondria and later converted to Acetyl coA for additional breakdown steps [43]. Thirdly, is the Citric Acid or krebcycle reaction that occur in the mitochondria matrix (liquid part of mitochondria). Due to attendance of oxygen (O_2), the hydrogen's produce is then wiped off by the Acetyl CoA (two by two molecules each), and then cutting to electron in order not to produce ATP. This is done until no further hydrogen ion remains and finally the remaining sugar of CO_2 is formed as a waste product and also water which is goes out of the cell [44]. In the final stage of the Kreb cycle, only four ATP are produced and many of NADH produced goes on to the next step and the cycle continues again [44]. Finally, is the last step; Electron Transport Chain, occurs in the christae of the mitochondria, which is the folded membrane found exclusively in the chloroplast. Proton are being passed through this gradient via the proton channel that phosphorylates the ADP (Adenosine diphosphate) where energy is then added to create a form ATP [45].

Retention of carbon dioxide by the lungs in human

Carbon dioxide (CO_2) is an efficient process that occur during respiration. It is colourless, tasteless, odourless and non-inflammable gas and about 1.5 times heavier than air which can easily accumulate at low levels, causing deficiency of oxygen [46]. Generally, the air breathed in by human beings is comprised of approximately oxygen (20.95%), nitrogen (78.09%), argon (0.93%) and CO_2 (0.04% and 400 ppm). At normal room temperature, CO_2 percentages are very low, around 0.04% [47]. Though the process of cellular respiration is realised to be a source of ATP; it also produces CO_2 waste [47]. The human body sends out excess CO_2 by breathing it out in the process described (1) below

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O \quad (1)$$

Carbon dioxide in its usual range of 38–42 mmHg, functions greatly in human. For instance, it helps in pH regulations, breathing stimulations as well as play a crucial role in influencing the haemoglobin's affinity for oxygen. Therefore, the variation of CO_2 in the body can be highly controlled and may cause instabilities in the human body if normal range cannot be upheld.

Health impact

In humans, CO_2 gas is produced through the intercellular metabolism located in the mitochondria. The volumes of the gas produced depend on the rate of metabolism and to the quantities of protein, fats as well as amounts of carbohydrate that are metabolized [48]. During inhalation of CO_2 into the lungs, it liquifies with the water and later disperse transversely via the alveolar capillary membrane and finally mingle inside the blood stream regarding the preceding product form, immediate contact with water, it forms carbonic acid and the pH of the blood decreases and the acidity increases, thereby making the blood acidic (Eq. 2) [48].

$$\underset{\text{Respiratory acidosis}}{CO_2 + H_2O} \longleftrightarrow \underset{\downarrow \text{pH (7.35)}}{H_2CO_3} \longleftrightarrow \underset{\uparrow PCO_2\ (48\text{mmHg})}{H^+} + \underset{\uparrow HCO_3}{HCO_3-} \quad (2).$$

CO_2 is discharge from the human body in order to maintain an equilibrium position between the acid and base reaction taking place within the cell [49]. This carbon dioxide formed within the cell through a process of internal respiration, where by, the by-product of the cell metabolism is being transferred by the blood through the veins to the lungs where it is exhaled (Eq. 3).

$$\underset{(PaCO2 > 45\text{ mmHg})}{\text{Alveolar blood}} \longrightarrow \text{Alveolar ventilation} \longrightarrow \underset{\text{(Respiratory acidosis)}}{H_2CO_3} \quad (3).$$

It is estimated that CO_2 concentration in human breath is approximately 3.8% and the mean value of each individual is two pounds of CO_2 per day [49]. Oxygen can be released from the oxyhaemoglobin when the pH or partial pressure of CO_2 (pCO_2) are lowered. Increasing the partial pressure (lowering the pH) a physiological deficiency known as hypercapnia (hypercapnia or hypercarbia) is then developed when the body response to an increase in $_PCO_2$ [50]. Equally, increasing the partial pressure which is transported to the lungs induces a rise in pCO_2 into the lung tissues (alveoli). Carbon dioxide diffuses across the lungs tissue (alveolar membrane) and then get into the blood, oxygen is then carried throughout the body by the arteries, which then leads to an increase in the tension of arterial partial pressure of CO_2 ($PaCO_2$) in the blood [50]. Along with this, when the $PaCO_2$ are elevated, the pH in the blood is lowered. A chronic or acute or respiratory syndrome called Acidosis can therefore be developed.

Acidosis is caused by the alveolar hypoventilation, where the lungs fail to remove the formed CO_2 from the tissue. This CO_2 accumulated in the blood which combines with water and resulted to carbonic acid and or respiratory acid. which further dissociates to produce HCO_3^- and H^+ ions (Respiratory alkalosis retrieved 2016). Increasing the concentration of H^+ ions reduces the blood pH; as a result, increases acidosis (refer to equation 2). The blood is considered to be acidic when the partial pressure of CO_2 in the arterial blood exceeds 60 mmHg [50], which in consequence causes a disproportion in the acid-base in the blood (pH < 7.35) [50,51]. It is worthy to note that the normal partial pressure of CO_2 in the arterial blood is approximately 40 mmHg. The presence of this condition is associated with several disorders such as headache, anxiety, confusion, stupor and drowsiness; which can be categorized as severe, acute or chronic.

Respiratory acidosis in its developing stage is tolerable; but as it severely progresses symptoms such as sleeping disorder, memory loss, in personality and as well as excessive daytime dizziness can be experienced [52]. Furthermore, there are diseases found to occur due to respiratory acidosis, and they are namely: gravis, myasthenia, lateral sclerosis, muscular dystrophy, Guillain-Barré, amyotrophic, sclerosis, thoracic deformities and severe restrictive ventilatory faults in the interstitial lung disease [52]. The accumulated CO_2 in the blood later circulates inside the brain and then transverse to the blood brain barrier. Thus, these signs and symptoms mentioned above has the ability to lower the pH of the central nervous system, which can result in higher CO_2 concentrations accompanied with low levels of O_2 present in the blood (hypoxemia) [53].

In principle respiratory acidosis occurs with respect to great exposure of CO_2 concentration. For instance, when a healthy individual is exposed for about 30 min to a 10% or 10,000 ppm of CO_2; is considered to be in a moderate physical load [54]. Therefore, an increase in the intake of CO_2 concentration may lead to a rise in the respiratory rate; whereby the blood–brain flow increases, resulting in an increase in slight breathing and metabolic stress. On the other hand, when the concentration is greater than 10,000 ppm, individuals suffer from reduce the labour activities in workers during breathing against inhalation and exhalation resistance (equation 3) [8,10]. However, in cases where CO_2 exposure level is more than 50% (i.e. >50,000 ppm), one may experience dizziness, headache, loss of consciousness in a second, confusion and dyspnea [55].

Concentration of CO_2 exposure in high level of 100% (>100,00 ppm), the human compensatory mechanism can become overawed and the brain and spinal cord can no longer functioned correctly (depressed). This identified disorder may result in vomiting, night blindness, hypertension, loss of consciousness, sweating, convulsions, disorientation, and may lead to coma and sometimes followed by death [56].

In addition to respiratory acidosis, when carbon dioxide is inhaled into the body, it quickly triggers other specific mechanism in response to the excess carbon dioxide concentration. As a result, the breathing rate is accelerated and the usual volume of air breathed in is increased; causing heart rate, blood pressure and the production of kidney bicarbonate to increasingly take place [55]. The latter occurs to help in buffering the effect of blood acidosis. This buffering process allows the blood vessels to contract; thereby preventing the normal flow of blood in the body. While this is ongoing, the spinal cord, arteries and the heart dilate to allow more blood to flow towards these crucial organs, in order to maintain proper and correct functionality of these organs. Hence, when there is a high level of CO_2 exposure, the body can become overwhelmed; causing the brain and spinal cord to no longer function efficiently and excellently [55]. The rapid abnormal breathing mentioned earlier also leads to a deficiency known as Hyperventilation (result from a small intake of CO_2), which can later result to the disorder Alkalosis. Thus, respiratory alkalosis is another condition that results in low CO_2 level in the body.

Respiratory alkalosis is a medical condition that occur when an increase in breathing rate raised the pH level in the blood from its original range (pH 7.35–7.54); while there is a simultaneous reduction in the level of carbon dioxide in the arteries [57]. Loss of CO_2 leads to a decrease in the formation of carbonic acid and a decrease in the release of H^+ ions concentration; thereby increasing the pH which in turn leads to respiratory acidosis. However, when there is a partial pressure below 20 mmHg, alkalosis may also occur. Alkalosis condition also has its own signs and symptoms of acute and chronic situations associated with it, which includes lethargy and confusion, light headache, convulsion, tetany and sweating [58].

The above disordered mentioned (respiratory acidosis and alkalosis) occurred through CO_2 partial pressure pathological changes or bicarbonate formed from the irregular arterial pH values in the artery, a summarised card of the acid-base disorder is shown below (Table 1). Based on our traditional experience, biological studies have highlighted that the increase in the exposure level to CO_2 can simultaneously increase the breathing rate. As a consequence, the levels required to optimise the fast gas exchange rate are increased, because at concentrations greater than 5000 ppm, an extra work load is enforced onto the human breathing system [58].

