Water Quality and Pollution in Time of COVID-19

Subjects: Water Resources
Contributor: Valentina-Mariana Manoiu, Katarzyna Kubiak-Wójcicka, Çiğdem AKMAN, Elvettin AKMAN

Researchers proposes an assessment of the COVID-19 pandemic positive and negative impacts on water bodies on different continents. Regarding the positive impacts, the SARS-CoV-2 monitoring in sewage waters is a useful mechanism in the promptly exposure of community infections and, during the pandemic, many water bodies all over the world had lower pollution levels. The negative impacts are as follows: SARS-CoV-2 presence in untreated sewage water amplifies the risk to human health; there is a lack of adequate elimination processes of plastics, drugs, and biological pollution in wastewater treatment plants; the amount of municipal and medical waste that pollutes water bodies increased; and waste recycling decreased. Urgent preventive measures need to be taken to implement effective solutions for water protection.

Keywords: water quality ; water pollution ; positive and negative impacts ; COVID-19 ; lockdown ; pandemic

1. Virus COVID-19 in Water—General Information

WHO reported [1] that there is presently no confirmation of COVID-19 survival in potable water or wastewater. The COVID-19 virus is similar to other human coronaviruses for which there are already scientific databases on their survival in the environment, as well as the efficient suppression measures [2].

Commonly used methods of treating tap water—filtration and disinfection—should eliminate or suppress the SARS-CoV-2, as per the instructions supplied by the American Centers for Disease Control and Prevention (CDC) [3]. Coronaviruses are distinguished by low resistance to UV radiation and disinfectants generally used in technological water treatment processes, such as Cl (chlorine), sodium hypochlorite or chlorine dioxide. Furthermore, viruses of this type, such as other similarly-sized suspended particles, are removed from the water by coagulation combined with flocculation assisted by polyelectrolytes and filtration through sand, sand-anthracite and/or carbon filters. These types of processes are most often used in water treatment plants. Water intended for human consumption provided by the collective water supply system is safe both for consumption and economic purposes.

COVID-19, like many other viruses, can be found in wastewater. Here, too, standard methods of disinfection of waste are sufficient to eliminate the virus [2]. It is necessary to emphasize that municipal wastewater, due to the fact that it is generated in households, public facilities, hospitals, schools, shops, service facilities, etc., carries millions of viruses, bacteria, parasites, and toxic and poisonous substances. It is worth noting that any virus present in wastewater is largely removed by wastewater treatment. Ensuring adequate water and wastewater quality requires systematic control and compliance with water and wastewater quality procedures.

In 2020, Al Huraimel and his colleagues [4] analyzed the SARS-CoV-2 presence in wastewater and concluded that the coronavirus is unlikely to be transmitted via wastewater. Coronaviruses are sensitive to disinfectants and organic solvents; therefore, they die rapidly in sewage (2–3 days). Studies in hospital wastewater showed that the virus was detectable in sewage water before and occasionally after Cl disinfection, but there was no living SARS-CoV [4]. Accidental contact with treated wastewater has a negligible potential risk of infection, while contact with untreated wastewater, especially in poorly sanitary areas, can be a potential route of infection. Temperature is the most important factor in coronavirus persistence: higher water temperatures reduce virus survival. The primary wastewater treatment and coronavirus adsorption may provide protection against the virus, but more research is needed to assess the viability of SARS-CoV-2 in wastewater.

2. Reviews and Analyses of the COVID-19 Effects on Different Water Bodies All over the World

The monitoring of SARS-CoV-2 in the wastewaters is a useful mechanism in the promptly exposure of collective infections at the pandemic debut. This powerful instrument can help policy makers to prepare adequate COVID-19 mitigation policies.

Real-Time Reverse Transcriptase–Polymerase-Chain-Reaction Testing (RT-qPCR) is the technology used for SARS-CoV-2 RNA detection in the sewage water. It must be stressed that RNA exposure in sewage water does not imply a viral viability and a transmission risk [5]. SARS-CoV-2 RNA was identified at the pandemic onset in wastewater samples from Valencia Region (Spain), Schiphol Amsterdam Airport and Tilburg (Netherlands—only a few days after the confirmed COVID-19 cases in the country), Australia, Massachusetts (USA), France, Milan (Italy), Istanbul (Turkey), Quito (Ecuador) and China. All these are confirmations of RT-qPCR method sensitivity as an early monitoring instrument, but no official conduct code for the primal SARS-CoV-2 detection and quantification in wastewaters has been drawn up yet [4].

