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Exploring What Lies Ahead in the Field of Disinfecting Coronavirus

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Abstract

Recently, huge awareness has been accorded to potential circulation of SARS-CoV-2 through water systems. This work deals with this problem and researches the behavior of coronaviruses (CoVs) in water media, with specific interest on the new data on the fresh SARS-CoV-2. The examination of the natural persistence of CoVs and the performance of the disinfection technologies are also discussed. All CoVs have a restricted stability in water media: 2 - 5 days in tap water and 2 - 6 days in wastewater were judged enough for 2-log reduction of SARS-CoV-2 titer. SARS-CoV-2 is distinguished by a weak construction and is vulnerable to traditional disinfection technologies that have been demonstrated to be very efficient in their neutralization. Approximately 5 min of exposure to sodium hypochlorite (1%), ethanol (70%), iodine (7.5%), soap solution and additional usual disinfectants was enough for reaching 7 - 8-log of SARS-CoV-2 titer decrease. Thermal treatment is efficacious in SARS-CoV-2 demobilization: 30 min at 56 or 5 min at 70˚C were enough for attaining the total depletion of the infectivity. Further, SARS-CoV-2 remains vulnerable to sunlight and quickly demobilized by UV radiation. UV-C at 254 nm and intensity of 2.2 mW/cm^2 yields 3-log of SARS-CoV-2 titer decrease in less than 3 s of application. Consequently for SARS-CoV-2 disinfection, usual injections of killing agents remain required for sanitation and for wastewater treatment. Relating to controlling CoVs diffusion and applying disinfection technologies, vigilance remains essential.

Subject Areas

Chemical Engineering & Technology

Keywords

Coronaviruses (CoVs), *Severe Acute Respiratory Syndrome Coronavirus*-2

(SARS-CoV-2), SARS-CoV-2 Stability, Disinfection, Microorganisms (MOs), Wastewater Treatment Plants (WWTPs)

1. Introduction

At the end of 2019, a fresh human coronavirus (CoV), called *severe acute respiratory syndrome coronavirus*-2 (SARS-CoV-2), was discovered in Wuhan (China) [1]. SARS-CoV-2 has provoked an epidemic of respiratory illness named COVID-19 [2] [3]. SARS-CoV-2 is a member of the *Coronaviridae* family that includes enveloped and single-stranded ribonucleic acid (RNA) viruses with sizes ranging from 60 to 220 nm [4] [5] [6]. Surrounding the viral RNA, the viral protein capsid is enveloped by a lipid bilayer membrane that holds proteins or glycoproteins and crown-like spikes on the surface [7] [8]. CoVs could contaminate birds, rodents, felines, canids, chiropters, and other mammals comprising humans [9] [10] [11]. Related to the zoonotic transmission, the first animal-to-person transfer of CoV seems to have happened through a natural genetic mutation authorizing the virus to pass infection to human beings [9] [12] [13]. In due course, the person-to-person transfer took place via inhaling infected aerosols and respiratory droplets [14] [15]. Nevertheless, additional probable ways of SARS-CoV-2 transmission have been proposed comprising transmission via fomites [16], ocular surfaces [17] and the fecal–oral path [18] [19].

During the 1960s, CoVs were primarily recognized and until now seven human CoVs have been mentioned [1]. Three of them spectacularly appeared lately: SARS-CoV, Middle East respiratory syndrome-CoV (MERS-CoV), and SARS-CoV-2 [1]. Controlling human mortality related to CoVs transmission and the number of people needing hospitalization imposes the implementation of rigorous isolation actions in the regions touched by the contagion. Throughout outbreaks, the elevated rate of transmission of human CoVs has mainly happened by the transfer of infected respiratory droplets [1] [14] [15]. Prior the arrival of SARS-CoV (below designated as SARS-CoV-1 to avert confusion with the SARS-CoV-2) during 2002 (in China), CoVs were seen as solely respiratory pathogens. Nevertheless, SARS-CoV-1 could also touch the human enteric tract [20]. Wastewater could be immediately polluted with CoVs through contaminated feces [21]. It is well-known that CoVs stay in water from few hours to few weeks, even if their viability and infectivity highly rely on many parameters.

