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Survival of SARS-COV-2 in untreated and treated wastewater—a review

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8.1 Introduction

Since the first reported case of SARS-CoV-2 in Wuhan, China on December 2019, there has been a considerable widespread of this disease (generally named as COVID-19 by WHO) and as on September 4, 2020 26.4 million confirmed cases have reported, 870K people have died, in more than 150 countries (WHO, 2020). This SARS-CoV-2 belongs to the Coronaviridae family and has human to human transmission capability. The size of corona virus varies between 60 to 220 nm, enveloping single stranded RNA virus with crown like spikes on their surface (La Rosa et al., 2012, 2020). SARS-CoV-2 has been declared as a pandemic by WHO on January 30, 2020. This virus is very infectious, and cause tract diseases that will be lethal (Yang et al., 2020). Recently, a new trend of asymptomatic patients is being confirmed as SARS-CoV-2 positive. Approximately 82% patients are asymptomatic and thus leading to a rapid increase in infected cases (WHO, 2020).

The virus transmits human to human through coughing, sneezing or via respiratory droplets by close contact with an infected person. These respiratory droplets enter to the human body by inhalation through nose and mouth. Unprecedented measures like social distancing, closing of school and workplace, and restriction on intra- and international movement have imposed by worldwide governments to stop the spread of SARS-CoV-2 and the world adapt to all the preventive measure imposed by respective governments. Several researches have reported the survival and transmission of this novel virus through the secondary sources like wastewater (Lodder and Husman, 2020; Mallapaty, 2020). The wastewater collection and treatment are the essential municipal services. This is routine and crucial, which can play a vital role in transmission of the virus. Thus, government should mention this in public health issues and impoverished the waste management and water treatment plan accordingly for the safety measures.

This article is a mini review to address the proof of survival of SARS-CoV-2 and related corona viruses (CoVs) in wastewater worldwide. Further the study discussed human exposure of SARS-CoV-2 through wastewater and addressed the major issues in the developing nations that are expected as a secondary transmission medium of SARS-CoV-2.

8.2 SARS-COV-2 in treated and untreated wastewater

Several researches have reported the CoV trace in wastewater, which comes from the hospitals especially from the fecal discharge of infected persons and related health workers (Hung, 2003; La Rosa et al., 2012; Leung et al., 2003). Growing concern on this issue also supported by the studies, which are emphasizing the presence of this viruses in aquatic system and wastewater plants (Casanova et al., 2009; Fong and Lipp, 2005). Wong et al. (2013) had reported

the existence of CoVs in wastewater during 2013. Recently, [Blanco et al. \(2019\)](#) investigated the molecular detection of animal CoV belonging to the genus Alpha corona virus in Saudi Arabia's surface water ([Blanco et al., 2019](#)). During severe acute respiratory syndrome (SARS) outbreak in China, SARS-CoV RNA was detected in untreated wastewater (10/10; 100%) and disinfected wastewater (3/10; 70%) samples of Beijing, China hospital ([Kitajima et al., 2020](#)). Minute traces of SARS-CoV-2 were found in the nonportable water supply in Paris, as claimed by the city water authority of France, in April, 2020. Simultaneously around 440 people were likely SARS-CoV-2 positive in the area near to a wastewater treatment plant in the USA, reported by Massachusetts Institute of Technology (MIT) along with Biobot Analytics, a biotech startup and Brigham and Women's Hospital. The infection may be due the presence of the virus in aquatic system and posing more health risk in rural and impoverished communities ([Naddeo and Liu, 2020](#)).

There are numerous reports, emerged from different countries regarding molecular detection of SARS-CoV-2 in untreated and treated wastewater ([Table 8.1](#)). The number of samples collected, and percentage of positive

TABLE 8.1 Presence of SARS-COV-2 in treated and untreated wastewater and primary sludge, reported from different countries worldwide.