Bhowmick et al. [6] stated that conventional methods of disinfecting wastewater can remove SARS-CoV-2 from sewage systems. In largely populated states with undeveloped wastewater treatment plants, such as India, the risk of SARS-CoV-2 infection is very high as the new coronavirus can persist for a few days in raw wastewater and for a longer time in areas with low temperatures. In order to control the possible spread of COVID-19 through water in India, water sources' pollution should be prevented; water should be treated before supplying to population; and then water should be stored in clean, airtight tanks. A free residual Cl concentration of ≥0.5 mg/L in the distribution pipes [6] proves the efficiency of water disinfection. In China, SARS-CoV-2 has been completely eliminated from wastewater generated by Zhejiang University's affiliated hospital by using sodium hypochlorite solution. Other effective methods of disinfecting domestic water are heating to 92 °C for 15 min, boiling, nanofiltration, solar/UV irradiation or free Cl addition in adequate concentration [6].

In India, during the COVID-19 confinement, most Ganga basin districts encountered a 60% excessive rainfall, which induced an escalation of the river flow and a pollutant dilution, as Casado-Aranda et al. [7] have attested. The lockdown had a positive impact on the water quality of Vembanad Lake, the longest in India, with a 15.9% reduction of suspended particulate matter (SPM) concentration, and the groundwater quality in Tuticorin, an industrial city in southern India, improved regarding the heavy metal concentrations (arsenic (As), selenium (Se), lead (Pb) and iron (Fe)) as a result of significantly lower wastewater flows from the metallurgical industry [7].

According to Cheval et al. [8], as a consequence of limited water transport and traveller activities, Venice cleaned its waters amid the citywide COVID-19 confinement, in the spring of 2020. Additionally, in Germany and Austria, a restraining effect of water consumption was noticed. Cheval and his colleagues [8] reiterated the idea that SARS-CoV-2 RNA monitoring of the sewage waters proved to be an efficient instrument for coronavirus dissemination surveillance. They also presented the pandemic time's negative effects on water bodies and stressed that many reports had asserted the significant harm caused by medical and individual hygienic consumables that were found on the shores in Hong Kong, Canada and many other regions.

In 2020, Espejo et al. [5] reported positive and negative, and direct and indirect COVID-19 impacts, on water quality. The medications used to cure COVID-19 consist of persistent, bioaccumulative and dangerous substances to aquatic organisms, and they are considered emerging pollutants. The sewage water treatment technology cannot eliminate these remedies, and they will be discharged into inland bodies of water. At the same time, COVID-19 diagnostic laboratories pollute all environmental elements with different plastic materials and chemicals substances. In addition, it is important to mention the methacrylate from plastic screens and other physical spacing equipment, which can pollute waters and land, and the masks and gloves noted on many beaches and the sea floor, in the Asian states [5]. The different water animals can swallow the masks or become trapped in their elastic cords. On the other hand, Espejo and his colleagues, like other researchers, revealed a better water quality in Venice (Italy), where suspended solids decreased as a result of lesser use of motorboats. Unfortunately, it is expected that, when humanity comes back to the pre-pandemic conditions and reality, the plastic and chemical water pollution caused by the fight against the new coronavirus disease COVID-19 will prevail for long periods of time and will need to be removed using adequate technologies [2][5].

Khan et al. [9] indicated that, during the COVID-19 confinement, water quality improved following the interruption of industrial wastewater discharge. The Central Pollution Control Board of India and the Indian Institute of Technology Roorkee [10] reported a 40–50% substantial upgrade of the Ganga River water quality based on the measured values of dissolved oxygen (DO), biochemical oxygen demand (BOD), total coliforms (TC) and pH. The Yamuna River improved as well; DO analysis indicated values of 2.3–4.8 mg/L, compared to zero in 2019. The BOD of the Ganga's and Yamuna's most degraded sectors diminished substantially [10][11]. Khan and his colleagues, like many other scientists, underlined the fact that in Venice, the water cleared after the COVID-19 confinement and the aquatic species could be observed after many years of absence. With the suspension of numerous cruises and of other marine activities, tourism scaled down and, consequently, aquatic organisms regained their environment, as happened in the Saudi Arabian Red Sea waters [9].

