Review Article

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What Do We Know About the Impacts of Novel Coronavirus (SARS-Cov-2) on Freshwater Ecosystems?

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ABSTRACT

The coronavirus pandemic (COVID-19), which has numerous effects in the world, has crucial importance for water resources. The COVID-19 pandemic has had an unpredictable impact on worldwide societies and the economies. On the other hand, lockdown and isolation implemented due to pandemic have decreased environmental damage such as air pollution and gas emissions. However, its unexpected effect was the increase of plastic pollution, medical waste, and wastewater as well as the presence of SARS-CoV-2 in aquatic ecosystem. The present study discussed the potential of the COVID-19 on freshwater ecosystems contaminated by wastewater discharge. The effects of climate change and the use of contaminated waters on spread of COVID-19 were addressed and the related situation in Turkey was discussed.

KEYWORDS: SARS-CoV-2; Wastewater; Contamination; Freshwater; Pandemic; Turkey

INTRODUCTION

The phylogenetic analysis shows that the virus causing pandemic belongs to Coronavirus (Beta coronavirus) genus of the family Coronaviridae. Being a zoonotic pathogen, Coronaviruses (CoV) have a high mutation rate in human beings and various animals [1]. CoV had not been considered highly pathogenic for human beings in Guangdong (China) until they first observed severe acute respiratory syndrome (SARS-CoV) between 2002-2003. It was recorded that more than 1000 patients died globally due to SARS-CoV [2]. About ten years after the effect of SARS, another highly pathogenic CoV, the Middle East respiratory syndrome coronavirus (MERS-CoV) was seen in the Middle Eastern countries [3,4]. Observed initially, a novel Coronavirus (nCoV) causing to the systemic (e.g. Fever, cough, acute cardiac injury, hypoxemia, lymphopenia, and intestinal symptoms) and respiratory disorders (e.g. upper and lower respiratory tract symptoms, pneumonia) and other multiple organ failures was officially announced in Wuhan (China) in December2019 [1,5,6]. The infection of coronavirus which was officially called as COVID-19 by the World Health Organization (WHO), has led to a pandemic with severe impacts on human health and COVID-19 has been classified as a β CoV of group 2B [7]. Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), the name of the new virus, was announced by the International Committee on Taxonomy of Viruses on 11 February 2020 [6,8]. As of October 15, 2021, over 239 million cases of virus infection were reported all over the world and 4.872.000 deaths were reported by WHO [9].

It is known that SARS-CoV-2 has a vigorous transmission capability when compared to the SARS-CoV [6,10]. The rapid increase in confirmed COVID-19 cases makes the prevention and control extremely crucial. SARS-CoV-2 is spread predominantly by respiratory droplets [1], but also can be aerosolized and has been detected in the stool. Symptomatic or asymptomatic patients may cause contamination [11]. Quarantine, the isolation of patients, and social distance are very effective in preventing COVID-19, which is highly contagious. Furthermore, disinfection and personal hygiene have crucial impacts. Clean water scarcity will restrict food and hand washing. Therefore, personal protective equipment and sanitizer will be needed for SARS-CoV-2 in a short time. Epidemiological alterations in COVID-19 infection should be monitored for a long term by considering the potential pathways of contagion, as well as the adaptation, evolution, and virus spread among humans and possible intermediate zoonotic hosts and reservoirs. In the present review, widespread transmission routes and pressures on water resources and freshwater ecosystems under the threat of COVID-19 with high mutation rate were evaluated. The climatic structure, aquatic ecosystem, water consumption, and wastewater

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of relations of the pandemic caused by Sars-CoV-2 with prevalence and distribution were reviewed in the current study. In this context, Turkey was examined. The critical importance of monitoring the aquatic ecosystem, wastewater management, and the aquatic environment as a receiving environment in Sars-CoV-2 and other possible viral outbreaks was discussed.