It is hard to estimate the influence of waterborne viral infections, so the action of such infections is frequently disregarded as was the case during the SARS epidemic in Hong Kong in 2003 [1]. Bioaerosols, formed from the aeration in sewer pipelines and not subject to particular disinfection treatments, were recognized to be source of the SARSCoV-1 spreading in Amoy Gardens (a private housing estate in Hong Kong) [22]. The random sharing of ponds by ducks, pigs and humans was mentioned as origin and hot spots of resurgence of the influenza A virus subtype H5N1 (an enveloped virus with spike-like proteins on surface similar to those of CoVs) [23]. The spillover transmission of H5N1 virus to humans happened from ducks, the original host species for the virus, through pigs as an intermediate species [23]. Animals have as well been confirmed to be reservoirs for the fresh SARS-CoV-2. Indeed, the virus has been observed to be efficiently replicant in cats and ferrets and comparatively and poorly replicant in dogs, pigs, chickens and ducks [1].

SARS-CoV-2 has been very quickly catching throughout the globe [1] [3] [24]. Likewise to respiratory dysfunctions, the virus causes grave enteric symptoms and has been observed in the feces of contaminated patients [3] [25]. Therefore, the digestive system has been seen as a possible way of contagion [3] and the virus RNA finished in wastewater. Urine and feces of patients touched by COVID-19 have been demonstrated epidemic, via assessing the viable SARS-CoV-2 virus particles in suitable host cells [26]. Nonetheless, regardless of the elevated levels of the RNA of the virus throughout the globe detected in wastewaters and the possible worries associate, new studies on the infectivity have pointed out a rare perseverance of the virus in such aquatic media [1] [27].

On the contrary, information on the presence of SARS-CoV-2 traces in wastewater could be employed by epidemiologists and government authorities for estimating the magnitude of propagation of the virus in the population associate to a water sanitation network [1] [2]. Numerous nations have started national wastewater surveillance programs [1].

Because of the likely diffusion of the virus through wastewater, its occurrence in this aquatic media represents a possible risk [28] [29] [30]. Furthermore, observing virus diffusion furnishes a strong tool in the hands of the scientific and health communities, as an epidemiological measure of the propagation of the virus, comprising the number of asymptomatic infections. In such circumstance, it is crucial the understanding of the state-of-the-art on the techniques for detection, quantification and determination of infectivity of the virus in aqueous matrices. The perception of the virus in wastewater is not directly related to the infectivity. Thus, Buonerba *et al.* [1] examined the technique for determination of the viable SARS-CoV-2 virions and the assessment of the probable hazards related.

As seen above, a great interest is accorded on the likely propagation of SARS-CoV-2 through water systems. This work aims to review the fundamental comprehension of behavior and persistence of the SARS-CoV-2 in water. Besides this grasp, understanding performance of the processes for disinfecting water authorizes establishing veritable hazards and the precise procedure for dealing with the expansion of virus through the water environment.

2. Natural Persistence of CoVs

The comprehension of the natural stability of pathogenic microorganisms (MOs) and the performance of usable disinfection processes render it easy to evaluate the dangers related to a contagion [1] [31] [32].

Recently, aerosol persistence of CoVs (especially SARS-CoV-2) has been largely examined [33] [34] [35]. The usual demobilization of CoVs in the nature is a function of numerous parameters like temperature, relative humidity and, in water media, on pH, level of particulate, organic matter [36] [37] [38], chemicals, and of antagonistic MOs [1] [39] [40].

2.1. Persistence of CoVs on Inanimate Surfaces

It was pointed out that inanimate surfaces are possible sources of CoV infection. Such contagion may be both directly (via fomite transmission) and indirectly (via water media which came into contact with the infected surface) [1]. Further, the aerosolization of fomites has been showed to be efficient in the circulation of viruses like the Influenza A virus [1]. Therefore, in such circumstances it is vital to establish the stability of CoVs on different surfaces and the sufficiency of disinfection implements utilized to treat them [41] [42]. Following the natural circumstances, human CoVs have the potential to stay contagious on inanimate surfaces from 2 h up to even several weeks [1].

