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# Survival and Fate of Novel Coronavirus (SARS-CoV-2) in Water and Wastewater: Possible Health Concerns

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**Abstract**

The deadly Covid-19 virus is contagious in nature and spreads through human respiratory droplets. Knowing about the characteristics of coronavirus in the water cycle is critical to save human lives. Recently miniscule traces of novel coronavirus found in non-potable water samples. COVID-19 virus is also found to exist in fecal matter indicating that the disease might spread through fecal- oral transmission. It is reported that Coronaviruses can remain infectious for days or even longer periods in sewage water as well as in the potable water. Coronavirus-infested water is a possible agency for human exposure and further transmission of disease. Essentially, the persons working at the wastewater/ sewage treatment plants must use standard hygiene practices, and sports personnel protective equipment to avoid viral infection. Though most water treatment practices are believed to kill or remove coronaviruses effectively in drinking and wastewater, but their effectiveness against SARS-CoV-2 needs extensive research. By maintaining the hygienic conditions and providing the amenities of clean drinking water, one can deal with any contagious disease including COVID-19. Keeping above in view, in this paper highlights the survival and fate of novel coronavirus (SARS-CoV-2) in water and wastewater and discuss the possible health concerns, besides the importance of wastewater-based epidemiology (WBE).

**Keywords:** novel coronavirus, SARS-CoV-2, health concern, wastewater based epidemiology

## 1. Introduction

First case of Corona virus disease 2019 (COVID-19) was reported in December 2019 in Wuhan, China. Since then, it has proliferated in the whole world with lakhs of confirmed cases and many deaths so far. This disease is marked by respiratory manifestations. Although this virus spreads through droplets and close contacts, there is possibility of its transmission through fomites, faecal excretion and environmental contamination (Ong et al.2020). During this pandemic, there are many reported cases of gastrointestinal symptoms and presence of virus RNA in anal swab or fecal matter of sick persons (Holshue et al., 2020; Xiao et al., 2020) indicating that the fecal-oral transmission could be the other possible route. Yeo et al. (2020) has apprised that in areas with improper sanitation facilities, fecal-oral transmission could be quite challenging to manage.

Environmental surveillance by examining wastewater for the detection of viruses in an area i.e. Wastewater based epidemiology, can be used to study coronavirus circulation in an area with great precision (Xagoraraki et al.2020). The presence of the virus can be seen early in wastewater whereas an affected person may takes 3 to 14 days to exhibit symptoms. This will help policy makers to monitor the disease transmission within a community, especially in densely-populated areas.

The Coronavirus presence in wastewaters has been recorded at Australia (Ahmed et al., 2020), Italy (La Rosa et al.2020), China (Bar-or et al., 2020), the United States (Nemudryi et al., 2020; WU et al., 2020), France (Wurtzer et al 2020), the Netherlands (Medema et al., 2020), Japan (Haramoto et al.2020, and Spain (Randazzo et al, 2020). These findings strongly suggest virus monitoring in the population as an early warning sign. It also suggests that the wastewater workers should practice basic hygiene precautions, use standard practices and wear personnel protective equipments, while on work. The Indian Institute of Technology, Gandhinagar, in a first-ever successful Indian effort to build an early warning system for Covid-19, has undertaken surveillance of sewage water to quantify excretion of the Sars-CoV-2 virus. This study being the first from India, and among the first ten worldwide of coronavirus gene detection in the environment. (Manish Kumar et al.2020)

These studies shows that, although the information on the presence of SARS-CoV-2 in sewage is scarce, the virus is being monitored by scientists in the water environment (WHO, 2020). To collect information on the occurrence and fate of the virus in sewage is necessary to know about the risk involved to the sewage workers or the chances of this virus making entry into the water cycle and contaminate the same. The virus can stay longer in the supply network by associating with bacteria in biofilms and it could even reach houses and may result in release of virus-containing droplets from showerheads (Casanova et al. 2009; Regan et al.2020). If aerosols are generated, there is a greater threat of viral spread on human exposure (Hung et al. 2003, Casanova et al. 2009). Previously, the leaking sewer was reportedly responsible for the SARS virus spread through bioaerosols, in Hong Kong (Watts, 2003; Yu et al., 2004), now the same is indicated for CoV-2 as well (Ong et al. 2020). Therefore it becomes important that the sewage workers should use standard practices, wear personnel protective equipment and practice basic hygiene precautions for work.