DISCUSSION

Freshwater Ecosystems

Water is crucial for two main reasons; firstly, water has a biochemical and physiological importance for organisms and secondly, it is an ecosystem as freshwater and marine systems. The function and balance of the ecosystem is an ecological integrity that affects all living things. Nowadays, there have been two critical problems for water: low water quality and water scarcity. These two problems are commonly seen in many parts of the world. Water needs for drinking and sanitation are relatively less in most of the countries. These primary needs have become a problem of access to existing water resources and quality. Moreover, climate change has a limiting effect on the use and quantity of water (stress / scarcity), like the growing human population. Irregularities in temperature rise and precipitation regime suppress the renewability of water resources hydrologically. Accordingly, the ecosystem structure is affected at the first degree.

When considering climate change, increasing population dynamics, and the decrease in water scarcity and quality, a severe water scarcity is seen in certain areas (drought/ low precipitation regime). Population growth plays an important role in increasing water scarcity. Consequently, per capita water availability reduces. In this case, water-borne diseases and sanitation problems are inevitable. COVID-19 pandemic is also extremely risky by taking water scarcity into account.

Today, 2.2 million people globally are not able to reach drinking water safely, and 4.2 billion people do not have access to safely WASH services (water, sanitation and hygiene) due to deficiency of water management [12]. By the year 2025, water stress could affect almost 3 billion people. Water stress is considered as a limiting factor for the socio-economic level of a country [13]. When considering economically the cost of using water and the difficulty of reaching the water in countries suffering from water stress/ scarcity, the level of WASH can inevitably reduce. In response to the increasing threat of COVID-19, most of Sub-Saharan African countries have launched in quarantine country [14]. USEPA [15] has reported that no COVID-19 has been detected in drinking water resources. However, people do not possess the right to equally reach to clean water and use water. With the influence of symptomatic and asymptomatic patients, SARS-CoV-2 was detected in sewage and untreated wastewater. This constitutes an important public health problem [16]. There is no sufficient information about the reuse of wastewater for irrigation purposes and COVID-19 contamination [17,18].

On the other hand, enteric viruses have been recorded in coastal waters and freshwater environments with wastewater pollution. Several studies have examined the qualitative and quantitative of the enteric virus in groundwater. Some enteric viruses (AdV, JCV, AiV, PMMoV, BacGB124P and BacARABA84P) have been recorded at very low concentrations in polluted groundwater in the USA (Arizona and Colorado) and Vietnam [19,20]. The zoonotic virus, SARS-CoV-2, is known to be ineffective for a long time outside. SARS-CoV-2 was not encountered when viral analyses of groundwater were made. However, the transports of sewage / medical wastes increasing due to contagious infection are a significant risk factor [21].

The waterborne contamination appeared primarily on enteric viruses. On the other hand, respiratory viruses including adenovirus, coxsackievirus, and CoV occurred in wastewater and freshwater polluted by wastewater. Battistini et al. [22] stated that human adenovirus can be taken by ciliates in wastewater and its activities can persist for up to 35 days; but the infectivity of the viruses could not be determined. There is not enough information about the zoonotic viruses in the aquatic ecosystem with their host organism. However, it has been observed that enteric viruses (T4 bacteriophage and echovirus 11) from water-borne diseases are transferred between the filter feeders Ciliata *Tetrahymena pyriformis* and *Daphnia magna* by means of a prey-predator relationship. In this case, *D. magna* can transfer the pathogen to higher trophic organisms and play a vector role for its spread in the ecosystem and the virus. It has been observed that viral transfer may occur within the food web in the ecosystem. However, no such finding has been recorded for SARS-CoV-2, yet. Changes in climatic conditions and water quality can contribute to the spread of viruses.