2.2. Persistence of CoVs in Water

Humans need water for their daily activities (e.g., drinking, personal hygiene, washing, irrigation, food production, and recreational objectives) [43] [44] [45] (**Figure 1**). Utilized water (comprising stormwater and runoffs) is in the end gathered as wastewater [1] [46] [47]. Feces, urine, or vomit contaminated with pathogenic MOs come in the human sewage polluting consequently the urban water cycle [48] [49] [50]. Understanding the stability of those pathogens in

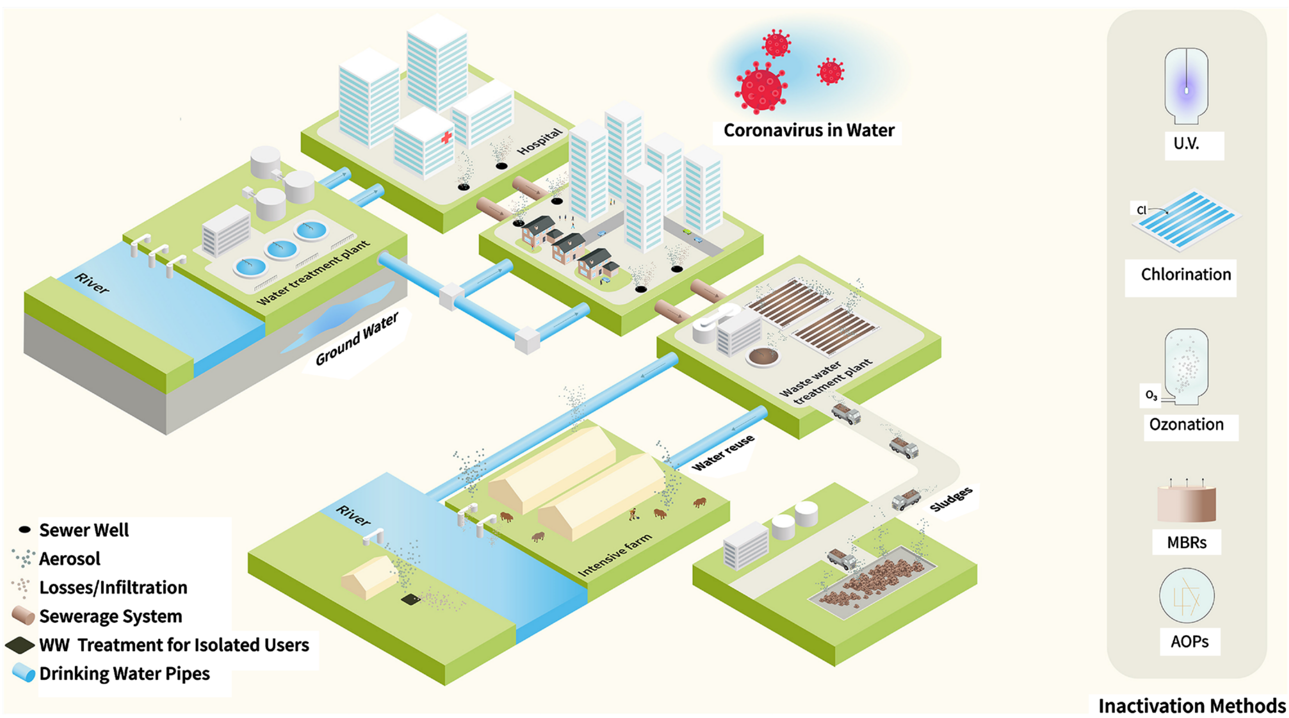

Figure 1. Integrated water cycle [1].

water permits to determine exactly the concentrations of dangers for both human beings and nature [51] [52] [53]. It is well-known that the formation of bioaerosols in aeration basins in wastewater treatment plants (WWTPs) forms a danger of contamination especially of enteric viruses [54] [55]. Researchers have explained that field workers are exposed to contagions from bioaerosols [56]. Studies affirmed that the existing disinfection methods employed in WWTPs (like oxidation with hypochlorite [57] [58] [59] or peracetic acid and demobilization by ultraviolet (UV) irradiation) were enough to keep safe the health of WWTP operators and the public [1] [60] [61].