Literatures studies have indicated that the greater the altitudes, the lesser the partial concentration of oxygen it becomes. Therefore, people traveling in aircrafts at higher altitudes without sufficient ventilation in exception to the cockpit, are likely to experience unconsciousness due to lack of oxygen. This unconsciousness is hardly noticed as people would not have a feeling of "air hunger" neither a sensation of "air hunger" [30]. In 1881 Pettenkofer and Flugge suggested that the permissible indoor concertation of CO_2 ranges between 700 and 1000 ppm. This therefore shows the indirect index of air conterminous in buildings. However, the suggested criteria had no physical root to justify it [59]. Additionally, according to Eliseeva suggested that very rapid breathing exposure to CO_2 (1000 ppm), can caused a noticeable in the movement of breath, and thereby leading to an increase in the cerebral cortex and the peripheral blood flow [60]. This exposure may lead into the cerebral cortex functional state and an increase in the peripheral blood flow. Therefore, indicating that the concentration of CO_2 exposure mentioned earlier (1000 ppm) has a direct effect on the human body; even though there were no experimental procedure and evaluation methods furnished in the literature. This explains why the organization in charge of CO_2 exposure at lower concentration than the preceding (<5000 ppm) discussed earlier, as well as human health continued to remain very limited during the 1960s [60].

Table1

Mixed acid-base disorder [60].

Status of disorder	pH	Partial pressure of carbon dioxide ($PaCO_2$)	Bicarbonate (HCO_3^-) HCO_3^-
Normal	7.35–7.45	4.7–6	22–24
Respiratory acidosis	↓	↑	
Respiratory acidosis			Normal
Respiratory alkalosis	↑	↓	Normal

Facemasks and categories

The mandatory wearing of facemask was first introduced in the Wuhan, Hebei city in 2020. This measure was taken as a prevention measure to the rapid spreading of the COVID-virus from human to human [30]. The WHO had estimated that about 89 million masks would be required every month, to combat and reduce the spread of this deadly pandemic [62]. As a result, the production of facemask skyrocketed across the world; with the Republic of China leading in the manufacturing of facemask. The fast spreading of the coronavirus has also raised the demand for facemasks worldwide in addition to the estimations given by WHO. For instance, the daily production rate in China has risen up to 14.8million of medical facemasks since the beginning of the February 2020 [30]. A report from the Ministry of Economy, Trade and Industry in Japan, as from April 2020, has indicated that more than 600 million orders of facemasks were secured for each month [31]. Moreover, it has been also observed that many nations around the world were rapidly releasing their lockdown orders, due a sudden drop in mental health of pupils and the economies at large due to coronavirus, in fear of a second wave of infection. Therefore, an increase in production and consumption of facemasks across the globe has created a new environmental challenge thereof; because several types of facemasks are now being used out by different individuals to protect them from contracting COVID-19. As the demand escalated greater than the supply, different facemasks are therefore recognised to do the needful; these includes; basic cloth facemask, surgical facemask, KN95 Respirator, Full length Face shield, Self-contaminated breathing Apparatus, P100 Respirator/Gas mask, Filtering Facepiece Respirator, N95 respirator. A summary of the variety of facemasks, beneficial and non-beneficiary effect are listed in Table 2 below.

Research strategies and method

In this section, we present some mathematical formulas that could help to determine how long the facemasks can be wear. To achieve our goal, first, we will consider a healthy person that breath normally. It is known that, the average human exhales approximately 2.3 lb of carbon dioxide on an average day, that means per minute he should exhale approximately 0.0016 lb of carbon dioxide for him to be healthy. Now let us assume, a healthier person put a mask that does not help releasing the expelling air or carbon dioxide, thus the person will directly re-inhale the exhaled carbon dioxide. As it is known that, since the loop is not entirely closed, the exhale amount of carbon should be exactly the amount inhale this in a minute. Thus if an individual wear a mask for example from 7 am to 5 pm the individual would re-inhale 0.864 lb of exhaled carbon dioxide, while this could not be detrimental in one day, but in 3 months if this individual repeat his daily routine then he would re-inhale 77.76 lb of exhaled carbon dioxide which could cause health problem in the long term. The choice of mask to use for work purposes should be wisely chosen, a mask that will help escape the exhaled carbon dioxide should be appropriated and recommended. However, while we give this recommendation, we shall recall that such mask maybe expensive for some workers for example workers from low income countries and they may not be able to afford to buy such masks, however, they need a mask to protect themselves from COVID-19. More especially if such mask is renewable this could be very difficult to some workers to afford. Although we have presented some disadvantages of wearing a mask for long time, it is very important to reiterate that the wearing of masks is very essential to reducing the spread of COVID-19 within humankind, even if one is not around humans, however, if he is outside it could still be imperative to wear a mask. Our argument come from the fact that, one of the front medical workers, Heymann, who played a major role during the SARS outbreaks and is known as public health experts raised a concern about the possibility of COVID-19 spread in open spaces [62]. Very recently WHO announced that they have evidence of COVID-19 being an airborne infectious disease that the virus

Table 2
Categories of facemask useful/not essential during the outbreak COVID pandemic [61–63].

Variety of Facemask	Appearance	Description	Advantages	Disadvantages
a-Basic cloth facemask		Recommended for shopping such as gas station, grocery stores or any public areas Also used to prevent the spread of COVID-19 pandemic.	Warm Repeatable Easy to clan and reusable Filter can be changed	Difficulty in breathing after used Several re-uses time Can lead to bacterial infection, pollution and unsanitary.
b-Surgical facemask		This mask consists of once-use thin material and has being approved by the Food and drug administration. This type of mask protects the nose, mouth, eye, cheeks and forehead. Mostly recommended for Medical professional dealing with operations drive through COVID-19 patients.	Accurate in filtering of virus and bacteria. Sanitary and clean	Poor sealing
c-N95 Respirator		This mask is mostly recommended by health care workers and first medical responder dealing with COVID-patients.	Virtuous filtering effect to virus and bacteria. Clean and practice good hygiene. Fine dust filtering effect. Good sealing effect	Stuffing and uncomfortable. Can cause respiratory diseases
d-Filtering facepiece respirator		Unlike the surgical mask, this type of mask is mostly used to stop the spread of airborne diseases and also is dispensable. It helps to decrease the exposure of particles that comes from animal danger, pollen and wood dust. Allergies patient are recommended to this type of mask during the COVID outbreak.	Good filtering of bacteria and virus	Adsorbate to odour, slightly toxic gases, formaldehyde
e-Gas mask /P100 Respirator		This type of mask is not recommended for health care. Mostly used by woodworkers, painters any anyone dealing with chemicals such as lead and asbestos. This type of mask is not recommended for COVID-19 virus	Efficient filtering effect to bacteria and virus	Poor Air permeability
f-Self-contained Breathing Apparatus		Mostly worn by firefighters in order to ease fresh breath when in contact with hazardous environments. Not recommended for COVID019 crises.	High filtering process to virus and bacteria	Difficulty in air penetration
g-Full length face shield		This mask is made of flimsier, which cover the entire face from the forehead to chin and secure with a headband cushioned. It similar with the glass plastic version type of mask worn by wielders. It is usually tough to breath with over time. Not recommended for COVID pandemic.	More comfortable Easy to clean Ease breath reduced patient anxiety	Glare, Fogging, Optical imperfection, Peripheral fit. Poorer than protective facemask
h-KN95 Respirator		Similar to N95 masks. Both N (% and KN95 can adsorbed about 95% of tiny air particles. The only difference lies in where the latent (N (95) lager particles can be adsorbed.	Fine dust filtering effect Good sealing effect	Uncomfortable and study Leads to lungs diseases.

(continued on next page)

Table 2 (*continued*)

Variety of Facemask	Appearance	Description	Advantages	Disadvantages
i-Full face Respirator		Mask recommended for people having difficulties in breathing. Or respiratory problem. Most used at home to advance project.	Ease breath, Unobstructed views, No jaw fatigue, No snorkel clearing, Less Fogging due to better air circulation Suitable for colder climates. No risk losing your regulator. Can be used when u have a beard. Optional under water communication	Less conformable

can stay 8 h in air. Beside the announcement of WHO and the concern raised by Heymann, several other experts believe that this situation is very possible own the size of the virus and the force exerted by the wing. For example, very recently the results of Guerrero et al. [32] showed that for a larger droplet ranging from 400 to 900 μm could spread between 2 and 5 m during 2.3 s, however, a smaller from 100 to 200 μm droplets are propagated from 8 to 11 m, their results were performed in open air. However, it is important to note that, the force of air could be a vehicle to transport this droplet very far. In this section, we present some mathematical models that could be used for possible simulations.

