Consequence of COVID-19 occurrences in wastewater with promising recognition and healing technologies: A review

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Abstract
Presently, the coronavirus (COVID-19) epidemic presents a major threat to global communal fitness also socio-financial development. Ignoring worldwide isolation as well as shutdown attempts, the occurrence of COVID-19 infected patients continues to be extremely large. Nonetheless, COVID-19’s final course, combined with the prevalence of emerging contaminants (antibiotics, pharmaceuticals, nanoplastics, pesticides, and so forth) in wastewater treatment plants (WWTPs), presents a major problem in wastewater situations. The research, therefore, intends near examine an interdisciplinary as well as technical greet to succor COVID-19 with subsequent COVID cycles of an epidemic as a framework for wastewater treatment settings. This research investigated the potential for wastewater-based epidemiology to detect SARS-CoV-2 also the enzymes happening in wastewater conditions. In addition, a chance for the incorporation into the WWTPs of emerging and robust technologies such as mesmeric nanobiotechnology, electrochemical oxidation, microscopy, and membrane processes to enhance the overall likelihood of environmental consequences of COVID-19 also strengthen such quality of water is resolved.

KEYWORDS
electrochemical oxidation, nanobiotechnology, SARS-CoV-2, treatment methods, wastewater-based epidemiology, wastewater treatment plants

1 | INTRODUCTION

Extreme and acute respiratory syndrome coronavirus-2 (SARS-CoV-2) was the COVID-19 pathogenetic factor, according to the World Health Organization (WHO). It spreads through respiratory secretions and contact channels. SARS-CoV-2 is related to subspecies of the coronaviridae family of viruses that are made up of ribonucleic acid (RNA). In addition, that virus utilizes the angiotensin-converting enzyme (ACE2) and a receptacle in human cells that is extremely high like in digestive organs such as an ACE2 RNA messenger. SARS-CoV-2 recognitions have been reported to be potent happening person fees but also COVID-19 patients’ excrement. Several investigations in sewage systems to identify the virus’s RNA have generated severe concerns regarding COVID-19’s growth and the impact of its microorganism on irrigation and wastewater systems.

The reason for proposing this method is that, regardless, COVID-19’s ultimate route, together with developing pollutants’ presence in wastewater treatment plants (WWTPs), offers a significant difficulty in WWTPs. As a result, the goal of this article is to examine an inter-disciplinary and technical strategy as a roadmap for fighting COVID-19 and future pandemic waves in water and wastewater environments. Wastewater appears to be all water that passes through households and public urban services (hospitals, schools, and so forth) as well as some sectors (if no particular treatment is required). This water is sent through the “sewerage system” to purified wastewater, which is then managed and discharged back into the environment. Wastewater as well as wastewater-based epidemiology (WBE) observation, like the Global Polio Eradication Program, is the method to direct epidemiology monitoring as well as prevention cause to treat malignant illnesses and discharge of wastewater degrades water.
quality and thus water cannot be directly used for potable water (via desalination) and industrial applications. Monitoring the prevalence of SARS-CoV-2 on an ongoing basis and taking effective steps to help minimize but also monitor illness transmission within our neighborhood is important. Still, because the majority of people are asymptomatic, monitoring the virus is challenging; additionally, due to resource and financial constraints, active clinical surveillance of all patients is impractical. Furthermore, COVID-19 can reflect second or more waves. In these situations, the proactive yet powerful drainage or wastewater observing system may be tracked and also control the existence of SARS-CoV-2 via its RNA biological information and display this overall public. This presence of SARS-CoV-2 in wastewater indicates inevitable for the reason that that could invade this digestive tube and also be released into the physician’s wooden chairs. It has resulted in a restriction on foreign flights and social gatherings at some airports and seaports, the use of quarantine procedures, the closure of schools and churches, and the closure of other quasi-entities.  