SARS-CoV-2 and Freshwater situation in Turkey

Climatic structure: At the beginning of the pandemic, the possibility of warmer weather reducing COVID-19 transmission in the northern hemisphere increased. Airborne transmission of SARS-CoV-2 is crucial. However, it has been observed that the temperature increase in the summer does not have a preventive effect on the spread of COVID-19. It is predicted that its spreading effect will increase in the cold weather period. Wind speed, humidity and temperature can be considered as important climatic components in Covid-19 propagation. Tosepu et al. [23] explains that the average temperature is positively correlated with COVID-19 spread. Şahin [24] stated that the wind speed together with the temperature was an important factor influencing viral survival and the spread of the pandemic in Turkey in March. However, the true impact of COVID-19 seasonality remains unclear. Temperature and incubation time are significant factors that provide persistence on viral survival in water [25].

Freshwater and wastewater treatment

Annual mean precipitation in Turkey is 643 mm, which corresponds to 501 billion m3 of annual water volume in the country (Figure 1). The gross (surface and groundwater) renewable water potential of Turkey is estimated as 234 billion m^3 including 41 billion m^3 net discharge into groundwater [26]. Treatment of wastewater is an important application to use freshwater more efficiently and preserve existing freshwater ecosystem. According to municipal wastewater statistics [27], 1357 of 1399 municipalities have sewerage systems. The types of wastewater treatment in Turkey are represented in (Figure 2). The receiving environments where the treated wastewater is discharged are given in (Figure 3). It was determined that 2.3% of treated wastewater was reused for industrial agricultural irrigation.

In 2018, 14.8 billion m^3 of wastewater was discharged directly to receiving environments by municipalities, villages, manufacturing industry workplaces, thermal power plants, organized industrial zones and mining enterprises (Table 1). 77.4% of wastewater discharged directly to receiving environments went to seas, 18.7% to rivers, 1.1% to dams, 0.9% to septic tanks, 0.5% to lakes/ponds, 0.2% to land, and 1.2% to other receiving environments in Turkey.

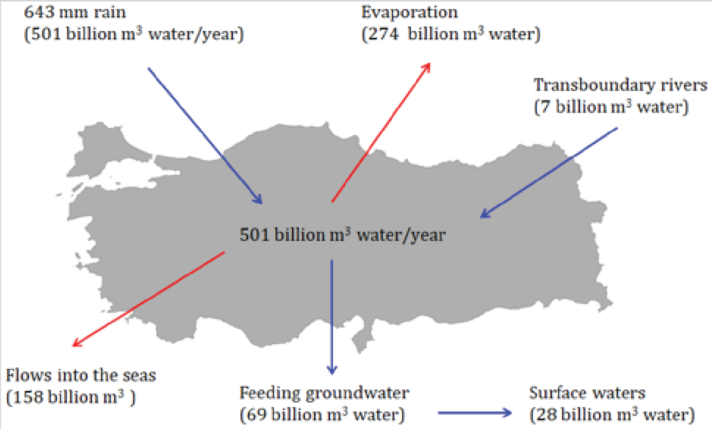

Figure 1: A volume of 274 billion m^3 water evaporates, 158 billion m^3 flows through rivers towards seas and lakes. 69 billion m^3 of water volume leaks into groundwater, whereas 28 billion m^3 is retrieved by springs from groundwater contributing to surface water. Furthermore, there is 7 billion m^3 volume of water coming from transboundary rivers. Consequently, total annual surface runoff is equal to a volume of 193 billion m^3 of water.