Assuming that, an individual infected with COVID-19 sneezes without mask, then releases in the air, a concentration of $c(x,t)$, where x is the distance and t is time, according to the latest news by WHO that suggested that, COVID-19 is airborne infection disease, and that it can stay in the air for some period of time, thus the concentration will then be a function of space and time. In this section, we shall use the simple advection dispersion, the function of concentration known the initial concentration release in an opened air by an individual affected by COVID-19. Let assume that the air velocity u is an average of 100 km/h. We assume that the concentration does not disperse but is transported by the force of air flow. One of the most important concepts used by mathematicians to evaluate an instantaneous change of a moving object is perhaps the notion of derivative. In this case, we would like to evaluate the continuous change in concentration of COVID-19 that was released by an infected individual. The suggested mathematical model associate to this behaviour can be:

$$\frac{\partial c(x,t)}{\partial t} = v\frac{\partial c(x,t)}{\partial x},\ v = -u \tag{4}$$

This equation states that, the rate of change of concentration respect to time is proportional to the rate of change of concentration with respect to space, where the coefficient of proportionality is the velocity of the air. We shall have four cases, the first case we assume that due to complexity of air, there is small resistance R that can be considered as retardation factor, also in this case we assume that the velocity depends on space.

$$\frac{\partial c(x,t)}{\partial t} = v(x,t)\frac{\partial c(x,t)}{\partial x} + R,\ v(x,t) = -u(x,t). \tag{5}$$

The second case, we assume that the velocity is constant, but the resistance is present.

$$\frac{\partial c(x,t)}{\partial t} = v\frac{\partial c(x,t)}{\partial x} + R,\ v = -u. \tag{6}$$

The third case, the velocity is a function of time, while the air is homogeneous with no retardation factor, then,

$$\frac{\partial c(x,t)}{\partial t} = v(x,t)\frac{\partial c(x,t)}{\partial x},\ v(x,t) = -u(x,t). \tag{7}$$

Finally, the velocity does not depend on time and space and there is no resistance

$$\frac{\partial c(x,t)}{\partial t} = v\frac{\partial c(x,t)}{\partial x},\ v = -u \tag{8}$$

The above set of mathematical equations are very important when the process is known to be Markovian, which in layman terms, refers to process for which predictions can be performed concerning forthcoming results based exclusively on its present state. It is worth noting that, such predictions are as efficient as the one that could be performed having the full history of the process. However, nature, especially the atmosphere is somehow complex that some external forces could be involved during the transport of such particles in air. The heterogeneity of the atmospheric space could influence the transport even change the direction of the wind. Another situation is perhaps to include the effect of non-locality of air into mathematical formulation, which also give the model the possibility to having memory. In this case, the above mathematical models can be transformed into four cases:

The first case we assume that the flow of air has some non-locality due to heterogeneity of the air, due to complexity of air, there is small resistance R that can be considered as retardation factor, also in this case we assume that the velocity depends on space.

$$\frac{AB(\alpha)}{1-\alpha}\int_0^t \frac{\partial c(x,l)}{\partial l} E_\alpha\left[\frac{\alpha}{1-\alpha}(t-l)^\alpha\right] dl = v(x,t)\frac{\partial c(x,t)}{\partial x} + R \tag{9}$$

The function

$$\frac{AB(\alpha)}{1-\alpha} E_\alpha\left[\frac{\alpha}{1-\alpha}(t-l)^\alpha\right] = \frac{AB(\alpha)}{1-\alpha}\sum_{j=0}^{\infty}\frac{\left(\frac{\alpha}{1-\alpha}(t-l)^\alpha\right)^j}{\Gamma(\alpha j+1)} \tag{10}$$

Has very important properties, for example, $(t-l)^\alpha$ helps to recall the history of the process, its beginning and end, as the parameter l varies from zero to the final time during which the transport is taking place. The function has a waiting time distribution able to describe two different states, including a stretched exponential and the power law, also the density distribution associate to this function is able to depict two states including normal and non-Gaussian distribution.

However, if we assume that the process has some fading memory effect, then the model can be converted to the following

$$\frac{M(\alpha)}{1-\alpha}\int_0^t \frac{\partial c(x,l)}{\partial l} exp\left[\frac{\alpha}{1-\alpha}(t-l)\right] dl = v(x,t)\frac{\partial c(x,t)}{\partial x} + R \tag{11}$$

The function exponential helps describe the effect of fading memory, for example if the wind is losing its speed, thus the transport that depends mostly on the force of wind will automatically lost its value, thus the concentration will not be able to go very far from the original point of release.

Finally, if the origin of the release is not well known but the wind does not really lose its speed, then, the model can be converted to.

$$\frac{1}{\Gamma(1-\alpha)}\int_0^t \frac{\partial c(x,l)}{\partial l}(t-l)^{-\alpha}dl = v(x,t)\frac{\partial c(x,t)}{\partial x}+R \tag{12}$$

The function $(t-l)^{-\alpha}$helps include into mathematical formula the effect of power law also the lack of origin knowledge.

It is worth noting that, if the air resistance is neglect then, the models are reduced to:

$$\frac{AB(\alpha)}{1-\alpha}\int_0^t \frac{\partial c(x,l)}{\partial l}E_\alpha\left[\frac{\alpha}{1-\alpha}(t-l)^\alpha\right]dl = v(x,t)\frac{\partial c(x,t)}{\partial x} \tag{13}$$

$$\frac{M(\alpha)}{1-\alpha}\int_0^t \frac{\partial c(x,l)}{\partial l}exp\left[\frac{\alpha}{1-\alpha}(t-l)\right]dl = v(x,t)\frac{\partial c(x,t)}{\partial x} \tag{14}$$

$$\frac{1}{\Gamma(1-\alpha)}\int_0^t \frac{\partial c(x,l)}{\partial l}(t-l)^{-\alpha}dl = v(x,t)\frac{\partial c(x,t)}{\partial x} \tag{15}$$

Also, if the velocity is constant, then the above can be further reduced to:

$$\frac{AB(\alpha)}{1-\alpha}\int_0^t \frac{\partial c(x,l)}{\partial l}E_\alpha\left[\frac{\alpha}{1-\alpha}(t-l)^\alpha\right]dl = v\frac{\partial c(x,t)}{\partial x} \tag{16}$$

$$\frac{M(\alpha)}{1-\alpha}\int_0^t \frac{\partial c(x,l)}{\partial l}exp\left[\frac{\alpha}{1-\alpha}(t-l)\right]dl = v\frac{\partial c(x,t)}{\partial x} \tag{17}$$

$$\frac{1}{\Gamma(1-\alpha)}\int_0^t \frac{\partial c(x,l)}{\partial l}(t-l)^{-\alpha}dl = v\frac{\partial c(x,t)}{\partial x} \tag{18}$$

Without loss of generality, we present the numerical solution of

$$\frac{AB(\alpha)}{1-\alpha}\int_0^t \frac{\partial c(x,l)}{\partial l}E_\alpha\left[\frac{\alpha}{1-\alpha}(t-l)^\alpha\right]dl = v\frac{\partial c(x,t)}{\partial x} \tag{19}$$

And

$$\frac{M(\alpha)}{1-\alpha}\int_0^t \frac{\partial c(x,l)}{\partial l}exp\left[\frac{\alpha}{1-\alpha}(t-l)\right]dl = v(x,t)\frac{\partial c(x,t)}{\partial x} \tag{20}$$

To perform the numerical solution, we defined the steps size in time and space as

$$t_{n+1}-t_n = \Delta t, t_n = n\Delta t, x_{i+1}-x_i = \Delta x, x_i = i\Delta x, t_0 < t_1 < t_2 < \cdots\cdots\cdots < t_n$$

Thus Eq. (19) can be solved numerically as follow:

First, we apply on both sides the integral transform associate to the used derivative

$$c(x,t)-c(x,0) = v\frac{\partial c(x,t)}{\partial x}\frac{(1-\alpha)}{AB(\alpha)}+\frac{\alpha}{AB(\alpha)\Gamma(\alpha)}\int_0^t (t-l)^{\alpha-1}v\frac{\partial c(x,l)}{\partial x}dl \tag{21}$$

Then we consider the solution at the point(x_i,t_{n+1}), then equation (18) becomes

$$\begin{aligned}c(x_i,t_{n+1})-c(x_i,0) = {}& v\frac{c(x_{i+1},t_{n+1})-c(x_{i-1},t_{n+1})}{\Delta x}\frac{(1-\alpha)}{AB(\alpha)}\\ &+\frac{\alpha}{AB(\alpha)\Gamma(\alpha)}\int_0^{t_{n+1}}(t_{n+1}-l)^{\alpha-1}v\frac{\partial c(x_i,l)}{\partial x}dl\end{aligned} \tag{22}$$