Typical CoVs (like human CoV 229E, cause of a frequent cold, and the feline infectious peritonitis virus (FIPV)) were tested defining the $T_{99.9}$ (the period needed for the virus titer to decrease of 3-log (99.9%)) [1]. Such virus titer decrease was noted in dechlorinated and filtered tap water in 10 days at 23˚C and in 130 days at 4˚C. Demobilizing such CoVs happened faster in wastewater with a $T_{99.9}$ of only 2-4 days. Below the identical circumstances, a non-enveloped virus (like the Poliovirus 1) was more solid than CoV 229E and FIPV [1]. CoV 229E depicted an identical persistence with 5-log of titer reduction during 9 days when suspended in minimum essential medium (MEM) containing antibiotics (penicillin and streptomycin), both in the presence and absence of 10% of fetal bovine serum. In a dried form, deposed on a polystyrene petri dish, 72 h were required [62].

The evaluation of viable virions of two surrogate CoVs, transmissible gastroenteritis virus (TGEV) and murine hepatitis virus (MHV), was performed in reagent grade water, lake water, and pasteurized settled sewage by determining the T_{99} (in turn corresponding to 2 log) [39]. Therefore, 2-log of virus titer decrease was noted at 25˚C for TGEV and MHV in reagent grade water respectively in 22 and 17 days; while at 4˚C, no notable decrease of the contagious titer for both viruses was noticed for 49 days. In a lake water sample at 25˚C, the identical infectivity decrease was discovered for TGEV and MHV respectively in 13 and 10 days. At 4˚C, 1-log of titer reduction of TGEV was attained in 14 days, while the MHV resulted in comparison more persistent. In pasteurized settled sewage at 25˚C, 9 and 7 days were indispensable for 2-log of TGEV and MHV titer reduction, respectively [1].

The natural demobilization of SARS-CoV-1 in water, feces, and urine was tested *in vitro* [1] [63]. The virus titer was observed decreased of 5-log after 2 days at 20˚C in dechlorinated tap water, domestic sewage, or hospital sewage; after 3 days in feces and 17 days in urine. By decreasing the temperature to 4˚C, the infectivity of SARS-CoV-2 continued for over 14 days in such media. Wet human specimens (blood serum, sputum, stool and urine) and biological media for cell and virus culture maintain quite well the infectivity of SARS-CoV-1 [62] [63] and that of other human CoVs [1]. The virus titer was decreased by 5-log in serum and sputum in 96 h and in urine in 72 h [1]. A slow rate of decrease of the titer at room temperature for SARS-CoV-1 of 0.5-log reduction over 9 days was noted in serum-free cell culture medium, while below the identical circumstances, CoV E229 lost its infectivity totally. Phosphate-buffered saline solution at pH 7.4 was demonstrated to guarantee valid persistence to CoVs. In such medium, E229 and OC43 remained during 3 days [64], whereas for SARS-CoV-1 over 14 days were requested for 5-log of virus titer decrease [63]. Recently, Chin *et al.* [65] established that SARS-CoV2 is very persistent at 4˚C in virus transport medium: 0.7-log of titer reduction was noted after 14 day.

CoVs could remain alive during 2-4 days in wastewater at room temperature and for a more prolonged time at lower temperatures like that of the winter [21] [39] [63]. The new SARS-CoV-2 was revealed infective in human stool samples [66] and observed through the globe in wastewater and surface water receiving wastewater [1]. The RNA of the virus was discovered in sewage during and even before the appearance of COVID-19 cases [67] [68]. Nonetheless, for the determination of viable viruses in WWTP influent and effluent wastewater, as well as in hospital wastewater and in river receiving contaminated wastewater, experiments proved the restricted resistance of the virus in those water media. The findings show that the latter water medium is mostly aggressive for SARS-CoV-2. Infecting wastewater with SARS-CoV-2, researchers [27] mentioned a persistence of 1.4 - 3.3 days for 1-log and of 2.9 - 6.5 days for 2-log of inactivation of the virus in this media. Nonetheless, these scientists noted an identical resistance for the virus in tap water. Indeed, at ambient temperature, the unforced decrease of the virus titer of 1-log and 2-log happened during 1.8 - 2.2 and 3.6 - 4.4 days, respectively [1]. Such result further asserts the restricted persistence of this virus in water media.