In the absence of disinfection, Coronaviruses can survive for long in wastewater and drinking water (Ellenberg et al.; 2016, Choudry et al. 2019). In a study on coronaviruses survival, it was found that temperature and organic matter content greatly affected their inactivation, light exposure (UV or solar inactivation), and the presence of antagonist microorganisms (Naddaeo et al. 2020). Again it was observed that the coronaviruses persisted longer at $4^0$C compared to

$20^0$C in household wastewater, hospital effluent, and drinking water lacking chlorine; and that free chlorine inactivates SARS-CoV faster than chlorine dioxide (Gundy et al.2009). Luckily the water treatment procedures can kill or remove coronaviruses effectively in drinking and wastewater, but their effectiveness against SARS-CoV-19 is yet to be proved. After 30 min of contact period of 10 mg/L chlorine, SARS-CoV could be totally inactivated in the above case, the residual chlorine was found to be greater than 0.4 mg/L.

## 2. SARS-COV-2 in Water Environment

As CoV-2 can sustain itself in situations that supports transmission through fecal to oral pathway, the virus could also spread possibly via this channel, as indicated by some studies (Yeo et al., 2020; Heller et al., 2020; Kitajima et al., 2020). In view of this fact, the chances of the viral entry into the sewage treatment systems cannot be ruled out, especially in areas with improper sanitation facilities. The threats to human health depend on the survival of SARS-CoV-2 in water domains. The conventional water treatment techniques using sedimentation, filtration, and chlorination could disable the virus. Knowing about the fate of SARS-CoV-2 in a water environment may help in adopting proper control measures and sewage treatment methods.

### *2.1 SARS-COV-2 RNA Detection in Wastewater*

The presence of coronavirus-2 in sewage has been established worldwide. In France, 31 samples of wastewater before and after treatment were collected from the Parisian area by Wurtzer et al. (2020). Reduction in viral concentration was observed after treatment. The rise in COVID-19 infection cases strongly correlated with an increase in viral RNA in the untreated sewage. In Paris, minuscule traces of coronavirus were found in non-potable water samples. A little amount of virus was found in 4 out of 27 non-potable water samples tested. The reason for the virus presence in the non-potable water could not be explained. In the Netherlands, Gertjan M. (2020) found viral RNA in 14 out of 18 sewage samples (77.8%), after the first cases of COVID-19 was reported. The Amsterdam airport wastewater sample tested positive for the virus indicating the possibility of fecal- oral transmission. Wastewater from 7 towns and the airport were collected for virus detection, no viral particle was found in February 6 samples i.e. 21 days before reporting of the first case in the Netherlands on February 27. The viral gene was found in samples of five and six sites on March 5 and on March 15-16 respectively. This was the first reporting of SARS-CoV-2 in sewage.

Giuseppina et al. (2020) reported Coronavirus-2 from water domains in Italy. Twelve sewage samples from Milan and Rome Wastewater Treatment Plants were lifted during February to April 2020. Coronavirus-2 found in 250 mL of sample from high epidemic (Milan) and low epidemic area (Rome), in 6 samples out of 12. Viral RNA was also found in a sample that was taken after few days of reporting of the first Italian case of SARS-CoV-2 in Milan. In this study, considering the safety concern of the laboratory workers, samples were heated for 30 minutes at $56^0$ C, before the centrifugation step to limit the viral virulence by over 5 log without distressing its RNA (Wang et al., 2020, WHO, 2003) The study projected Wastewater Based Epidemiology as an effective way to observe pattern of virus presence in an area. 5.38 log genomic copies/L of the Coronavirus-2 RNA was estimated in raw sewage from two Spanish areas by Randazzo et al. (2020). Two treated effluent samples, out of 18, were positive and all twelve final effluent samples after chlorination were negative for viral genome. Nine sewage samples (100–200 ml), concentrated by using electronegative membranes, tested the concentrates with RT-qPCR, obtaining confirmed result at a small concentration of 1.2 and 1.9 genomic copies/100 ml and with only one set of primers (Ahmed et al. 2020)). Coronavirus-2 was detected (roughly 100 copies/ml) by Wu et al. (2020) in all the 10 samples of Wastewater Treatment plants in the USA (Massachusetts). On storing them for 24 h and for 7 days at 4 °C, the same result was obtained. Nemudryi et al (2020) in the USA (Montana), lifted 7 samples of wastewater which were found to contain 100 to 2000 viral RNA copies/L.

To build a timely alert mechanism for Covid-19 and to appreciate the role of WBE in India, the Indian Institute of Technology Gandhinagar undertook surveillance of sewage water. Samples were collected from a Gujarat WWTP on 8 and 27 May, 2020. The 28 million gallons per day (MGD) WWTP receives wastewater from Civil Hospital handling COVID-19 patient. In a first-ever successful endeavor, a number of gene copies correlated strongly with that recorded in the wastewaters of China, Turkey and Australia and found to be less than the USA, France and Spain. Ten times hike in gene copies i.e. 0.78x102 and 8.05x102 copies/L, was noticed on 8 and 27 May, which corresponds to the COVID-19 cases in Ahmedabad i.e. 4912 and 10674 patients respectively. This study being first from India of SARS-CoV-2 gene detection in the environmental domains, focussed at making surveillance plans for early detection of the virus in a community.