After some manipulation, including using the Lagrange interpolation and integrating, we get

$$\begin{aligned}c(x_i,t_{n+1})-c(x_i,0) = {}& v\frac{c(x_{i+1},t_{n+1})-c(x_{i-1},t_{n+1})}{2\Delta x}\frac{(1-\alpha)}{AB(\alpha)}+\frac{\Delta t^\alpha}{AB(\alpha)\Gamma(\alpha+2)}\sum_{j=1}^{n}\left\{\left\{v\frac{c(x_{i+1},t_j)-c(x_{i-1},t_j)}{2\Delta x}\right\}((n-j+1)^\alpha(n-j+2+\alpha)-(n-j)^\alpha(n-j+2\right.\\ &\left.+2\alpha))-\left\{v\frac{c(x_{i+1},t_{j-1})-c(x_{i-1},t_{j-1})}{2\Delta x}\right\}((n-j+1)^{\alpha+1}-(n-j)^\alpha(n-j+1+\alpha))\right\}\end{aligned} \tag{23}$$

Using a similar routine, we derive the numerical solution of equation (20)

$$\begin{aligned}c(x_i,t_{n+1})-c(x_i,0) = {}& v\frac{c(x_{i+1},t_{n+1})-c(x_{i-1},t_{n+1})}{2\Delta x}\frac{(1-\alpha)}{M(\alpha)}\\ &+\frac{\alpha}{M(\alpha)}\left\{\left\{\frac{3v\Delta t}{2}\frac{c(x_{i+1},t_j)-c(x_{i-1},t_j)}{2\Delta x}\right\}\right.\\ &\left.-\left\{\frac{v\Delta t}{2}\frac{c(x_{i+1},t_{j-1})-c(x_{i-1},t_{j-1})}{2\Delta x}\right\}\right\}\end{aligned} \tag{24}$$

Eqs. (23) and (24) can be used to provide numerical simulation and this will be presented in next section.

Results and discussion

Using Eqs. (20), (21) and the software called MATLAB, we present here some numerical simulations. The following parameters were used to performed the simulation, we assumed that the speed of wing is v = 100 km/h, the initial concentration released by an infected person is considered to be 100 mol/litre, we assume that the retardation factor could varies from 0 to 0.4. We assume that without any effect of wind the function of the initial concentration follows a fading memory process meaning

$$c(x,0) = c_0, c(0,t) = c_0\exp(-\psi t)$$

The parameter ψ can be obtained using the concept of half live time. Additionally, we chose the space and time steps to be $\Delta t = 0.01, \Delta x = 0.01$. The numerical simulations are depicted in Figs. 2, 3, 4, 5, 6, and 7 below.

Fig. 2a); b) and c) and Fig. 3a); b) c) and d) represent the concentration as a contour plots, the speed of the wind is assumed to be 100 km/h. We shall mention that, contour plots are known as structural maps depicted from a three-dimensional function or data. It is known that the variable x is represented on the straight axis, while the second variable t is depicted on the vertical axis and finally the third variable is depicting the colour gradient and isolines which are lines of constant value of the concentrations. In Fig. 2, numerical solution was plotted using the concept of differentiation with fading memory, here we assume that there was no retardation factor in the air, the solutions were presented for different order of fractional order alpha. For example in Fig. 2a) the initial concentration released was assumed to be $c_0 = 0.1$, and the fractional order representing the fading memory effect was $\alpha = 0.9$; Fig. 2b) the initial concentration was considered to be $c_0 = 0.1$, and the fractional order is $\alpha = 0.95$, Fig. 2c) we chose the initial concentration to be $c_0 = 100$, and the fractional order $\alpha = 0.9$. Thus, the results obtained from Fig. 2a) and 2c) showed that with no resistance in the air, with a fading memory effect of fractional order 0.9, the concentration of COVID-19 by infected patient can be carried as far as 300 m with linear patterns. However, with a fading memory effect of 0.95, the concentration can be transported as far as 300 m with wave patterns.

Fig. 3 showed the numerical solution as contour plot using the fractional differential operator with the generalized Mittag-Leffler function, for Fig. 3 a) we assumed no retardation factor, we chose the initial condition $c_0 = 0.1$, fractional order $\alpha = 0.95$; Fig. 3b) we assumed a retardation factor to be $R = 0.1$, an initial concentration $c_0 = 0.1$, and a fractional order to be $\alpha = 0.9$; Fig. 3c) we chose air retardation factor to be $R = 0.1$, an initial condition to be $c_0 = 0.1$, and a fractional order to be $\alpha = 0.95$; Fig. 3d) the retardation factor is taken to be $R = 0.1$, initial concentration $c_0 = 100$, and a fractional order $\alpha = 0.9$. Fig. 3a show a crossover behaviour of transport, this means the model is able to depict transport with two different state, and the first transport follows fading memory then later power law. Fig. 4 showed numerical solutions of concentration as function of time and space. Fig. 4a) the retardation factor $R = 0$, the initial concentration is $c_0 = 0.1$, the fractional order is given $\alpha = 0.9$; Fig. 4b) we assume no retardation factor $R = 0$, the initial concentration $c_0 = 0.1$, a fractional order $\alpha = 0.95$, Fig. 4c) $R = 0$, $c_0 = 100$, $\alpha = 0.9$; Figure d) $R = 0.1$, $c_0 = 100$, $\alpha = 0.95$. The fractional derivative used is that with fading memory kernel, the results show that the transport follow a fading memory process however, the concentration released can be transported as far as 300 m. However, regarding Fig. 5, Fig. 5a) and b) show a very interesting results where the variation in concentration expresses a backward transport and the positive showing the forward transport. The same applies to Figs. 6 and 7. It was also observed that the transport followed a crossover behaviour, where during the first period, the transport followed a fading memory process but later a power law behaviour, with no steady state, this was very interesting as this shows that, when the COVID-19 infected person sneezed there were no wind effect, thus concentration released in the air with initial speed was able to spread like in the results described in [64] see Fig. 8 below.

This after this, the spread is carried by wind and transport the droplet as far as 300 m. Another scenario was presented by Guerrero et al. [32] where the author presented simulation of wing with speed of 2 km/h transporting droplet released by a single sneeze as far as 11 m. The results of their simulations showed that, in different metropolitan regions, under typical microclimatologic circumstances, the range of particles breathed out by a sneezing person and available could be transported by turbulent wind could be 3 times higher than the suggested cautionary distances as suggested during the present COVID-19 pandemic. The author claimed that their results are depicting a daily metropolitan condition based the simulated realistic situation, see Figure below, which is an extraction of Fig. 9, one of their work.

The results obtained in this paper and those obtained by Guerrero et al. [32] and Bourouiba [66] lead us to ask the following fundamental questions: Did the wind contributed in spreading COVID-19 around the globe? Did we observe hot spot of COVID-19 infections in winding places around the globe? Could a winding beach be a place of high COVID spread? While we may not have yet a direct answer to these questions, but we could highlight some information from the California beach. Prather presented some interesting information regarding the danger of being in beaches, although this author did not directly link the study or the spread of COVID-19 through wind, however, the results obtained in this investigation showed that, the ocean mixes up all types of particulate and microscopic pathogens. More importantly, the results suggested that the spry of big wave, cause particles to spread into the air. In particular, the author believes that since the weight of COVID-19 is light enough, it could be floating through the air much faster than what

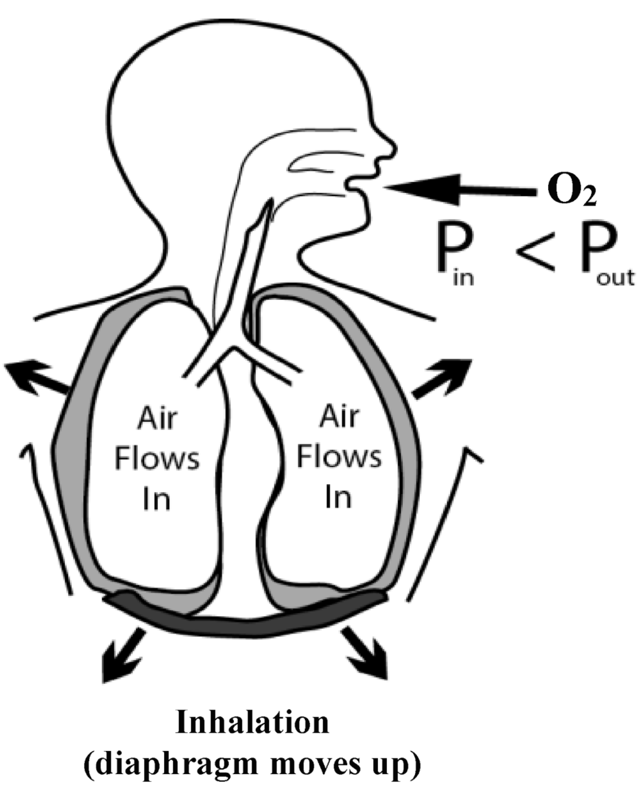


Fig. 1. The movement of the chest during breathing in and out of the lung in human. P = pressure, O_2 – oxygen [39].