According to the WHO statement, nearly 5 million COVID-19 cases have been reported worldwide as of May 29, 2020, with 362,614 deaths and 2,596,004 survivors. As a result, distinguishing SARS-CoV-2 measures such as personal sanitation, particular hygiene, handwashing, and disinfection from a steady water supply is challenging. As a result, in the middle of combatting this worldwide epidemic, the water and wastewater sectors will display significant economic repercussions. Nations such as India, South Africa, as well as the United States of America have been anticipated to incur enormous monetary damages in the vast sums as a significant impact of COVID-19 to the worldwide economy structure owing to payment decreases on major utility companies. Studies are useful in determining and creating a successful epoch among every environment of water also wastewater treatment toward mitigating the complexities of COVID-19 on this basis, and several more are expected to return in days.

The pharmaceuticals that are taken for the treatment of therapy are Remdesivir, Nirmatrelvir, Ritonavir, Paxlovid, and Pfizer’s oral antiviral drug. Remdesivir is a broad-spectrum antiviral drug that has become popular because of its ability to treat coronavirus disease. Remdesivir is a prodrug (prodrug of nucleotide) type of drug in which only 200 mg IV quantity is used and is generally followed by an infusion of 100 mg. And for Paxlovid three pills are taken twice daily for 5 days for a full course that adds up to 30 pills (Table 1). Previous technologies or in previous papers have not considered the use of membrane bioreactor (MBR) technology which did not give an effluent recycling processing. This created a large impact on the system which did not process anything efficiently. The result was not clear in the case of the process. But in the proposed technique as an MBR technology is considered the effect of the system is more efficient since it gives a better result while ion the stage of processing itself. This made the system more effective when compared with the previous papers. As a result, the goal of this study is to discuss the current state of the COVID-19 virus, including its genesis, occurrence, and removal from wastewater, as well as integrative and technological techniques as a guide for wastewater treatment region to join the COVID-19 campaign. Furthermore, the study recognized electromagnetic nonmaterial, nanoparticles, and biological treatment as sophisticated and reliable ways for increasing sewage treatment detoxification while minimizing COVID-19 impacts.

TABLE 1  Pharmaceuticals volume and types

| Pharmaceuticals | Volume          | Type                      |
|------------------|-----------------|---------------------------|
| Remdesivir       | 200 mg IV followed by an infusion of 100 mg | Prodrug (prodrug of nucleotide) |
| Ritonavir        | 100 mg          | Antiretrovirals           |
| Lopinavir        | 100 mg          | Antiretrovirals           |
| Paxlovid         | 100 mg          | Oral antiviral pill       |

FIGURE 1  The configuration of the virus
were found within neighborhoods. From this corresponding report, they additionally reported because viral RNA transcripts existed spelled out utilizing this qualitative polymerase chain reaction reverse transcriptase, culminating were two instances of confirmed identification from the WWTPs inside one six-day period duration.15–18

2.1 Tracking of wastewater-based epidemiology for COVID-19

WBE is an effective option for better understanding the prevalence of viruses in the drainage population of WWTPs as the WW includes microbes emitted at a specific location under research from symptomatic and asymptomatic individuals. Wastewater observation serves a role in a better possibility of recognizing early signs of diagnosis with SARS-CoV-2 in the general community, particularly happening people who have only mild symptoms or none at all. Including WBE’s implementations for public health initiatives such as monitoring Enterococcus viral epidemics, including norovirus, hepatitis virus, as well as poliovirus,15 few kinds of investigating this accumulation also identification of SARS-CoV-2 in the wastewater background have been documented.20 Binary RTq-PCR data was reported by Reference [21], whereas yet a further incident research described ~250 copies/mL of SARS-CoV-2 in wastewater in Massachusetts, USA. Furthermore, all researchers who conducted those experiments admitted thus approximate deliberation 5% of all fecal samples found in the drainage basin) was much greater than the number of belongings recorded (0.026%). The author suggested multiple variables for the differences and regarded their findings conservatively. In the analysis by Ahmed et al.,4 these estimated SARS-CoV-2 strains are observed to be three to four magnitudes similar to those reported by Hamidouche and Belmessabih.22

One of the most serious issues is a viral transmission from contaminated natural waters to human communities. On the one hand, water is polluted through homo sapiens, and water, on either extreme, could be a provider of illness for people. Screening for infections within sewerage and other ambient waterways which absorb discharge from sewerage systems will disclose the real incidence and genomic of gastrointestinal pathogens since water absorbs pathogens that are resisted by everybody, irrespective of their competence, as well as the hazards to public wellbeing (WWTPs).23,24 This information might become an example of beneficial display, particularly because it could be beneficial to impoverished nations to make epidemiological surveillance quick, accurate, and inexpensive. In such a situation, the connectivity of the plumbing system and its condition are the two most important factors to consider to prevent infection spread, particularly in high-risk areas like hospitals.25 The sewerage pipe infrastructure is intended to serve as a precursor to harmful bacteria which could transmit viruses like SARS-CoV-2 via air.