Country	State/City	Water type	Virus concentration method	Positive results of samples in %	References
Australia	Brisbane, Queensland	Untreated wastewater	Electronegative membrane-direct RNA extraction; ultrafiltration	2/9 (22%)	Ahmed et al., 2020
The Netherlands	Amsterdam, The Hague, Utrecht, Apeldoorn, Amersfoort, Schiphol, Tilburg	Untreated wastewater	Centricon (Merck) ultrafiltration of centrifugated supernatant	14/24 (58%)	Medema et al., 2020
USA	Massachusetts	Untreated wastewater	PEG precipitation of filtered sample	14/14 (71%)	Wu et al., 2020b
	Bozeman, Montana	Untreated wastewater	Corning Spin-X ultrafiltration of filtered sample	7/7 (100%)	Nemudryi et al., 2020
	New Haven, Connecticut	Primary sludge	Direct RNA extraction	44/44 (100%)	Peccia et al., 2020
France	Paris	Untreated wastewater	Ultracentrifugation	23/23 (100%)	Wurtzer et al., 2020
		Treated wastewater		6/8 (75%)	
Italy	Milan	Untreated wastewater	PEG/dextran precipitation of centrifuged supernatant	6/12 (50%)	Usman et al., 2020
Japan	Yamanashi	Secondary-treated (before chlorination) wastewater	Electronegative membrane vortex (EMV)	1/5 (20%)	Haramoto et al., 2020
China	Wuchang Fangcang Hospital	Treated wastewater	PEG precipitation of centrifugated supernatant	7/9(78%)	Zhang et al., 2020
Israel	Various locations	Untreated wastewater	Primary: PEG or Alum precipitation of centrifuged supernatant. Secondary: Amicon ultrafiltration	10/26 (38%)	Bar Or et al., 2020
Spain	Valencia	Untreated wastewater	Aluminum flocculation—beef extract precipitation	12/15 (80%)	Randazzo et al., 2020
		Treated wastewater		0%	
	Murcia	Untreated wastewater	Aluminum flocculation—beef extract precipitation	64%	Randazzo et al., 2020
Treated wastewater	27% (Secondary) 0% (Tertiary)				
	Ourense	Untreated wastewater	Amicon ultrafiltration of centrifugated supernatant	100%	Balboa et al., 2020
		Treated wastewater		0%	
Turkey	Istanbul	Untreated wastewater	Amicon ultrafiltration OR PEG precipitation of centrifugated supernatant	7/9 (78%)	Kocamemi et al., 2020
India	Ahmedabad	Untreated wastewater	PEG precipitation of centrifugated supernatant	100%	Kumar et al., 2020
		Treated wastewater		0%	

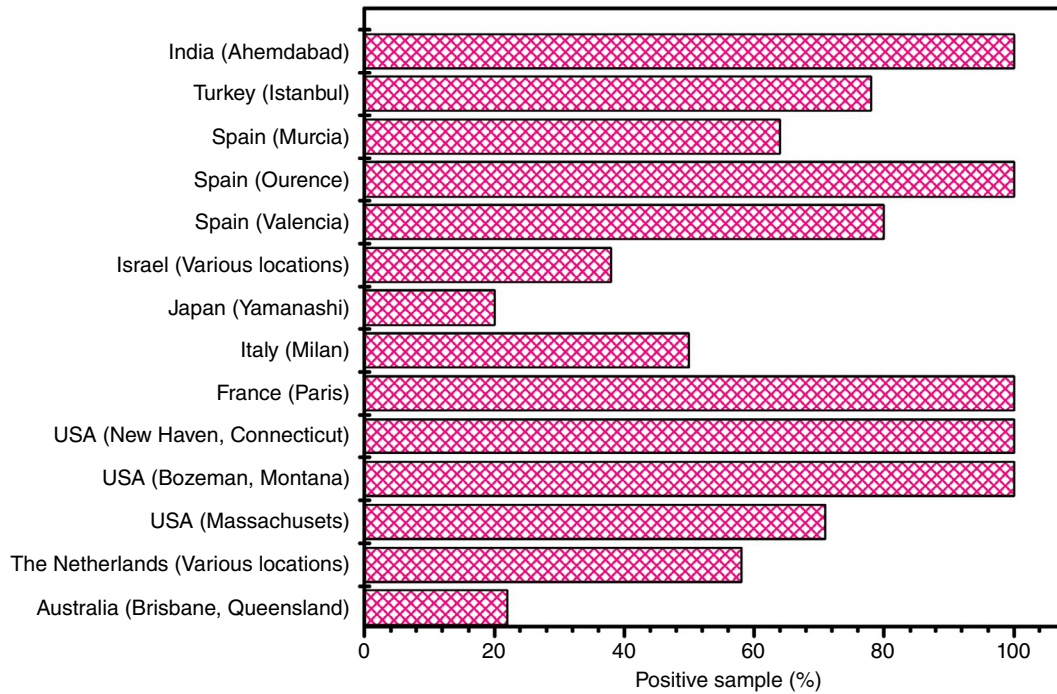


FIG. 8.1 A comparison of the COVID-19 detected in untreated wastewater, from different countries (Ahmed et al., 2020; Medema et al., 2020; Wu et al., 2020b; Wurtzer et al., 2020; Nemudryi et al., 2020; Randazzo et al. 2020; Kumar et al., 2020).