3. Techniques for Demobilization of CoVs

Lipid-enveloped viruses with elevated hydrophobicity [69] (like CoVs) remain less stable in water when juxtaposed to non-enveloped viruses (**Figure 2**) [1]. Ostensibly, the efficiency of water sanitation techniques for CoVs could be assessed founded on the demobilization information of non-enveloped viruses with greater durability. Unlikely, the estimation of infectivity founded just on determination of viable CoVs in wastewaters is very simplified. The present guidelines for wastewater sanitation comprise the next important options: 1) thermal treatment [70], 2) UV irradiation [71] [72], 3) chemical disinfection [73] [74] [75], 4) holding wastewater for a prolonged time [76] [77] [78]; 5) sedimentation [79] [80] [81]; 6) membrane filtration [82] [83] [84]; and 7) attenuation in subsurface [1] [85]. The efficiency of such disinfection techniques concerning CoVs (especially SARS-CoV-2) from drinking water to wastewater effluent is reviewed in this Section.

3.1. Thermal Demobilization

Temperature is viewed as one of the most powerful parameters for demobilizing enveloped virus [62] [86] [87]. This is related to the fact that membrane and

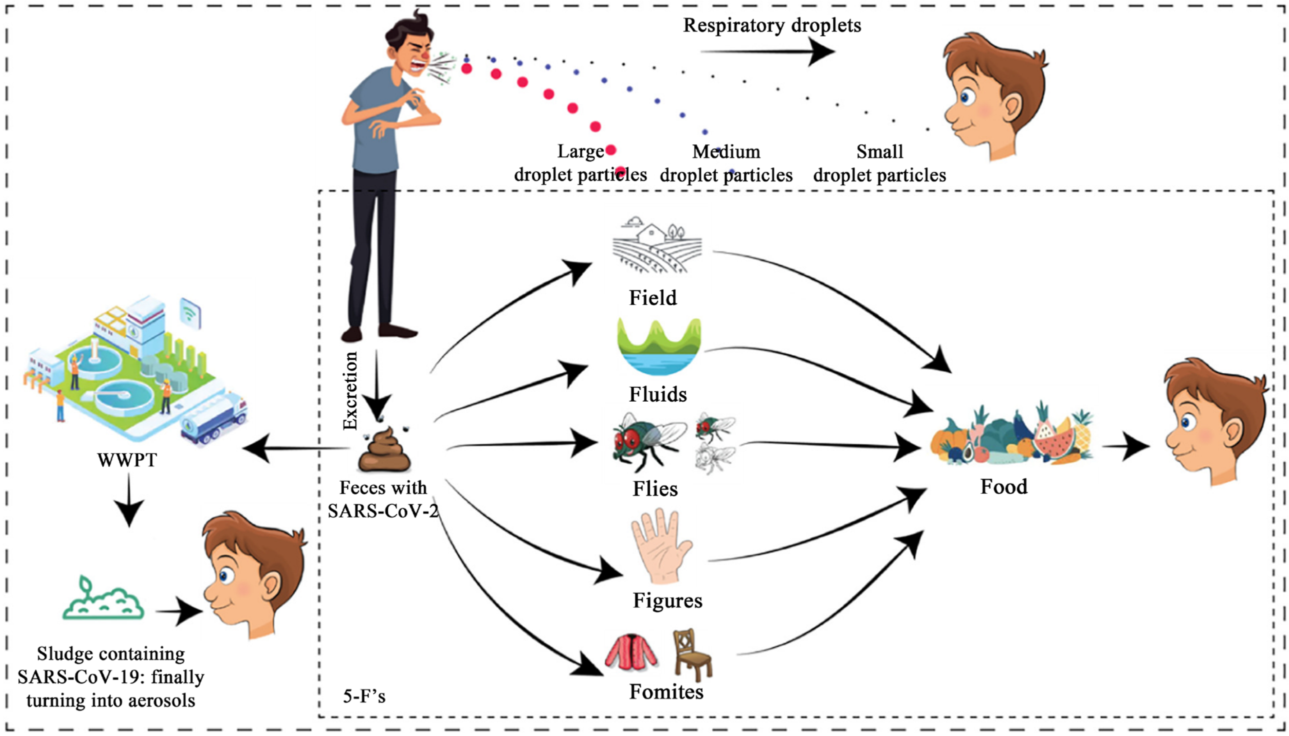

Figure 2. Schematic representation of SARS-CoV-2 spread via the fecal-oral route [33].