The hereditary substantial of SARS-CoV-2 is now human several investigations in far too numerous nations have discovered COVID-19 individuals’ excrement. SARS-CoV-2 transgene had been found inside the feces of COVID-19 individuals often with digestive problems, as well as in healing individuals that no longer have symptoms.26 However, infection or sickness is not generally suggested using this existence of SARS-CoV-2 hereditary substantial in the stool. There were contradictory findings in a few experiments that tried to identify a viable pathogen that is contagious throughout intestinal feces. Three experiments discovered a live virus in the stool, although one study found no live virus despite the presence of genetic material. SARS-CoV-2 is a virus that causes SARS. SARS-CoV-2 was isolated but also detected in sewerage for the earliest time by investigators throughout the Netherlands.27 Within days of the first human case of COVID-19 being identified, Scientists proved that genes of the coronavirus could be found next to various locations for sewerage collections. Wurtzer et al. confirmed the hypothesis (https://www.sciencemag.org/news/2020/04/coronavirus-found-paris-sewage-points-early-warning-system). That reveals, as this inaugural occasion, the overall quantity of genomic sequences has been determined found over sewerage is growing in accordance therewith amount of hospitalizations associated with COVID-19 next to this territorial alongside. Initial data, collected much more regularly around that identical time locations, indicate a substantial decrease in overall infectivity from sewerage, which is thought to be the result of containment measures for virus propagation.

More recently, Australian researchers have also proposed sewage monitoring in the region for SARS-CoV-2 surveillance.4 Researchers are currently working on methods to monitor the emergence of novel flaviviruses in the water. This virus will be identified by the advanced alert and surveillance system’s genetic material or RNA. Researchers from the University of Queensland also the Australian National Science Agency (CSIRO) collected Flug virus was found in industrial effluents specimens collected out of a metropolitan hydroelectric plant as well as a WWTP. Using RT-PCR tests, they analyzed the sewage treatment samples, helping to distinguish gene particles of the SARS-CoV-2 pathogens. That’s precisely one procedure used by physicians to detect the pathogen in clinical specimens. Consequently, the proactive observation by sewage processing and tracking of SARS-CoV-2, using a subsection of the National Water Quality Monitoring Network, can be used in COVID-19 pandemic and post-pandemic scenarios to determine community or public health. Observing ought to begin in red, orange, and green localities will notify wellness authorities of a likelihood of a next COVID-19 outbreak.

Viruses could be identified and information about the virus’s viability can be obtained using cultural techniques. However, for SARS-CoV-2, these approaches are still more complicated and time-consuming than other scientific methods, this reasons why these were less commonly utilized. Work is currently underway just before improvement also validate procedures intended for the watching of SARS-CoV-2 inherited materials vogueous dirt.28 With this method, the prevalence of the disease in populations can be measured, places, where few tests are conducted, can be established, a potential second wave of infection can be predicted and vaccine effects can be tracked. The technique is not ready yet and is not an alternative to human research.