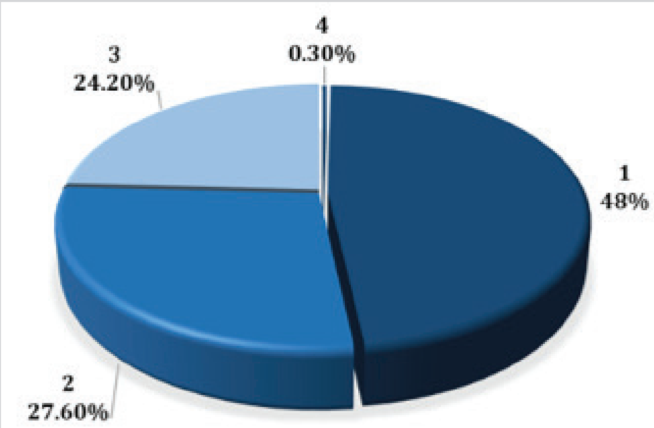

Figure 2: 4.2 billion m^3 of the total of wastewater (4.8 billion m^3) discharged from the sewage system is treated in the different kinds of wastewater treatment plants in Turkey (adapted from [27]). 1) the wastewater is treated with advanced treatment; 2) biological treatment; 3) physical treatment; 4) natural treatment.

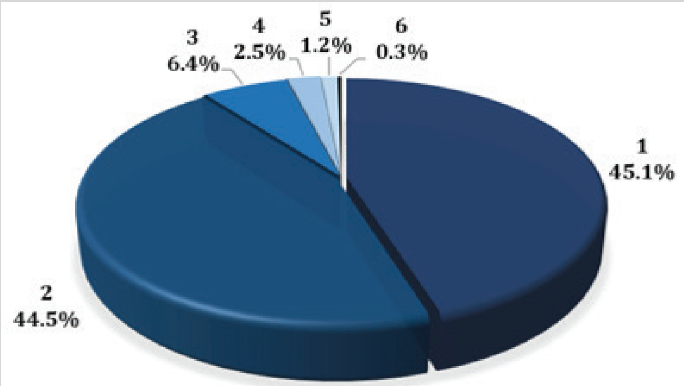

Figure 3: Distribution of receiving environments where treated wastewater is discharged in Turkey is given. 1) 45.1% of the treated wastewater goes to river; 2) 44.5% to sea; 3) 2.5% to dam; 4) 1.2% to lake-pond; 5) 0.3% to land and 6) 6.4% to other receiving habitats.

Table 1: The amount of water drawn by sectorial use (Billion m^3, $year^{-1}$).

Years	2008	2010	2012	2014	2016
Municipalities	4.55	4.78	4.94	5.23	5.83
Villages	1.22	1.01	1.04	0.43	0.38
Manufacturing Industry Activities	1.31	1.56	1.79	2.2	2.12

Thermal Power Plants	4.54	4.27	6.4	6.53	8.61
Organized Industrial Zones	0.11	0.11	0.14	0.14	0.15
Mining Facilities	NA	0.05	0.11	0.21	0.23
Irrigation	33.77	38.15	41.55	35.85	43.06
Total		49.95	55.96	50.59	60.38

The daily average of wastewater discharged by municipalities through the sewage system increased 62 L/person from 1994 to 2018. Water exploitation index of Turkey was 21.3% in 2010, 23.9% in 2012, 21.6% for 2014, and 25.8% in 2016. Index of > 20% reflects water scarcity for Turkey. According to these data, Turkey needs to take precautions for sustainable water resources management. Rapid urbanization, the lack of sufficient sewage and treatment systems and the resulting wastes play a significant role in water pollution. The growing population in Turkey has increased inhibitory effects on water scarcity. Drought experienced in Turkey in 2007-2008 showed that it increases the risk of serious negligence and water treatment in freshwater resources. Many cities especially Ankara and Istanbul were affected by the drought. Today, stress on the freshwater ecosystem is increasing as the most obvious result of increasing climatic changes [28]. Problems are seen in many provinces such as Istanbul, Ankara, Konya, Kütahya, Düzce, Zonguldak. Further, these provinces have had the highest COVID-19 infection. In Turkey, the first COVID-19 case was reported by the Republic of Turkey of Ministry of Health on March 11, 2020. A total of cases was 7.183.000 and 64.265 death were recorded by October 15, 2021, in Turkey [29].

