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SARS-CoV-2 Transmission Route in Wastewater and Possible Solutions

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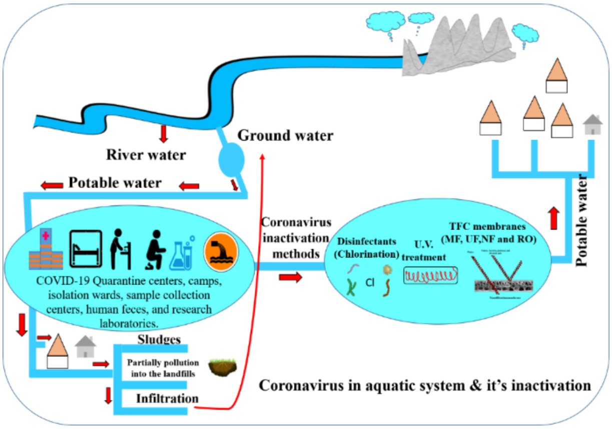

Abstract: In the view of present SARS-CoV-2 pandemic a study on the presence of this novel virus in wastewater treatment facilities is proposed. Other coronavirus species are known to survive in wastewater for days to weeks. Present data also shows that SARS-CoV-2 can be present in waste product generated by infected humans. This generated waste can be source of this virus to wastewater stream and being an enveloped virus can survive for longer period, which can be aerosolized and act as secondary transmission source. Here we propose this pathway of transmission should be rigorously studied, especially in countries like India, where minimum hygiene and sanitation can be tough to achieve because of high population density. We further propose to look into different disinfection methods, which can be most useful to deactivate this lethal virus

Keywords: Corona Virus, Pandemic, Waste Water, SARS-CoV-2

Background

Since the first reported case of SARS-CoV-2 (Generally named as COVID-19 by WHO) in Wuhan, China there has been a considerable widespread and as of 9th May,2020

39,74036 cases have been confirmed in more than 150 countries (https://www.worldometers.info/coronavirus/) Among the known coronavirus to infect human, SARS-CoV-2 is the seventh of its kind which can cause severe disease [1,2].This virus belongs to the β group of corona viruses and has human to human transmission capability [2]. Along with other viruses like Middle East respiratory syndrome virus (MERS-CoV, 2012, Saudi Arabia), and severe acute respiratory syndrome virus, SARS-CoV-2 belongs to the Coronaviridae family [3]. The size of corona virus varies between 60 to 220 nm, enveloping single stranded RNA virus with crown like spikes on their surface [4].

SARS-CoV-2 has been declared as a pandemic by WHO on January 30, 2020 and is a major disaster which shook the roots of almost all the economies round the globe. Corona viruses are very infectious, and which cause tract diseases that will be lethal mild symptoms of corona include respiratory illness, cough, and fever [5]. Severe symptoms can cause multiple organ failure and result in death (https://www.cdc.gov/)

In early January, the pandemic began to increase rapidly in many areas. On January 24, 2020, several other countries also reported the patients plagued by the identical virus. At the moment number of cases infected with SARS-CoV-2 continues to grow. The number of deaths caused by this virus exceeds the death caused by other corona viruses. The outbreak continues to be going, with a mortality rate of 16%. (https://www.worldometers.info/coronavirus/).The number of confirmed cases crossed the mark of 3 million globally April 27. Till now there's no specific treatment to cure or there's no vaccine that may cater to SARS-CoV-2. The recovery time for patients varies from 2 weeks or 3-6 weeks in severe case. People infected with SARS-CoV-2 generally develop symptoms including respiratory signs and fever on a median of 5-6 days. Symptoms and signs shown by patients are dry cough, fever, tiredness. Some patients also develop chest congestion, aches and pains, diarrhoea, runny nose, inflammatory disease.

Recently a new trend of asymptomatic patients being confirmed as SARS-CoV-2 positive. Around 82% patients are asymptomatic and thus causing increase of number of cases [6]. The human to human transmission of this virus is because of the close contact with an infected person liable to coughing, respiratory droplets of aerosols or sneezing. These respiratory droplets enter the physical body by inhalation through the nose or mouth.

COVID-19 in the Aquatic System

There are few studies which have reported the presence of corona viruses in sewage water as well as the water coming out from the hospitals from the fecal discharge of infected persons and related health workers well [3,4,7,8]. There are also few reports which have highlighted the presence of these viruses in aquatic systems and wastewater plants as well [9,10].