capsid proteins are vulnerable to heat-induced denaturation [1]. Aqueous foods (e.g., milk and fruit juice) and potable water could be treated in pasteurization methods at moderate (56˚C - 65˚C for 30 min) or high temperature (80˚C - 135˚C for 1 - 4 s), with a view to destroy or demobilize MOs, enzymes and viruses. Killing SARS-CoV-1 (-6-log) was realized at 56˚C, 67˚C, and 75˚C, respectively within 90, 30, and 30 min [1]. Identical findings were mentioned on thermal inactivation of SARS-CoV-1 *in vitro* in media for cell or virus culture [62] [86]. A non-human CoV (the canine coronavirus (CCoV)) was observed to be contagious even at 56˚C; nonetheless, it was demobilized at temperatures higher than 65˚C [88].

The controversy about the impacts of environment temperature on the rate of transmission of SARS-CoV-2 stays still open [89] [90]. However, the neutralizing influence of heat on the virus is not questioned [1] [70] [91]. Chin *et al.* [65] examined the thermal influence on the infectivity of SARS-CoV2 in virus culture media at 56˚C and 70˚C, establishing that treatments of 30 min and 5 min were respectively enough for attaining 6-log of virus demobilization. In wastewater, 2-log of virus reduction was achieved at 50˚C during 28 - 34 min; whilst 70˚C was observed adequate for 3.7 - 5.7 min [27].

3.2. Demobilization by Ultraviolet (UV) Radiation

Presently, demobilizing pathogens via ultraviolet (UV) radiation becomes largely used for disinfecting surfaces, potable water, as well as in tertiary treatments of wastewater for the reduction of the loading of highly resistant species [92] [93]

[94]. A comparatively big number of the viruses, in most cases enteric ones (like noroviruses, rotaviruses, reoviruses, sapoviruses, astroviruses, enteroviruses, and adenoviruses) remain in the effluent of full-scale WWTPs with less than 2-log of loading removal [1] [95] [96]. Different from the aforesaid viruses, enveloped viruses seem to be more sensible to UV subjection. An extended subjection period of 40 - 60 min was requested to reach a favorable level of demobilization for SARS-CoV-1 *in vitro* [86] [97]. Kariwa and Fujii [97] revealed 5-log of SARS-CoV-1 decrease at 134 μW/cm^2 in 15 min and further 1-log after additional 45 min.

Scientists found SARS-CoV-2 vulnerable to sunlight [1] [98] [99] and fast demobilized by UV-C (λ = 100 - 280 nm) [100] [101], UV-B (λ = 280 - 315 nm) and UV-A (λ = 315 - 400 nm) radiation [98]. Scientists [101] determined *in vitro* the kinetics and the light fluence for SARS-CoV-2 demobilization by UV-C at λ = 254 nm and light intensity of 2.2 mW/cm^2. The reduction of 3-log of viruses was noted in less than 3 s of irradiation, while for 5-log of demobilization were needed almost 50 s.

3.3. Chemical Disinfection

Traditional antiseptics and disinfectants, like halogenated compounds (chlorine, sodium hypochlorite, chloramine and povidoneiodine), alcohols (ethanol and 2-propanol), aldehydes (formaldehyde and glutaraldehyde), quaternary ammonium compounds, phenolic compounds, and other decontaminating agents, have been observed to be efficient in disinfecting the surfaces polluted by 229E and SARS- and MERS-CoVs [1]. The chemicals put out the infectivity during a short subjection period of 1 min [62] [102]. A considerable SARS-CoV-1 titer decrease of 1.6 - 5-log was noticed *in vitro* testing for 0.5 - 2 min utilizing disinfectants, like 2-propanol, formaldehyde, glutaraldehyde, Desderman, Sterillium, and Incidin plus [62] and of 6-log by employing for 1 min commercially available disinfectant as povidone-iodine, isodine® solution, Isodine Scrub®, Isodine Palm®, Isodine Gargle® and Isodine Nodo Fresh® [97]. Traditional disinfectants, like sodium hypochlorite (1:99), ethanol (70%), iodine solution (7.5%), chloroxylenol (0.05%), chlorhexidine (0.05%) and benzalkonium chloride (0.1%), were observed efficient in demobilizing SARS-CoV-2 in 5 min of treatment, with exception of the soap that requested bigger period for the reduction of 7 - 8-log [1].