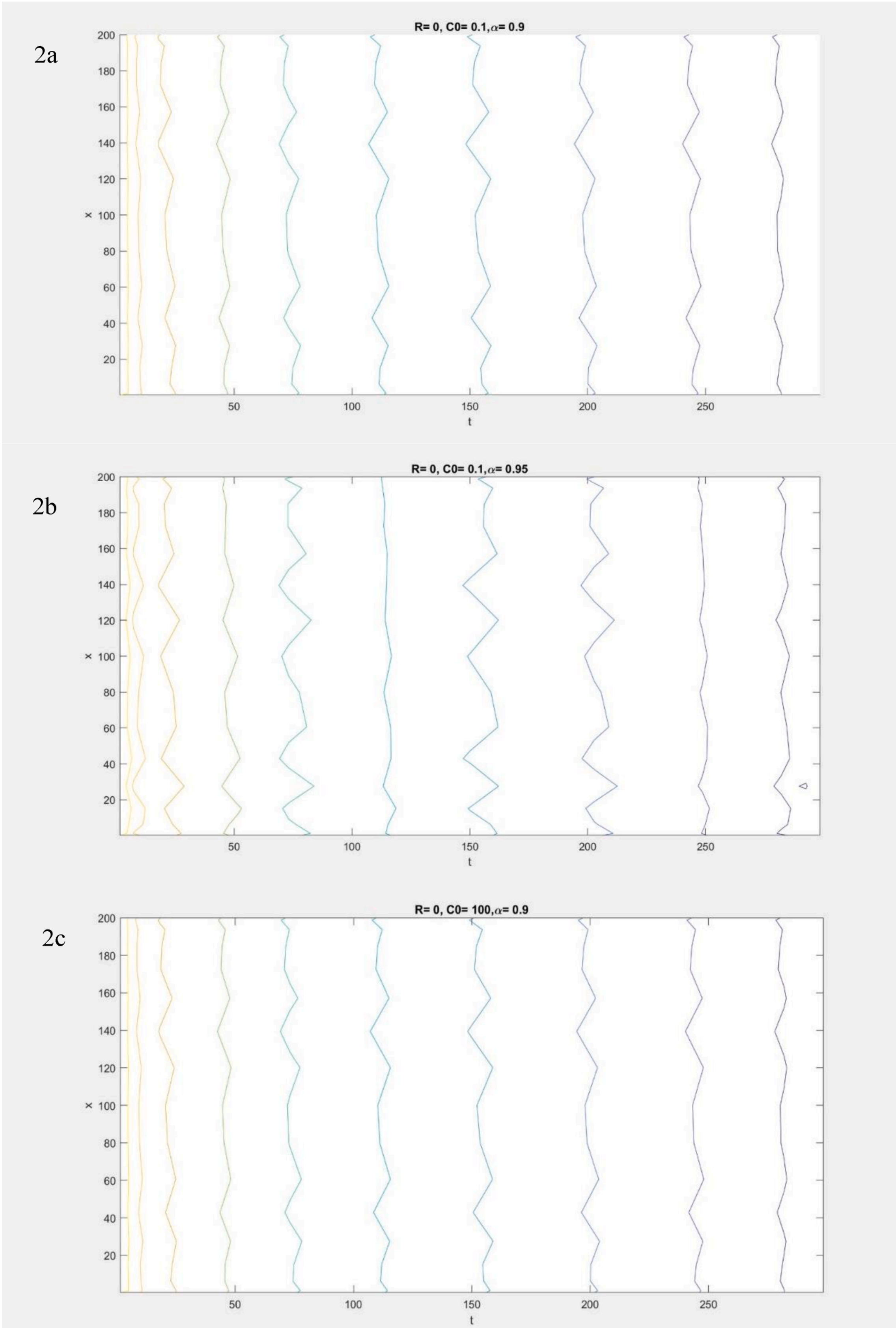
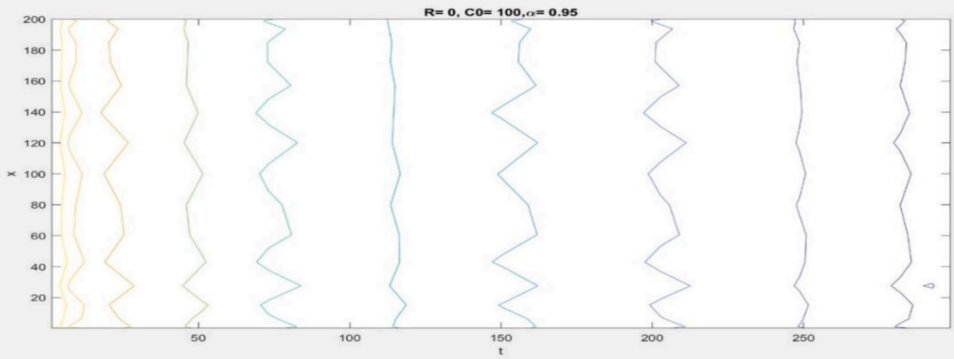
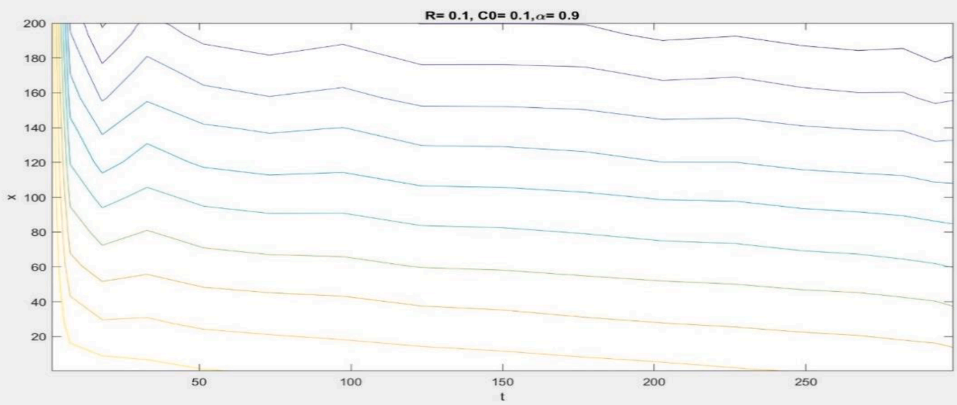


Fig. 2. Numerical solution as contour plot for a) R = 0, $c_0 = 0.1$, $\alpha = 0.9$; b) R = 0, $c_0 = 0.1$, $\alpha = 0.95$ and c) R = 0, $c_0 = 100$, $\alpha = 0.9$.

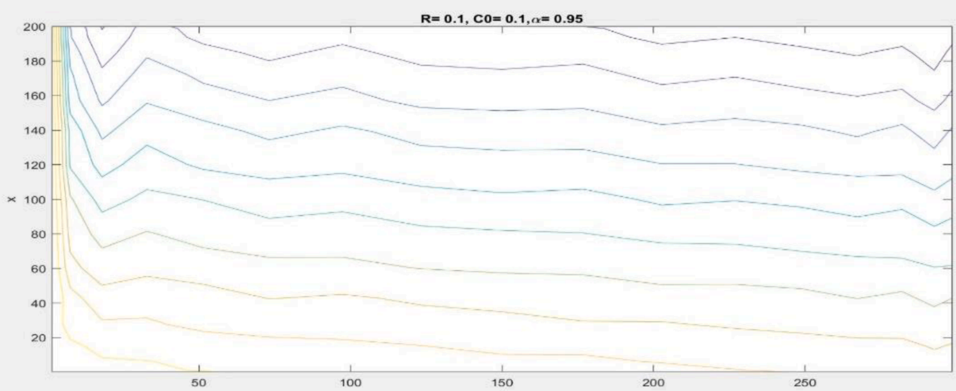
3a



3b



3c



3d

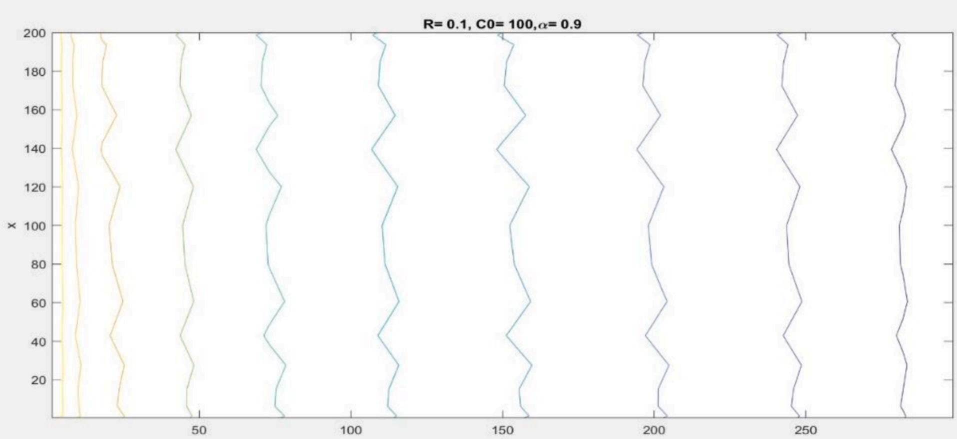


Fig. 3. Numerical solution as contour plot for a) R = 0, $c_0 = 0.1$, $\alpha = 0.95$; b) R = 0.1, $c_0 = 0.1$, $\alpha = 0.9$ and c) R = 0.1, $c_0 = 0.1$, $\alpha = 0.95$; d) R = 0.1, $c_0 = 100$, $\alpha = 0.9$.