Wang et al., (2005) [11] had reported that SARS associated coronavirus (SARS-CoV) was found in the sewage system by the positive result of RT-PCR in the feces of SARS-CoV patients indicates that the feces of SARS-CoV patients or the sewage containing the feces can transmit SARS-CoV. They used a new type of electropositive filter media particles to concentrate SARS-CoV from sewage in two hospitals in Beijing received from SARS-CoV patients. Similarly, the laboratory studies have shown that corona virus is excreted in the feces of SARS CoV patients, in Amoy gardens, Hong Kong and possibly transmitted through the sewage system [12].Thus, there may be a high chance of persistence of SARS-CoV-2 in the water system and waste water plants as it also belongs to the same corona virus family.

Infection Through Wastewater

Previous studies reported the existence of viruses in wastewater as well as its infectious nature to human body [9,13,3]. Conferring from the literature, the virus can spread by microscopic water droplets or aerosol or faeces even enter to the air over evaporation or spray [14]. There is a report of 2003 SARS which says the aerolization of water droplets containing corona from a leaking sewage pipe in an urban area had resulted few cases in Hong Kong [3]. Again, it can be infectious through drinking water if proper disinfectants are not used. The stability of virus in this type of water will be maintained by colonizing bacteria in biofilm and it may possibly go into individual houses. There may be a possibility of aerolization of these viruses from the shower water of individuals while taking shower at their homes. Thus, the aerosols which originated from infectious water can be a potential medium in transmission to human body.

There are several factors which should be taken into consideration regarding the survival of SARS-CoV-2 in water like temperature, exposure to UV radiation, organic matter as well as microorganisms. Report says other virus like SARS-CoV, 2003 and MERS-CoV 2012 has, existence in wastewater and it also transmits through water to human body [15,16].

Table 1. Researches on virus transmission through secondary sources in different parts of world.

SL No	Virus	Country	Exposure	Year	Reference
1	SARS	HongKong	Sewage Pipe	2003	(Hung) [3]
2	Enterovirus	Australia	Untreated Sewage	2008	("AWQC, 2008.) [17]
3	Cryptosporidium	-	Storm Water	2009	(Council et al., n.d.) [18]
4	Rotavirus	-	Storm Water	2009	(Schoen et al., n.d.) [19]
5	HCoV	USA	Tap Water	2009	(Gundy et al., 2009) [20]
6	Bovinevirus	Australia	River	2010	(Hundesa et al., n.d.) [21]
7	Adenovirus	Japan	Wastewater	2013	(Lee and Park, 2013) [22]
8	Mastadenovirus	-	Storm water	2017	(Schoen et al., n.d.) [19]
9	SARS CoV-2	Netherland	Wastewater	2020	(Ahmed et al., 2020) [23]
10	SARS CoV-2	USA	Wastewater	2020	(Lodder and Maria de Roda Husman, n.d.) [24]
11	SARS CoV-2	Australia	Wastewater	2020	Wu et al. [25]

Currently studies are being carried out to develop vaccine and measures are taken to prevent the transmission of virus from human to human through direct contact. Enough focus is not given to understand the transmission through secondary sources such as wastewater. Other countries as mentioned in the Table1 have been focussing on the secondary sources like sewage and wastewater influence on the virus but the country like India lags behind.

On the other hand, we have vast population (around 1.3 Billion). Thus SARS-CoV-2 pandemic disease may raise the water demand due to the high consumption of water for washing hands for 20 seconds each time. Each day per person, at least 20 to 25 liters of water are needed. Even a family of 5 persons needs an average 100 to 150 liters of water for only hand washing to prevent the spread of SARS-CoV-2 pandemic disease. The calculation of wastewater generation is based on 90 per cent of water used, including the volume wasted when taps are on while scrubbing soap (https://www.downtoearth.org.in/). In such a case, water is the utmost necessary for controlling and avoiding contagion [26]. This situation will lead a serious issue like limited resource of water which has a threat of contamination due to this pandemic. Thus, in this present study we are recommending a study should be carried out on existence of SARS-CoV-2 in aquatic system and its transmission to human body. Further, we suggest that necessary steps should be in place to minimize SARS-CoV-2 in wastewater.

How to minimize SARS-CoV-2 in water?

The use of disinfectant in the drinking and wastewater plants must be taken into serious consideration to inactivate and kill off abroad spectrum of pathogens. Countries like the United States have taken this issue seriously and have released a new guideline from February 2020 onwards for wastewater treatment. Thus, employed the disinfection technologies, like oxidation with free chlorine or paracetic acid and inactivation by ultraviolet irradiation for wastewater management [15].