samples detected in untreated and treated wastewater is provided (Table 8.1 and Fig. 8.1). A maximum level 106 and 105 copies/L of SARS-CoV-2 RNA was detected in untreated and treated wastewater, respectively (Kitajima et al., 2020). Detection of SARS-CoV-2 RNA in treated wastewater was reported in China and Spain. Similar findings were observed from the study made in Spain and India (Randazzo et al., 2020; Kumar et al., 2020) and it was observed that the positive rate of the samples is reduced after secondary and tertiary treatment (Fig. 8.2) by several processes like decantation, coagulation, flocculation, sand filtration, thermal hydrolysis, activated sludge and disinfection by NaClO or peracetic acid or UV. Spain (Murcia, Valencia, and Ourense) has reported 64%, 80%, 100% and India (Ahmedabad) has 100% of positive signatures in untreated wastewater samples (Fig. 8.1). However after the waste water treatment by activated sludge (A2O process), disinfection using NaClO and thermal hydrolysis in Spain (Murcia and Ourense) (Randazzo et al., 2020) and also in India (Ahmedabad) by UASB treatment and aeration pond (Kumar et al., 2020); the SARS-CoV-2 RNA was significantly reduced with 0% of positive samples (Fig. 8.2). Though the treatment mechanism for each genotype must be brought out with several replications. It was initially promising to advice 100% of virus removal by the mechanisms adopted in studies for the samples from Spain (Valencia, Murcia, and Ourense) and India (Ahmedabad).

8.3 Transmission through wastewater

One of the scientific evidences proves the existence of virus in water and wastewater and its infectious nature to human (Choudri and Charabi, 2019). Since the CoV can sustain for a longer period in water and wastewater, it can be a potential medium for human exposure if it is aerosolized (Hung, 2003; Casanova et al., 2009). There was a report during 2003 SARS outbreak that states, the aerosolized water droplets from a leaking sewage pipe in an urban area contains CoV, which had resulted cluster of cases in Hong Kong (Hung, 2003). It was also noticed that virus transmission through drinking water is possible, if proper disinfectants are not used. The virus could multiply by colonizing bacteria in biofilm through distribution systems and enter into individual homes (Naddeo and Liu, 2020).

The current global pandemic has been focusing on preventing person to person transmission. Based on the earlier research findings, there is every possibility of SARS-CoV-2 spread through wastewater by aerosol formation.