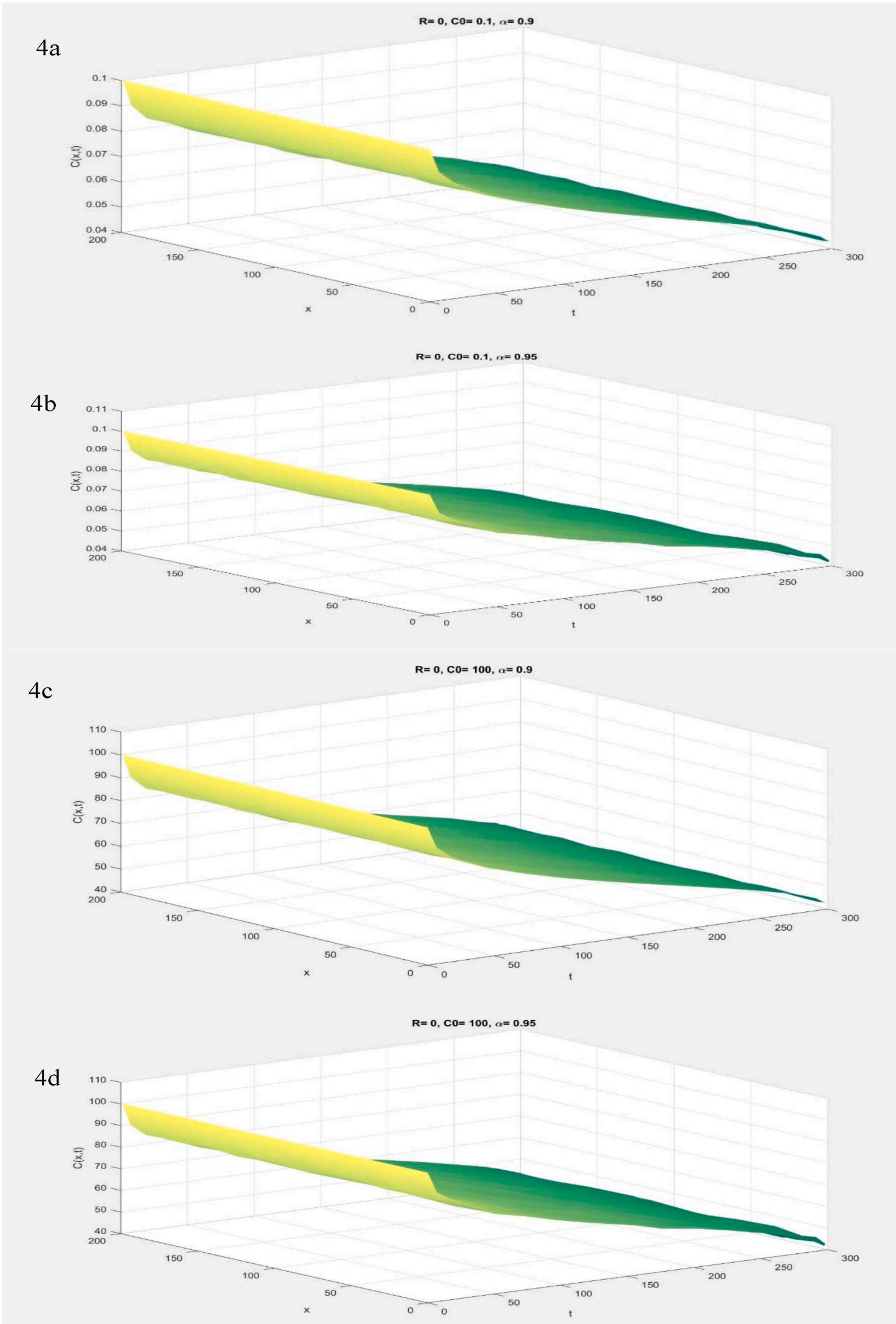


Fig. 4. Numerical solution of concentration as function of space and time for a) $R = 0$, $c_0 = 0.1$, $\alpha = 0.9$; b) $R = 0$, $c_0 = 0.1$, $\alpha = 0.95$ and c) $R = 0$, $c_0 = 100$, $\alpha = 0.9$; d) $R = 0.1$, $c_0 = 100$,$\alpha = 0.95$.

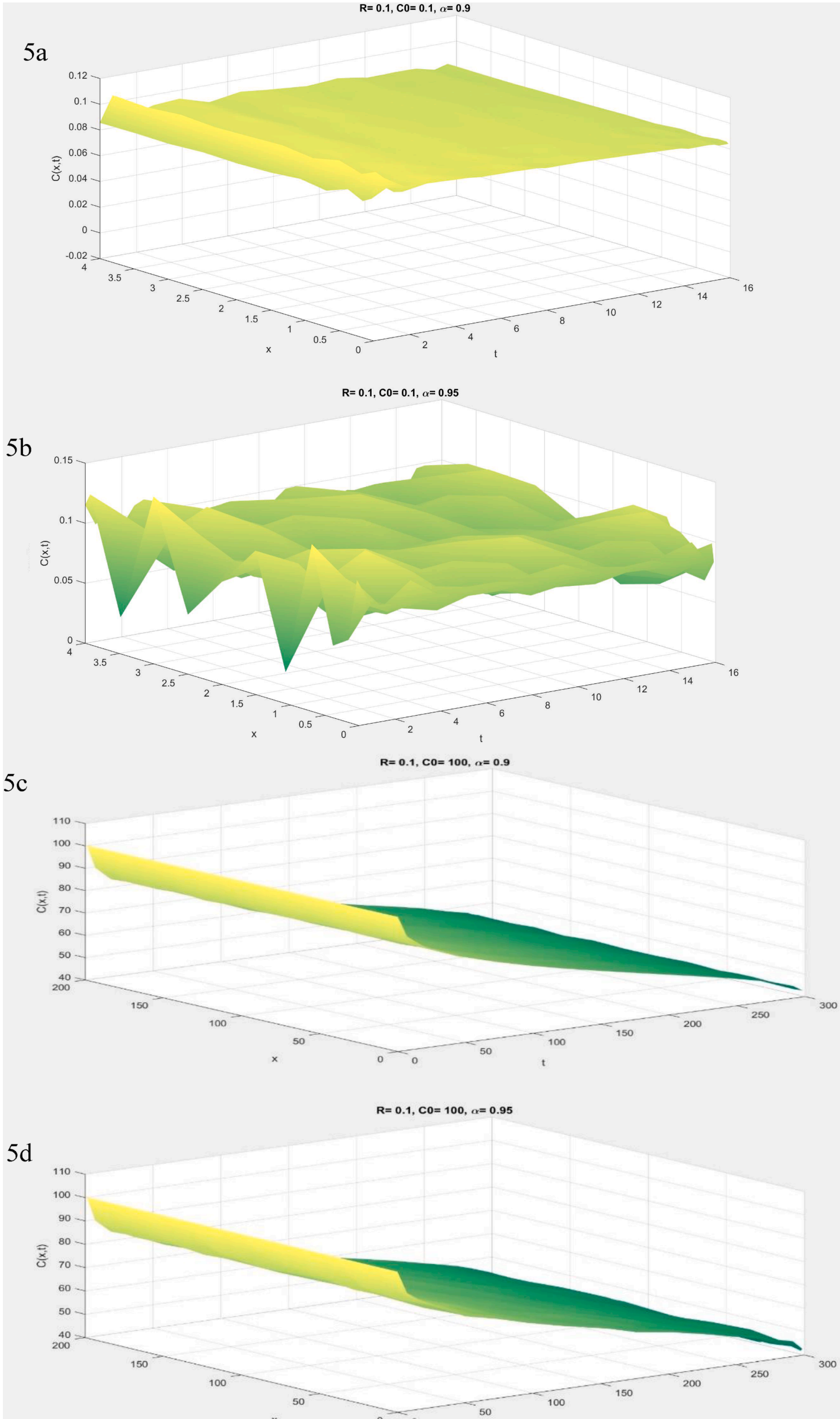


Fig. 5. Numerical solution of concentration as function of space and time for a) R = 0.1, c_0 = 0.1, α = 0.9; b) R = 0, c_0 = 0.1, α = 0.95 and c) R = 0, c_0 = 100, α = 0.9; d) R = 0.1, c_0 = 100, α = 0.95.