The viral detection, during low COVID-19 occurrence, suggests the use of wastewater surveillance as an effective way to study the viral occurrence in an area and as pre alert system for rising cases in near future in unaffected areas. It also advocates that the wastewater workers should practice basic hygiene precautions, use standard practices, and wear personnel protective equipment for work related tasks.

### *2.2 Importance of Wastewater Based Epidemolog*

Most of the patients, with or without symptoms, discharge virus in the fecal matter, even after they have recovered from the infection (Wu et al., 2020). This contributes to the viral load in the wastewater treatment plants (Haramoto et al., 2020). According to Zheng et al. (2020), the viral gene can remain present in feces for average period of 22 days, indicating the possibility of its detection in the wastewater. The WBE accuracy is subject to the viral gene presence in affected person’s fecal matter. As per recent studies, coronavirus-2 was found in sewage, whenever 1-100 positive cases were reported per 100,000 of persons (Ahmed et al. 2020, Bar-or et al. 2020, Medema et al. 2020, Wurtzer et al. 2020, WU et al. 2020, Nemudryi et al.; 2020). As the virus can be spotted in feces two to three days before symptoms appear in humans, the environmental surveillance may be used as a sensitive tool, as the amplified positive cases will ensure the increased virus content in the wastewater, and can be considered as an alert sign for the spread of infection in an area (Wurtzer et al.2020; Ahmed et al., 2020). Recently, the Indian Institute of Technology Gandhinagar conducted a study of sewage water to quantify excretion of the coronavirus-2, to appreciate the use of WBE surveillance in India. Results of the study proved its capability in native setup and supported its implementation in monitoring of COVID in India.

*2.3 Human Exposure Threats and Health Concerns*

Since the coronaviruses can remain active for a long period, the aerosol to human passageway is considered significant as the water polluted by coronaviruses may cause infection in people on aerosol development. This phenomenon was responsible for the community spread of SARS, from a leaking sewage pipe in a Hong Kong housing complex in 2003, (Watts et al. 2003; Yu et al.2004). Moreover, coronavirus may enter into drinking water distribution systems if the residual disinfectant amount is low, in this case, the viral constancy is upheld by bacterial cohabitation in biofilms, and the virus could even enter individual homes from there (Wigginton et al. 2015). There are chances of emergence of virus-laden water from showers as well (Hung et al.2003; Casanova et al.2009) Knowing about the presence and fate of SARS-CoV-2 in water environments, and about different treatment approaches for its removal will definitely equip the authorities for controlling the pandemic in an efficient way.

*2.4 Survival and Persistence*

The coronaviruses-2 is unstable in the surroundings, is vulnerable to disinfectant and has a breakable outer membrane. Their morphology and chemical structure is similar to those of other surrogate human coronaviruses on which information is already available on endurance in the surroundings and disinfection techniques (WHO, 2020). The coronavirus persistence in case of improper sanitation increases the probabilities of the infection spread (Casanova et al.2009, Wigginton 2015). Based on the findings of the previous studies, it can be assumed that it is easier to destabilize this virus as compared to other enteric viruses such as adenoviruses and hepatitis-A (Ellenberg 2016).

Wang et al. (2005) studied the existence of SARS-CoV in various environments and found that a surrogate human coronavirus survived longer at $4^0$C (14 days) compared to 20° C (2 days) in hospital wastewater, municipal supply, and in domestic sewage. The same study also dealt with the impact of the contact period of SARS-CoV in sewage with different chlorine and chlorine dioxide concentrations. It was found that the free chlorine was a better choice in destabilizing SARS-CoV than chlorine dioxide. Residual chlorine of >0.5 mg/L and chlorine dioxide of 2.19 mg/L in sewage were enough for their inactivation (Li et al. 2002; 2004) Environmental factors like temperature may have an impact on the existence of the virus in water. Gundy et al. (2009), in an experiment to determine the survival of representative coronaviruses, observed that the inactivation of coronavirus relies heavily on temperature, organic substances, and occurrence of hostile bacteria. Coronavirus is disabled in ten days at $23^0$C, as compared to >100 days at $4^0$C, Coronavirus are inactivated quickly in sewage, with $T_{99.9}$ value (i.e. the period in which the viral load reduces by 99.9%) of 2 to 4 days. The study demonstrated that in the aqueous environment, the transmission of coronavirus would be less than enteric viruses as the coronavirus are incapacitated faster in the aqueous environment at normal temperature. There is need for further studies to examine tenacity of CoV in water with reference to different environmental situations. As per previous data; various degrees of inactivation exists for CoV depending on the kind of virus and water. Also CoV is unsteady in the atmosphere and is vulnerable to disinfectants like chlorine, as compared to non-enveloped viruses (WHO 2017)

*2.5 Inactivation Techniques*

The recent pandemic stresses upon the significance of disinfection in saving human lives. As far as the selections of disinfectant is concerned, chlorine is the top cost-effective choice. The role of the proper dosing of disinfectant is crucial for water supply network. Coronaviruses could be totally disabled with more than 10 mg/L chlorine and 30 minutes of contact period (greater than 0.4 mg/L residual chlorine). (Wang et al. 2005).