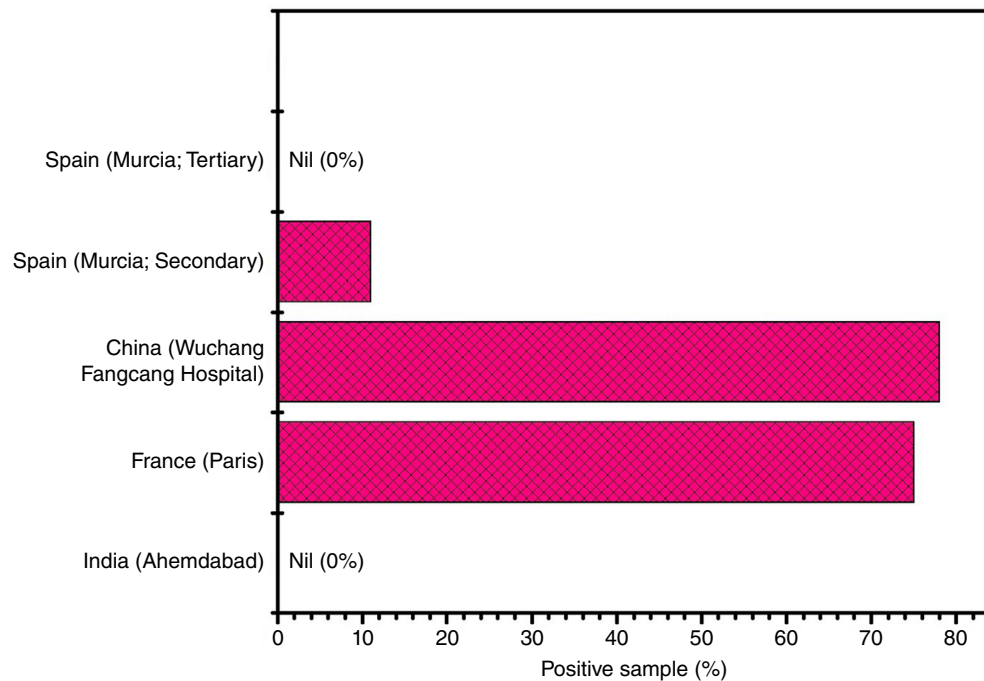


FIG. 8.2 A comparison of the COVID-19 detected in treated wastewater, in different countries (Randazzo et al., 2020; Zhang et al., 2020; Wurtzer et al. 2020; Kumar et al., 2020).

A study by Quilliam et al. (2020) states that the virus can transmit via wastewater through aerosol formation from wastewater treatment plants or waters used for both open sewers and domestic water sources. SARS-CoV-2, transmission through aerosol has recently been reported by two hospitals in Wuhan (China) (Liu et al., 2020). Aerosol and total suspended particle samples were collected and analyzed by University of Nebraska Medical Centre (Omaha, USA). They have reported that, out of sample analyzed 63.2% samples show positive for SARS-CoV-2 and RNA level ranged between 2 and 9 copies/L (Santarpia et al., 2020). The possible transmission of the virus through sewage, contaminated water, air condition system and aerosols to human body is reported by Yuen et al. (2020) after Diamond Princess cruise incident. They have reported 742 passengers confirmed cases of SARS-CoV-2 and as one of the super spreading events. There are also possibilities of transmission of SARS-CoV-2 through environmental surfaces (fomites), aerosols and the fecal–oral route (Long et al., 2020). Thus, specific measures to mitigate SARS-CoV-2 must be taken before waste and wastewater collection in order to avoid the transmission.

8.4 Impact

Atmospheric water droplets from wastewater it not well understood but might give a further direct respirational path for human exposure, especially at sewage pumping station and wastewater treatment plants. It is highly risky if there is survival of novel viruses in the wastewater system of the developing countries with inadequate water and sanitation systems and high levels of open defecation. The situation becomes critical, when water channels are used as both open gutters and domestic waters. Such settings are generally accompanied by poorly resourced and fragile healthcare systems, thus augmenting both exposure risk and potential mortality.

Several countries (Residence of around 2 billion people) now face severe water scarcity, and around 4 billion people face rigorous water paucity at least a month of the year (World Water Development Report 2019). There are few examples like Chennai in India, Cape Town in South Africa, and Mexico City in Mexico, which at a risk of severe water scarcity. The inefficient sewage-management infrastructure could worsen the impact of SARS-CoV-2. The wastewater from sewerage (untreated) finds its mode into polluted water bodies that are proliferation for every types of pathogens, which may raise the water borne pandemic. In such a case, water is the utmost necessary for controlling and avoiding contagion. This situation will lead a serious issue like limited resource of water, which has a threat of contamination.

8.5 Future research needs to be carried out

Research is required to develop new infrastructure for the wastewater treatment in hot spot regions and to revise the existing guidelines for the inactivation of the virus to minimize contagion and secondary transmission. Additional revisions in the regulatory guidelines for wastewater treatment and circulate to the authorities of existing wastewater treatment plants. Large amount of wastewater should be tested and purified to monitor another wave of upsurge contagion. The change in wastewater management policy and guidelines is the need of the hour especially in the developing countries. Understanding the effectiveness of the emerging disinfection technologies for the virus inactivation is an important research need. Another important research area needs to be focused is distribution of drinking water systems. The major distribution systems are likely service line pipes and premise, plumbing in residential buildings, which are at a risk of developing bacterial colonies and biofilm growth. Studies must determine if these biologically active systems host viruses and impact their viral stability. The development of the wastewater management, treatment guidelines and changes in dependent policies along with health and sanitation system in order to prevent the spread of any such disease is another important research need to be focused. An awareness program needs to be initiated by all the NGO in a public domain, which will help to sensitize people toward the issue to come up with their own strategy to face the problem.

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Conflict of interest

Authors declare that there is no conflict of interest.

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