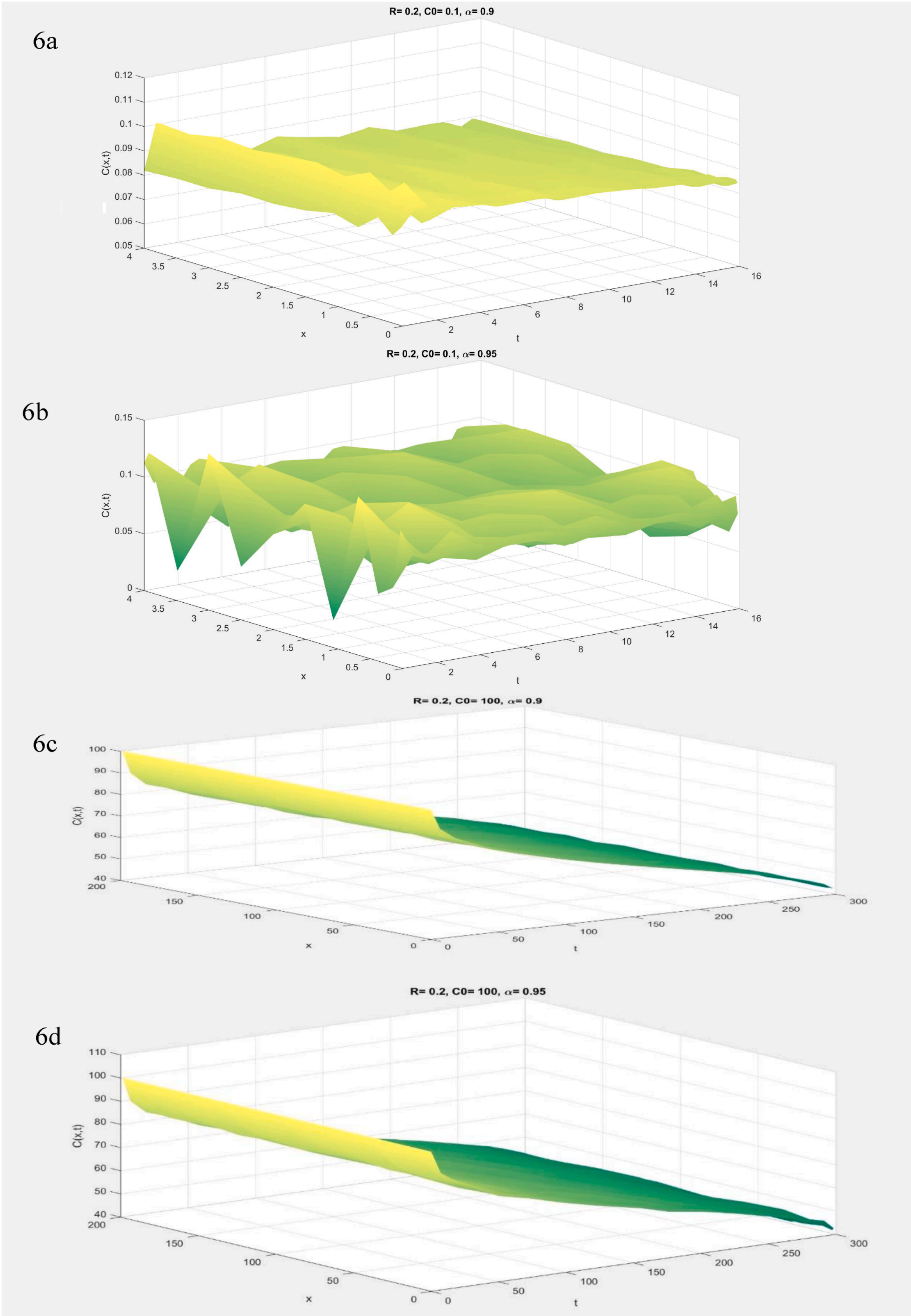


Fig. 6. Numerical solution of concentration as function of space and time for a) $R = 0.2$, $c_0 = 0.1$, $\alpha = 0.9$; b) $R = 0.2$, $c_0 = 0.1$, $\alpha = 0.95$ and c) $R = 0.2$, $c_0 = 100$, $\alpha = 0.9$; d) $R = 0.2$, $c_0 = 100, \alpha = 0.95$.

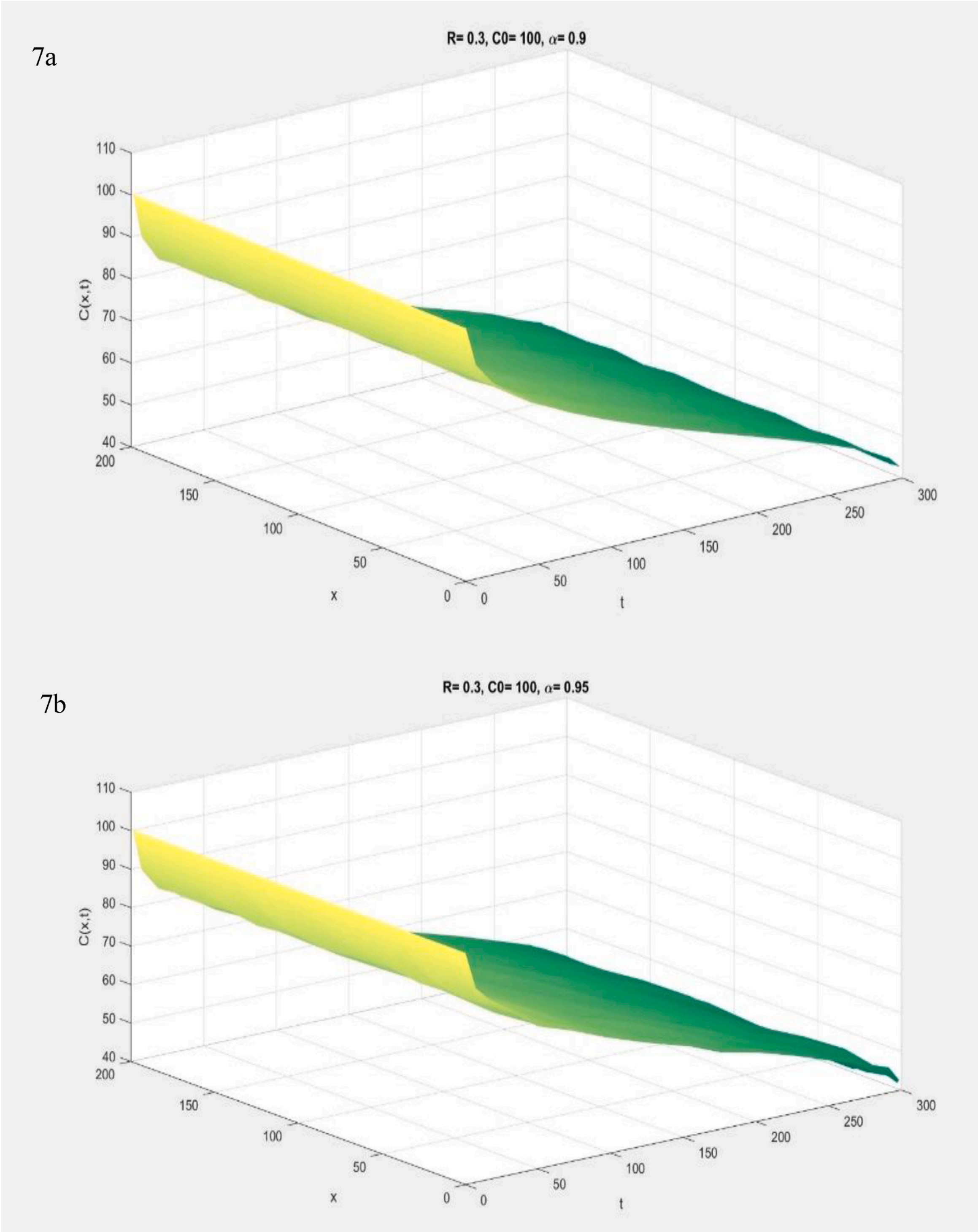


Fig. 7. Numerical solution of concentration as function of space and time for a) R = 0.3, $c_0 = 0.1$, $\alpha = 0.9$; b) R = 0.3, $c_0 = 0.1$, $\alpha = 0.95$ and c) R = 0.3, $c_0 = 100$, $\alpha = 0.9$; d) R = 0.3, $c_0 = 100$,$\alpha = 0.95$.

is believed [65,66]· Additionally, the author added that, although the government has imposed a six-feet physical distancing regulation, such may not be useful in the coastal region as the coastal winds can get stronger as we described with the mathematical model, and send viral particles soaring [65]. These arguments together with our mathematical simulations, also the results obtained by Guerrero et al and Bourouiba can help us conclude the winds have helped spread the COVID-19 virus in some places around the globe. One of the reasons could be some individual may not have been closer to infected persons with COVID-19, however due to negligence of wearing masks, especially with the believe that he or her is not 200 m closer to anyone, the person could have contracted COVID-19 through winds. While we have indicated that, wearing some specific masks for a long periods of time could lead to heath problem in future, we stress on the fact that being in outdoor without mask could be very risky and should not be recommended for any reason as far as humans are still in war against the invisible enemy called COVID-19 virus.