Researchers tested the impact of pH on the persistence of CoVs for CoV 229E [103], MHV [104], TGEV [105], and the CCoV [88]. Because of the lipid acidic envelope, CoVs were discovered to be responsive to the change of pH and the bigger virus solidity was noted at slightly acidic pH degrees of 6 - 6.5 [106]. Reciprocally, SARS-CoV-2 was observed extremely persistent in a large domain of pH levels (3 - 10) at ambient temperature [1] [65].

Founded on the information acquired from other viral indicators, employing chlorine for water disinfection remains the most efficient and economical solution for such issue [107] [108] [109]. Chlorine efficiently demobilizes the virus via demolishing the viral envelope or capsid [58] [59] [76]. Specially, free chlorine has been confirmed to touch directly the proteins existing in the viral envelope, rather than the less reactive lipidic material and the RNA core [1] [110] [111]. Further, chlorine could react with the ammonia existing in wastewater to generate combined chlorine such as chloramines [112] [113] [114]. Such chemicals possess the potential to kill pathogens, even if throughout disinfection they are less performant and behave diversely from free chlorine [115] [116] [117]. As a consequence, it remains fundamental for every WWTP to assess the chlorine species and their relative abundance throughout the disinfection stage [118] [119] [120].

Researches of the treatment of municipal water and wastewater utilizing chlorine and its derivatives have affirmed notable demobilization performances for SARS-CoV-1 [1] [121] [122]. In hospital wastewater, domestic sewage, and dechlorinated tap water, the virus remained active only for 2 days [1] [31]. In addition, SARS-CoV-1 became more sensitive to disinfectants juxtaposed to *Escherichia coli* and f2 phage. For SARS-CoV-1 demobilization, free chlorine was more efficient juxtaposed to chlorine dioxide. Free residual chlorine exceeding 0.5 mg/L or chlorine dioxide exceeding 2.19 mg/L in wastewater secured the total demobilization of SARS-CoV [1]. In addition, extreme pH degrees (*i.e.*, $pH > 12$ or $pH < 3$), formalin, and glutaraldehyde were confirmed to demobilize SARS-CoV-1 quite well [123]. Peracetic acid has been established to possess the capacity to demolish some non-enveloped viruses (like norovirus) that are known to be more resistant to chemical agents juxtaposed to enveloped viruses [124] [125] [126].

The certified occurrence of SARS-CoV-2 RNA in wastewater influents and sludge, as well as in effluents released from WWTPs have elevated the worry of the personnel of the WWTPs [1].

Investigations have proved that the virus is inclined to show restricted resistance in wastewater [1] [27]. As a rule, studies on viable SARS-CoV-2 in real influents and effluents, both from domestic and hospital sewages, have conducted to negative findings [1] although the RNA molecules of the virus have been demonstrated to be greatly stable, even up to 50 days in wastewater at ambient temperature [27]. Worries have as well been elevated because of the environmental dangers related to an immoderate usage of disinfectants for wastewater, such as the sodium hypochlorite that forms high levels of disinfection by-product residuals [127] [128] [129].

3.4. Impacts of Wastewater Holding

The viral envelope of CoVs may be compromised by solvents, detergents and disinfectants, commonly existing in wastewater [1] [28] [91]. Furthermore, throughout the biological treatment step in WWTPs [48] [49] [130], the occurrence of antagonistic MOs could boost the demobilization rates of numerous viruses [30] [87] [131].

It is well-known that the analysis of bacteriophages furnishes a convenient index for the behavior of enveloped viruses in sewages [21] [32] [132]. The instant demobilization of bacteriophage Φ6 was adopted as a tolerable model for the survival and demobilization of enveloped human viruses [1] [133]. Such virus endures demobilization of 5-log in 2 and 6 days at 22˚C and 30˚C, respectively. Greater holding periods, as safety measure, has to be considered at lower temperatures [50] [51] [134]. Surprisingly for a more aggressively enveloped virus (e.g. Ebola), scientists suggested holding wastewater in a reservoir for 7 days prior to further handling or transport as holding wastewater assisted diminish the viral activity [1] [52] [53].