The membrane bioreactors (MBRs) could be crucial in the effective reduction of coronaviruses in Sewage Treatment Plants, (Chaudhry. 2015; Bodzek et al. 2019) Effluent was collected from a clinic in China by Wang et al. (2020) and was treated with different doses of sodium hypochlorite 5 samples were tested with RT-qPCR (3 without any treatment and one each at different treatment steps). The inlet sample and the one after preliminary disinfection step were positive, the sample after final disinfection was negative for coronavirus. For effective disinfection, the residual chlorine should be ≥0.5 mg/L after contact period of 30 minutes at pH < 8.0. It is important to maintain chlorine residual all over the supply network (WHO, 2017).

In areas lacking centralized water facilities. various point of use water treatment technologies including ultrafiltration or Nano membrane filters, solar treatment; and in case of clear water, UV and chlorine treatment are effective in destroying viruses (Duan 2003; WHO 2017).

## 3. Safety Precautions

The recent pandemic stresses the importance of disinfection in human health protection. As indicated by coronavirus related record from medical field, it can be safely assumed that the disinfection techniques, like chlorination and inactivation by ultraviolet irradiation, used at wastewater treatment plants, are effective in protecting the health of wastewater workers and the public, from coronavirus (OSHA 2020). The SARS-CoV-2 morphology resembles the other humanoid coronaviruses and it can survive and multiply in the absence of proper disinfection. Sufficient data is available on survival and inactivation methods for coronaviruses. Thus WHO guidelines on protection against COVID-19 virus in water environment is based on that data. (WHO, 2020)

In view of the above reports, it is required that the sewage workers should practice basic hygiene, use standard practices, take necessary precautions and wear personnel protective equipment (PPE). The significance of regular and proper hand hygiene should be stressed upon and touching face should be avoided with unclean hands during work tasks. (WHO, 2020)

## 4. Conclusion

With evidences of fecal elimination of SARS-CoV-2, concerns on its possible secondary transmission through water are increasing. The research findings on its extended persistence in colder ambience, indicates the probability of its presence in the sewage treatment facilities, that too in a virulent form, in cool climates. However, very less information is available on this aspect. Initially, it was believed that as enveloped viruses are unable to stay alive for long in the water, the SARS-CoV-2 virus cannot spread via this route. The idea of its non-existence in our surroundings needs further research on this topic, as SARS-CoV-2 RNA has been reported in sewage by various scientists.

The current situation and rapid spread of the virus calls for fresh concern on looking for its presence in water environments. Currently the presence of coronaviruses in water sources or its transmission via polluted water is nowhere indicated. The lack of data about survival and fate of the virus in the surroundings demands immediate investigation in this area. The survival capability of CoV in water can be affected by temperature. More research work is needed to investigate tenacity of SARS-CoV-2 in water with reference to seasonal and climatic conditions. For this effective ways for concentrating and testing encased viruses from water need to be developed. Depending on the virus and the water type, various viral inactivation rates exists for CoV as shown in various studies. There is evidence that coronaviruses are not stable in the atmosphere and vulnerable to oxidants like chlorine as compared to non-enveloped viruses. Also, there is an urgent need to evaluate the effectiveness of water treatment methods to avoid contamination from virus-infested wastewater; and setting up of a surveillance system for sewage monitoring. Presently, the increasing use of disinfectants, bactericide and virucides will add to the antibiotic-resistant bacterial presence in the surrounding. This will indirectly affect the human health and the ecosystems, which needs an in-depth study. The quantum of health hazards depends on the existence of COVID-19 virus in water. Knowing about the viral RNA fate will eventually improve regulatory mechanisms and sewage treatment techniques.

The ongoing pandemic can be dealt with by adopting certain safeguards and assuming that its further spread is possible. It is required that the wastewater workers should take necessary precautions for work related tasks. Luckily most water treatment practices are able to remove coronaviruses effectively from drinking water and wastewater, however their effectiveness against SARS-CoV-2 need research. The COVID-19 virus is vulnerable to chlorine and other disinfection methods as compared to other viruses as these are enclosed by a lipid host cell membrane. For disinfecting the drinking water in individual households, light emitting diode (LED)-based UV point-of-use systems are quite helpful. Furnishing clean water, sanitary and germ-free conditions can safeguard from any contagious disease and COVID-19 is no exception.

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