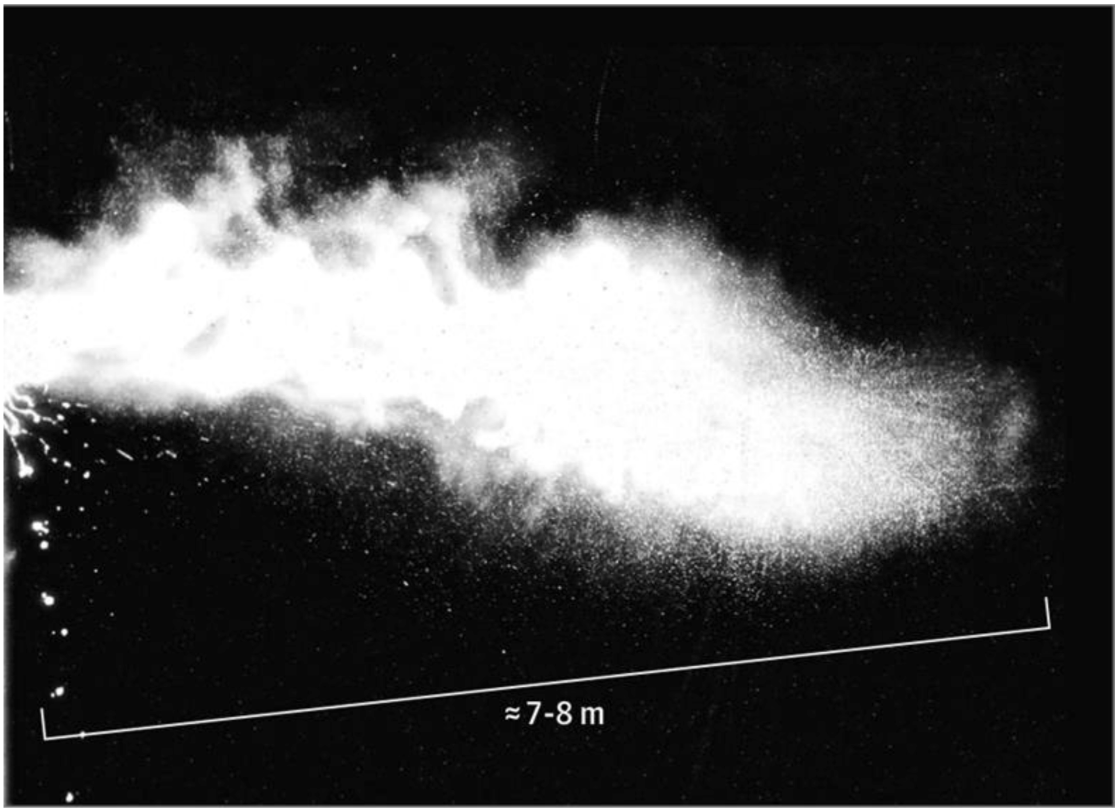


Fig. 8. Multiphase Turbulent Gas Cloud from a Human Sneeze [64].

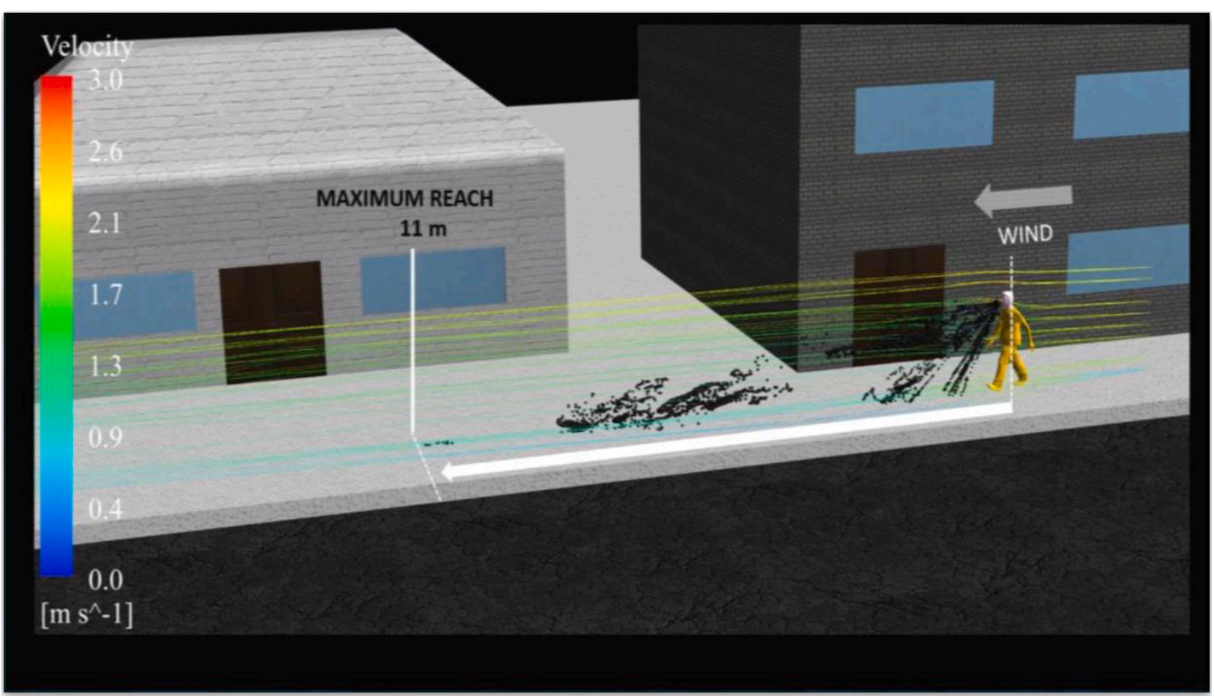


Fig. 9. Possible range of particles breathed out by a sneezing person [32].

Conclusion and recommendation

With the aim to flatten the curve of COVID-19 spread across the globe, humans from all backgrounds have put strict measures in place that could help slow or even stop the transmission of COVID-19 spread. One of these methods is the swearing of facemasks that cover both nose and mouth. This method was suggested to avoid human inhaling COVID-19 through droplets released by a sneezing infected individual. Research from virologist and epidemiologist showed evidence that mouth and nose are the primary points of transmission of COVID-19 virus, therefore covering these entries points could help reduce the spread. However, while a mouth is also considered as entry point, we could differentiate that, the nose is the main respiratory organ, through which humans even other animals inhale oxygen from external atmospheric environment and then exhale a certain quantity of CO_2, helping humans and animal to stay alive and at some extend healthy. Nevertheless, the re-inhaling the exhaled carbon dioxide using a facemask has not been taken into consideration, in particular, facemasks that do not allow a total release of exhaled CO_2 into the atmospheric environment. We stress that, excess inhaled concentration of CO_2 could lead to hypercapnia. The hypercapnia symptoms are fatigue, discomfort, muscular weakness, headaches as well as drowsiness. Rebreathing usually occur when an expired air that is rich in CO_2 stays long than normal in the breathing space of the respirator after a breath. Our investigation was first devoted to the discussion underpinning the use of appropriate facemasks, those able to release into the atmospheric environment the exhaled CO_2. Thus, to slow the spread of COVID-19 virus through airborne transmission, social distancing policy of 1.83 m was adopted, a policy that need to be scrutinized as several research indicated that, due to the weight of COVID-19, the wind could transport droplets containing transport as far as 11 m when the initial wind speed is 2 km/h. These simulations together with some information available in the literature, using some elementary concepts, presented some mathematical models able to replicate the spread of droplets containing COVID-19 concentration through wind with high speed up to 100 km/h. Several cases were considered, the wind flow to following a Markovian process meaning the wind has unit direction, the speed does not depend on space and time, but has a constant retardation factor, such that the solution of such mathematical model depends on the initial condition, the retardation factor and the generator of the solution. Secondly, we assumed the wind following a non-Markovian process, in this case, we considered three cases, first the wind flow could follow a power law process, secondly a declining memory process, and finally the wind could follow a two-states process. We used an efficient mathematical numerical scheme based on the Lagrange interpolation to provide the numerical solution to the case with fading memory and two-states process. The obtained numerical solutions were simulated using the software MATLAB with different initial conditions, retardation factors, fractional orders. The results obtained from the numerical simulation showed a possibility of the droplets being transported as far as 300 m if the wind speed happened to be 100 km/h. The results obtained by other researchers with those discussed in this paper lead us to provide the following recommendations:

- Suitable facemasks that will help release into the atmospheric environment exhaled CO_2 should be recommended, for example the full mask respirator described in Table 2i could be suggested due to the following: No jaw fatigue, no snorkel clearing, less fogging due to better air circulation, suitable for colder climates, no risk losing your regulator, can be used when u have a beard, optional under water communication.
- The use of beaches in coastal areas should be prohibited as the wave spry of the ocean could help spread droplets containing COVID-19 on beachgoers.
- In all winding regions around the world the port of facemasks outdoor should be imposed even when not in public, as droplets containing COVID-19 could be transported by wind and make a non-facemasks wearer a victim.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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