Since the beginning of pandemic, the growing volume of medical waste has become a critical risk to population health and to the environment at the planetary scale. In countries such as China, India, Spain, and Bangladesh, the medical waste quantity doubled or even tripled, as happened in Catalonia region, in 2020 [12][13]. As a result of the lack of education regarding infectious waste handling, many people dispose of these wastes either in open spaces or together with domestic waste. Such disorganized dumping of this kind of trash blocks the water ways and aggravates water pollution [12][13], including with microplastic fibers, dioxin and other elements that are toxic to aquatic life. Once present in water bodies, both personal protective equipment (PPE) and plastic trash will obstruct the sewage system (especially in developing countries) and will also negatively alter the water drainage. Furthermore, plastic pollutants in the aquatic environment will deteriorate and fragment, which results in the formation of micro- and nano- size plastic particles [14] that affect the aquatic life by their ingestion.

Poursadeqiyan et al. [15] showed that the pandemic will have a delayed negative impact on the environment. The asepsis of the roads led to the presence of residual Cl in treatment plant effluents, which contaminates water and jeopardises water organisms. The COVID-19 outbreak increased the municipal and infectious waste quantities and, consequently, the environmental pollution, including water deterioration, in countries such as China and Iran. The new coronavirus increased the biological pollution, especially in hospitals and SARS-CoV-2 mortuary wastewaters, and this demands distinctive biological wastewater treatment methods [15]. Another pandemic time consequence is the more frequent washing of hands and higher consumption of soap and detergents, which results in an emergent focus on eliminating chemical compounds from wastewaters. In China and Iran, the disposal of contaminated wipes, masks, and gloves can pollute the surface water bodies and groundwater [15].

Rume and Islam [13] also indicated in their study that the pandemic lessened the water contamination in different countries and reduced the pressure on tourist destinations but increased the quantities of medical waste, disinfectants and the untreated PPE, which all finally affected the quality of water bodies.

During the lockdown, in India and Bangladesh, water pollution decreased because the most important industrial polluters reduced or halted their activity, visitor numbers dropped and volumes of sewage and industrial wastewaters diminished considerably [13]. As a result, the rivers Ganga and Yamuna, analyzed by numerous scientists, attained an unprecedented water quality proven by monitoring data, especially DO and BOD values [13]. As Rume and Islam mentioned, water contamination decreased on the shores of Bangladesh, Malaysia, Thailand, Maldives, and Indonesia. Moreover, due to the lower commercial activity, the traffic of merchant ships and other vessels decreased globally, which also reduced marine pollution.

At the same time, the absence of sightseers because of the social isolation imposed by the COVID-19 pandemic induced a remarkable positive impact on many seashores across the world [14].

Rupani et al. [16] reiterated the valuable effect of the new coronavirus pandemic on Ganga River water quality, which improved significantly. Water pollution decreases were apparent in Wuhan (China), Italy, France, Spain and Los Angeles (USA) [16].

Usman and Ho [17] asserted once more that in Italy and India, the quality of surface waters ameliorated. At the same time, according to these scientists, there is a SARS-CoV-2 contamination risk and health danger when the virus is detected in wastewaters, waters destined for recreational activities, and in physical therapy pools [17].

Yusoff et al. [18] evaluated the positive and negative impacts of pandemic on aquatic bodies. The COVID-19 lockdown resulted in an improvement of the water bodies' quality, wild angling capital and biodiversity; in the reduction of macroplastic concentration, chlorophyll a (Chl-a), phytoplankton and nitrogen in the Indian coastal area [18]; and in a turbidity decline in Wuhan lakes (China) and Malaysian waters. Water quality improvement has been seen in the Chinese rivers, estuaries and seas, and in the Morocco's estuarine and coastal waters.

The negative repercussions consisted of the escalating water contamination with microplastics, pharmaceuticals and disinfectants, and with the new coronavirus from the sewage treatment plants, mainly from hospitals, which may have important effects on the environment and human health. Hospital wastewaters should be treated efficiently to avoid the virus dissemination [18].