Navarro et al. [30] stated that domestic sewage, agricultural runoff, and wastewater discharges can all introduce waterborne pathogens and SARS-CoV-2 into the municipal water cycle. Consequently, efficient residential water cycle management and treatment process must be evaluated, as it is crucial to know how SARS-CoV-2 is transported before it reaches wastewater outflows or surface waters, which including marine, river, and lake habitats. In Turkey, water treated in 50 of 603 WWTPs is discharged into the dam. The total flow rate of these plants is 1.4 million m^3/ day. Most of these dam's function as irrigation dams. Furthermore, the disinfection units are found in only 53 of 603 WWTPs. Effluent water of 221 WWTPs is used for irrigation and only 42 WWTPs have disinfection units [31-34] investigated SARS-Cov-2 in the sludge from WWTP in Istanbul (Turkey). Istanbul has 65 % of COVID-19 cases. All samples collected from different WWTPs for this purpose were found to be SARS Cov-2 positive.

SARS-CoV-2 and Freshwater: One of the major risks in reusing such water for agricultural irrigation is the irrigation of raw vegetables. Some coronavirus species were detected by 19.6% from samples taken from lettuce [35]. The use of non-disinfected used water, especially in raw vegetables, will cause great risks. This situation poses a significant risk in the transmission of viruses to humans. Especially since the irrigation process is carried out with the sprinkler system, the viruses in the irrigation water can easily spread to the environment. Furthermore, livestock grazing and drinking water are common in freshwater habitats where wastewater flows in Anatolia. This can be considered as a very serious source of SARS-CoV-2 contamination through livestock-based food products.

Floods can also increase the viral load in the environment by allowing sewage to leak into the ecosystem. Severe floods in Istanbul, Bursa, Rize, and Giresun in June, July and August might cause a high spread of SARS-CoV-2 throughout Turkey in 2020 and 2021. Similarly, the floods that took place in China and India (Mumbai and Gujarat) in July 2020 has a possible negative impact. Although there are canonical factors as water contamination and floods that increase the infection, India is one of the countries with the highest number of cases. In the Black Sea region in Turkey, Kastamonu province which had affected by catastrophic flooding in August 2021, has a very high total of cases [29]. Similarly, Rize was severely affected by heavy rains, and it is noteworthy that the number of Covid-19 cases was high. SARS-CoV-2 can be spread and persist in aerosols, therefore, its detection in wastewater aerosols would give critical information for risk assessment [36]. However, there has been no study conducted to date testing SARS-CoV-2 in aerosols from wastewater plants. Fears et al. [37] explained that a laboratory-scale study on the persistence of coronaviruses in aerosols showed that SARS-CoV-2 could maintain its infectivity in aerosols for up to 16 h, suggesting potential human exposure if wastewater aerosols contain viable SARS-CoV-2.

CONCLUSION

Today, considerable knowledge deficiency exists in the role of wastewater in the spreading of SARS-CoV-2. The activity of SARS-CoV-2 in freshwater habitats, including floods, remains mostly unknown. It is accepted that one of the crucial risks for human health is fecal contamination of water resources. Until today, various studies have recorded SARS-CoV-2 RNA in wastewater and explained the persistence and survival of Coronavirus in aquatic environments.

Consequently, although SARS-CoV-2 has been inactivated in wastewater, their persistence could still be of concern for WWTP, overflows, floods, and intrusion of wastewater in drinking water. Changes in climatic conditions and water quality can contribute to the spread of viruses. Turkey, which is stated to be in the fourth wave confirmed by the authorities, will have a great risk in the next dry months for water stress/scarcity. The water quality of freshwater resources and the use of clean water are very important. At this point, the cost of water usage is also important for sanitation, especially during the pandemic period. Although vaccination studies and applications have reached important stages, it will take time to decrease the virus load from the ecosystem. The existence of SARS-CoV-2 needs to be detected in wastewater and freshwater for different climatic regions as the persistence may be highly variable in different temperatures and UV in the ecosystem. The Wastewater treatment technology needs to be improved and monitored in a multidisciplinary framework to prevent the transmission of SARS-CoV-2 and other potential pathogens through the water.

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