Among all the choices of disinfectants for SARS-CoV-2 in wastewater, usage of chlorine is still the best in economic point of view. Generally, the wastewater has a high percentage of ammonia. Thus, chlorine is highly reactive with ammonia to form chloramines, differentiating chlorine during disinfection. This shows the importance of understanding the chlorine/chloramines speciation and breakpoints specific to the wastewater chemistry for each facility. The optimal dose for residual disinfectants has an effective role in the drinking water systems.

Pressure related polymer membranes played a vital role in the removal of disinfection from raw water due to the higher fluxes and selectivity of the virus and disinfection of municipal wastewater.

These membrane separation processes are divided into four different types which are Microfiltration (MF), Ultra filtration (UF), Nanofiltration (NF), and Reverse Osmosis (RO) [27]. MF is a process to remove the particles having average molecular weight >400 kDa or of size varying between the 0.05 to 10 µm under an operating pressure of less than 2 bar. MF is used to remove pathogens and bacteria, also removal of turbidity and flocculants in wastewater treatment. The UF membranes are mostly used for the removal of suspended solids and disinfection. The UF membranes pore size, which in general lies between 2 nm to 200 nm and operating pressure from 1 to 10 bar [28]. UF has versatile applications like removal virus from water and wastewater treatment. However, MF and UF membranes pore sizes are relatively larger and surface encompasses imperfection which lead to virus penetration is more in filtration. The properties of NF Membranes lie between the properties of UF and RO membranes.NF membranes have a pore size between the 0.5 to 2 nm, and operating pressure varies from 5 to 15 bar [29]. Because of the smaller pore size and higher fluxes of NF membranes may accomplish removal of virus from contaminate wastewater. The rejection properties of these membranes are controlled by two different phenomena, the first one is the sieving mechanism which is suitable for the rejection of neutral components and the second one is electrostatic interaction which is suitable for the rejection of negatively charged virus i.e. charge exclusion. The ability of RO membranes to separate small solutes from water has been known for a very long time. So far, four leading pressure-driven membrane filtration technologies (MF, UF, NF, and RO) have been used for disinfection from sewage wastewater systems.

However, coronavirus has a different structure and size ranging from 60 to 220 nm and considering these properties NF membranes may perform to eliminateSARS-CoV-2 from wastewater. Sufficient research should be conducted.

Concluding Statement

There should be development of new or up-gradation of existing infrastructure near to the hot spot region of the SARS-CoV-2 for the treatment of waste water, which basically comes from hospitals and quarantine centres. In this way it can reduce the existence of virus in the aquatic system and human transmission as well.

The lowering of our activities and shutting down of our daily works affects our lifestyle and the economy of our countries but the significant use of disinfectants will increase the environmental presence of antibiotic resistant bacteria from an environmental point of view. This indirectly affects the human health and the ecosystem but from another point of view it is reducing the global emissions in the atmosphere. Are we continuing with this sustainable measurement for the betterment of the nature as well as human health system? Well in the future it's necessary for us to support the research and innovation projects that establish the integrated management of this type approaches combining the certain research areas of emerging contaminants, pathogens and antimicrobial resistance genes.

The developing countries like India have lower and insufficient water and sanitation systems which are often ineffective in comparison to developed countries. It's highly risky to find novel viruses in the places having inadequate water and sanitation systems. That's why it's an essential duty for the governments of these developed countries to financially help and support those developing countries to advance their water and sanitation systems to protect their own citizens and to have an ideal scenario. The research work to be carried out which mainly focused on the development of the health and sanitation system in order to avoid the spread of any disease like SARS-CoV-2. There should be an awareness program to be initiated by all the NGO in a public domain now onwards in this way it will create an environment in that if in near future we are going to face this kind of pandemic then we will be more sensitive towards the issue and people will have their own strategy to face the problem.

As we have already discussed the stability of corona virus is maintained by colonizing bacteria in biofilm. The distribution of water to the residential building in urban area through pipes known to have bacterial colonies as well as biofilm growth. This can be a potential medium for hosting virus and their stability. More researches should be carried out regarding this topic to prevent the waterborne viral infection.

There should be release of new regulatory guidelines for wastewater treatment and circulate to the authorities of waste water treatment plants. Large amount of water and wastewater systems should be tested and purified to monitor another wave of upsurge contagion. In addition, a plenty of research should be done on the disinfection technologies like UV-based advanced oxidation processes (UV/AOPs), ozone/biologically activated carbon (O_3/BAC), membrane bioreactors (MBR) and polymer membranes to inactive SARS-CoV-2 in water. Polymers thin films have void range of pore sizes, film forming properties, high filtration efficiency, and breathability, washable and reusable, hence in near future it can be used for face mask materials which may help may help to control the contaminants; virus and germ also protect the limiting exhaled particles and prevent users from inhalation.

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