COVID-19 beneficial and adverse impacts on the environment, including water bodies, were also analyzed by Zambrano-Monserrate et al. [19] in countries such as China, USA, Italy, Spain, Mexico and Ecuador. In their study, Zambrano-Monserrate and his colleagues mentioned the favourable connection between contingency measures; the lack of tourists; and the cleaner beaches with pure waters, e.g., those of Acapulco (Mexico), Barcelona (Spain) or Salinas (Ecuador). At the same time, unfavourable effects such as less recycling, more waste and the SARS-CoV-2 RNA presence in municipal wastewaters, which may endanger and contaminate water bodies, were investigated by the same scientists in countries such as Australia, Bangladesh, India, Netherlands, Sweden and USA [19]. New wastewater treatment methods should be developed, as China did by using a higher concentration of Cl to hinder the novel coronavirus transmission, but the surplus of Cl in water bodies may lead to dangerous by-products.

3. Analyses of COVID-19 Effects on Different Water Bodies in South Africa

In South Africa, 7.9 million people (13.5% of the population) have HIV and the acquired immune deficiency syndrome, and half of them are being treated with antiretrovirals (ARVs) that pollute waters because ARVs cannot be effectively removed from the sewage system [20]. If this treatment is also used against SARS-CoV-2, South Africa will face a severe ARV water pollution escalation. During the COVID-19 pandemic, this country experienced water quality problems posed by the higher use of PPE and of chemicals such as triclosan, triclocarbon, and acrylate copolymers in sanitizers. Triclosan is one of the precursors of dioxins, which are very harmful and persistent compounds in the environment, including water. Future studies and thorough monitoring are necessary regarding the presence and effects of ARVs in South Africa's water bodies [20].

After one year, in 2021, Molekoa et al. [21] directed a spatiotemporal surface water quality analysis in Mokopane, Limpopo province of South Africa, and investigated different physico-chemical parameters in water samples collected from five water monitoring locations. The year 2020 showed a water quality improvement as the result of the lockdown period.

4. Analyses of COVID-19 Effects on the Water Bodies of Lombardy (Northern Italy) and on Meriç—Ergene River Basin (Turkey)

Binda et al. [22] evaluated the adverse effects of the abundant PPE use on the Lombardian environment, including the water bodies, which were extremely altered by the pandemic.

The high consumption of PPE can become a concerning plastic pollution issue. The 2020 impact assessment and the 2021 forecasts evidenced a considerable growth of PPE plastic waste in rivers, lakes and the sea [22].

PPEs negatively affect aquatic life because they suffer leaching processes in fthe water environment, and they are also disintegrated by UV radiations and abrasion, which generate microplastics that absorb pollutants and can be ingested by organisms.

The Lombardian population should avoid the improper dispersion of PPEs in order to limit their environmental impact.

Ergene River and Çorlu Stream, from the Meriç—Ergene River Basin in Turkey, are heavily polluted. The nationwide lockdown caused by COVID-19 led to a surface water quality upgrade. Tokatlı and Varol [23] evaluated the lockdown impact on water quality in the above-mentioned river basin by analyzing the physico-chemical parameters and metal(loid)s in water specimens of 25 monitoring stations. The results showed an important recovery of water quality for metal(loid)s as a consequence of industrial effluent cutback [23].

5. Analyses of COVID-19 Effects on Different Water Bodies in South America, Bangladesh and China

Ardusso et al. [24] stressed, in their scientific paper, the fact that this pandemic led to a greater usage and manufacturing of face masks, gloves and other PPE elements fabricated with polymers and antiviral textiles that end as microplastics and emerging contaminants, drawing attention to South America. The authors tried to sound the alarm about the use and mismanagement of this PPE, which represents an environmental issue, particularly for water bodies. Ardusso et al. pointed out that the pandemic escalated plastic usage and reduced plastic recycling, worsening the pollution of the South American shores [24].

The scientific work performed by Islam et al. [25] in Bangladesh found that more than 50% of online survey respondents declared dumping their used tissues, masks, gloves and household waste, which is dangerous for public health and the environment, including the state of water bodies. This study [25] revealed the necessity of an accurate infectious-waste management policy in Bangladesh.