Without disinfection applications, SARS-CoV-1 has been proved to keep its infectivity in municipal and hospital wastewater until 2 days at 22˚C and for over 14 days at 4˚C [1]. A decreased stability of the virus was mentioned in hospital wastewater in which is usually existing an elevated amount of disinfectants [1].

Regardless of the restricted resistance of the SARS-CoV-2 in sewages, fecal-to-oral way and aerosolization of these media may take place in the circulation of the virus [1]. The aerosolizations of contaminated urines and feces from sewage pipelines, as well as throughout the washing of urinals and toilettes, have been signaled as possible courses of SARS-CoV-2 transmission [34].

3.5. Sedimentation and Demobilization in Bioreactors

Suspended solids [135] and particulate organic matter [36] [37] [136] in both water and wastewater participate in the physical protection of viruses, which could extend the infectivity of CoVs [1] [137] [138]. When the virus is adsorbed on the porous surface of the particulate, perhaps, it will be sterically preserved from the arid of hostile pathogens. Indeed, the elevated concentrations of suspended solids and organic matter in primary wastewater ensure extended viral infectivity with respect to secondary wastewater effluents [1] [57] [139]. Nonetheless, the elimination of suspended solids jointly with the adsorbed viruses via sedimentation guarantees the decrease of infectivity [1] [79] [140]. Researchers found that CoVs demobilization in filtered tap water resulted bigger than that in unfiltered samples [1].

Membrane bioreactors (MBRs) possess a considerable contribution in eliminating particulate matter, comprising viruses [1] [83] [141]. Enveloped viruses could be efficiently demobilized in MBRs [1] [130] [142]. Suspended solids and viruses could be hold utilizing membrane filtration even if in the occurrence of hostile pathogens and unfavorable physicochemical circumstances (like aeration [143] [144] and chemical dosing [145] [146] [147]) in the MBRs [1] [129] [148]. Such attachment conducts to the performant demobilization of enveloped viruses like CoVs [1].

4. Conclusions

This work discussed the fundamental comprehension of behavior and persistence of the SARS-CoV-2 in water. Further, understanding performance of the disinfection technologies authorizes establishing veritable hazards and the precise procedure for dealing with the expansion of virus through the water environment. The main conclusions drawn from this review are listed below:

1) All CoVs have a restricted stability in water media: 2 - 5 days in tap water and 2 - 6 days in wastewater were judged enough for 2-log reduction of SARS-CoV-2 titer [1].

2) Examining viable virus particles furnishes important data on the likely infectivity of a polluted specimen. Few studies followed the infectivity of SARS-CoV-2 in influents and effluents of municipal WWTPs and in hospital wastewater [1].

3) CoVs could be spread mostly through airborne routes and the dangers linked with the likely water-mediated diffusion of the SARS-CoV-2 seem to be of low epidemiological importance. Nevertheless, circulation of SARS-CoV-2 can be potential through fomites, fecal-oral route and aerosolization of infected sewages from urinals, toilets and sewage pipeline. Thus, the preventive warnings relating to the observation of SARS-CoV-2 in wastewater need more tests [1].

4) SARS-CoV-2 is distinguished by a weak construction and is vulnerable to traditional disinfection technologies that have been demonstrated to be very efficient in their neutralization. Approximately 5 min of exposure to sodium hypochlorite (1%), ethanol (70%), iodine (7.5%), soap solution and additional usual disinfectants was enough for reaching 7 - 8-log of SARS-CoV-2 titer decrease. Thermal treatment is efficacious in SARS-CoV-2 demobilization: 30 min at 56 or 5 min at 70˚C were enough for attaining the total depletion of the infectivity. Further, SARS-CoV-2 remains vulnerable to sunlight and quickly demobilized by UV radiation. UV-C at 254 nm and intensity of 2.2 mW/cm^2 yields 3-log of SARS-CoV-2 titer decrease in less than 3 s of application [1].

5) Large use of disinfectants has been related to ecological and human health troubles [149]; consequently for SARS-CoV-2 disinfection, usual injections of killing agents remain required for sanitation and for wastewater treatment [1] [128] [150].

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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