In a 2021 scientific work, Liu and his colleagues [26] surveyed 27 villages in Chinese provinces Jiangxi and Hubei and discovered that pit latrines could cause SARS-CoV-2 water pollution. Putting an end to the pit latrines and fertilizers of untreated excreta could ameliorate the state of living environment and water body quality. This study results could be implemented in low-income countries, notably in Africa [26].

6. Analyses of COVID-19 Effects on Different Water Bodies in Southeast and South Asia

The environmental impacts of COVID-19 in Southeast Asia, including on water bodies, were examined by Praveena and Aris in 2021 [27].

One positive outcome of the COVID-19 lockdown and movement restrictions the scientists identified was, as in many other regions and countries, the improvement of water quality. For example, there were ameliorations in the Malaysian rivers' water quality, i.e., a decrease in the TSS and an increase in DO, which were explicable by the decline in the total amount of waste and the reduction in domestic and industrial pollution loads during the lockdown. The negative effects comprised a rise in the use of plastics and the generation of medical waste, which may finally have a high potential pollution impact on water bodies in Indonesia, Malaysia, Thailand, the Philippines and Vietnam [27].

In 2021, Shafeeque and his colleagues [28] investigated the COVID-19 lockdown benefits on South Asian aquatic ecosystems, linked to less intense anthropogenic activities. The results revealed an important drop of Chl-a concentration and turbidity, on the coastlines of Karachi, Mumbai, Calcutta, and Dhaka, respectively, but also lower nitrogen emissions in the air, which contributed to water quality improvement.

According to Shafeeque et al. [28], the application of the territorial constraints regarding fossil fuel use and population transport for certain periods (two weeks—one month) will help with "healing the planet's environment".

7. Conclusions

The present article analysed the positive and negative SARS-CoV-2 impacts on the status and quality of water resources of rivers, lakes, seas and oceans, identified over the course of the COVID-19 pandemic. No scientific divergence has been detected on beneficial impacts nor on adverse effects on water bodies and types.

The study managed to highlight the fact that water quality problems were diagnosed in densely populated territories where, even before the pandemic, the communities had issues with supplying water of adequate quality and treating wastewater using advanced and effective technologies. In heavily inhabited countries with inadequate wastewater treatment plants, the risk of contamination is particularly high as the new coronavirus can persist for a few days in raw sewage water and for a longer time in areas with low temperatures. Researchers highly recommend that in these countries, urgent preventive measures be taken to implement effective solutions for water protection and wastewater treatment. This is only possible by improving existing water policies.

To summarize, the positive impacts are as follows:

- The SARS-CoV-2 monitoring in the wastewaters is a useful mechanism for the prompt exposure of collective infections at the pandemic debut. This valuable tool can help authorities implement the most adequate COVID-19 mitigation policies, and, in this respect, no discrepancy between scientists has been found. While SARS-CoV-2 RNA can be identified in the sewage water using RT-qPCR testing, no official conduct code for primal SARS-CoV-2 identification and quantification in wastewaters has been drawn up yet, which researchers acknowledge to be a priority.
- During the COVID-19 lockdown, many surface and ground-/subsurface water bodies all over the world saw lower pollution levels as a result of a significant decrease in domestic and industrial wastewater discharge and agricultural activities, boat/vessel traffic and tourist activities. This positive impact has been emphasized by all researchers who analysed the environmental benefits linked to the COVID-19 lockdown.

Succinctly, the negative impacts are along these lines:

- Following the COVID-19 pandemic outbreak, the SARS-CoV-2 virus could be detected in wastewater, but it is unlikely to be transmitted through contact with this type of water, due to its sensitivity to disinfectants, solvents, detergents and treatment methods and, in general, due to its poor stability when exposed to the environmental conditions of wastewater. Even if genetic fragments (RNA) can be detected in wastewater, the virus is not viable once its envelope is damaged. On the other hand, untreated wastewaters could be the agent for a high contamination risk. Due to the fact that a scientific uncertainty has been identified, researchers strongly recommend further analyses of SARS-CoV-2 viability in sewage waters.
- Many reports asserted the significant harm along the shorelines caused by the disposal of sanitary consumables (masks, gloves, contaminated wipes, protective suits, safety shoes, etc.) arising from the medical activities or personal protection. The different water animals can swallow the masks or get tangled in their elastic cords.

- COVID-19 diagnostic laboratories pollute all environmental elements, including water, with different plastic materials and chemicals substances. In addition, it is important to mention the methacrylate from plastic screens and other physical spacing equipment, which finally may also reach water bodies.
- The medications used to cure COVID-19 consist of persistent, bioaccumulative and dangerous substances to aquatic organisms, and they are considered emerging pollutants. Sewage water treatment technology cannot eliminate these remedies, and they will be discharged into inland water bodies. In this sense, new water treatment technologies should be developed by medical and technical scientists.
- Chemical compounds such as triclosan, triclocarbon and acrylate copolymers in sanitizers already posed environmental issues.
- Plastics and drugs in wastewaters, especially non-biodegradables, produced during the COVID-19 pandemic will persist for longer periods of time after pandemic end.
- The asepsis of the roads led to the presence of residual Cl in treatment plant effluents, which contaminates water and jeopardises water organisms.
- The new coronavirus increased biological pollution, especially in hospitals and SARS-CoV-2 mortuary wastewaters, and researchers consider this demands distinctive biological wastewater treatment methods.
- Since the COVID-19 outbreak, municipal and medical waste production has increased globally and represents a considerable danger for population health and the environment, including water bodies; this co-occurred unfortunately with a decrease in waste recycling.

These positive and negative impacts are briefly presented in Table 1:

Table 1. Positive and negative COVID-19 impacts on water bodies/systems/types.

Positive COVID-19 Impacts on Water Bodies/Systems/Types	**Negative COVID-19 Impacts on Water Bodies/Systems/Types**
SARS-CoV-2 monitoring in wastewaters—a useful mechanism in the promptly exposure of community infections	SARS-CoV-2 presence in wastewaters > high risk of untreated wastewaters
Many surface and ground-/subsurface water bodies all over the world saw lower pollution levels caused by domestic and industrial wastewater discharge	Plastic, drugs/chemicals and biological pollution in wastewaters > lack of adequate elimination processes at wastewater treatment plants
	Greater amounts of municipal and medical waste (sanitary consumables, disposable supplies, etc.) that may pollute surface water bodies, shorelines and beaches, and lower waste recycling rates.

As humans and the environment interact constantly, any environmental damage directly or indirectly affects human health, and any pandemic has inevitable consequences on the environment.

Researchers highlight that this pandemic provides an unprecedented opportunity to the worldwide scientists: to re-estimate the impact of the development of human society and, implicitly, of the constant feedback of nature, in pre- and post-COVID scenarios.

Environmental deterioration is accompanied in many situations by pandemic risks. Human wellbeing and environmental health are deeply connected in a holistic circle. It seems that researchers have forgotten this. Nothing of this holistic form should be disturbed, destroyed or fragmented. Reseasrchers, as humanity, a society, the government or simple human beings, should reflect on what forced us to slow down during the pandemic lockdown, which had beneficial influences on the environment. Researchers should enact this “slow and careful behaviour” in researcher's daily life without any health emergency or threat.

Biologists (geneticists, virologists, etc.) should continue their sustained and hard work on SARS-CoV viruses and their possible recombination effects. At the same time, maybe this is the right moment for a new legitimate scientific field: food education. Our society should decrease animal protein consumption, should reduce wildlife exploitation and should improve husbandry practices. It is impossible to turn the entire world population vegetarian and/or vegan suddenly, but food education in order to diminish meat consumption is compulsory.

Additionally, certain social and economic practices and behaviors should be installed in the lives of communities after the COVID-19 pandemic ends: traffic reduction during the weekends or in city centres or on certain highways/avenues; temporary close of some polluting entities, without jeopardising local economies or jobs; increased hygiene awareness; access to safe drinking water and bathwater; investing in wastewater treatment plants in territories where they do not exist; and public education (using all mass media outlets) about the all-type-waste management: education in schools, high-schools, universities, education for youth and seniors, education for merchants and consumers, education for medical staff and patients, etc.

Let us hope that researchers have learned and are still learning valuable lessons from this pandemic crisis, which will be the basis for the proper, ethical and correct definition of society's priorities for the imminent future.

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