In some of the above studies, developing measurements from viral RNA test samples in comparison with the overall exact incidence
per instance in the population has been a serious hurdle. To address essential elements, from efficient conservation but also surveying to information collection, more systematic research in the WBE proposal regarding SARS-CoV-2 illnesses may be needed. In isolated places and restricted populations, this may be helpful, which allows it quite critical. As a result, it is recommended that techniques for concentrating encapsulated viruses with file systems just on occurrence, as well as the intensity of SARS-CoV-2 among individuals, be developed and/or classified. In addition, the concentration of viruses should be considered a significant cause, through special consideration paid en route for enhancing the thoughtfulness of the detection of SARS-CoV-2 happening sewerage. Idumah et al. estimated in, depending on confined circumstances, the detection of one hypertensive or endemic impaired noncontaminated incident from 100 over 2,000,000 individuals may theoretically be detected in the sewage and wastewater of such a community. This is due to some viable achievements becoming compensated for from across the globe at present. Thus, 2.1 billion individuals might become affected also tracked internationally with around 105,600 waste disposal facilities that can be put under control. According to the European Centre for Disease Prevention and Control (ECDPC) (2020), there have been approximately 27,609,408 occurrences of COVID-19, including 898,087 fatalities. Worldwide were reported as of September 9, 2020.

### 2.2 | Social virus module observation

Developed nations, in contrast to developing countries, have more mature infrastructure. Correspondingly, in the identification of COVID-19 in the wastewater treatment system, the approach for detecting highly contagious contents in clinical and subclinical individuals’ feces in discharge regions could be rapidly adapted due to the interconnectedness and properly built wastewater treatment systems linked to the community wastewater treatment center. However, some populations do not have integrated and centralized sewage systems in most developing countries to adopt the WBE strategy of identifying the virus in drainage systems. For example, on March 14, 2020, BBC World announced that almost half of India’s 1.2 billion population do not have access to toilet facilities (BBC News, 2020). 46.9% had access to lavatories while 49.8% committed open defecation, and 3.2% had access to public toilets. According to an analysis of the virus’s existence in sewerage infrastructure as well as probable indicators of any impending disaster epidemic, this downfall of sewerage infrastructure in municipalities in South Africa presents a danger to residents and neighboring populations of infection. Other researchers’ findings using adequate but also efficiently built sewerage treatment in developing nations indicate that WBE is the most reliable. For example, in the first quarter of 2020, wastewater at Amsterdam Airport was sampled once a week, 4 days after case registration in the Netherlands, findings showed an identification of RNA virus using the quantitative RT-PCR methodology. Sodré et al. support those observations, pointing out that identification of the sewerage pathogen, particularly though COVID-19 frequency is small, shows potential sewerage observation might be utilized to track that disease's distribution throughout the community.

Additional research found about 55% of the 74 patients with COVID-19 had SARS-COV-2 in their faecals for an extended period. In China, a mean of 27.9 days was found in 55% of experiments conducted, compared with a mean of 16.7 days. The therapeutic combined WBE a year for every diagnostic cost may vary greatly depending on geographic locations, labor cost difference rates, supporting infrastructure, and health standards, among other factors. According to Mao et al. the cost per clinical virus test kit in patients can vary from USD 10 to USD 20, depending on the patient's position with a global mean of USD 15 on average. Currently, approximately 600,000 viral genomes of SARS-COV-2 have been identified per mL of human excreta with a faecal load of 100–400 g. SARS-COV-2 load to urban sewerage per contaminated individual each person is predicted to be connected to approximately 56.6 million to 11.3 billion genomic sequences, having lowest as well as maximum bounds ranging from 56.6 million to 11.3 billion, according to Sodré et al. This equates to infectious replication quantities ranging from 0.15 to 141.5 million every liter in the effluent.

### 2.3 | COVID-19 mitigation in living creatures

Sadly, there appears to be no viable strategy for medicating the mixture or using it to cure SARS-CoV-2 ailment beyond this stage, given the potential consequences being deadly violent responses as well as severe pulmonary damage. Several experiments have been performed to correct and track the complete degradation of contaminated patients’ immune systems.

Hamidouche and Belmessbaib have indicated that one of the most attractive antiviral drug targets is SARS-CoV-2 Mpro protease, especially inwards such design was also developed due to SARS medications. Furthermore, Borges do Nascimento et al. observed while Chinese therapy recommendations also this WHO’s Center aimed at Disease Control and Prevention (CDC) mentioned medications such as the experimental drugs (remdesivir), ritonavir, and lopinavir. Nearby almost here none remedy to all of that with the virus so far also thus, as shown in Figure 2, the WHO recommendations such by way of protection measures aimed at humanoid defense as well as pathogen protection. This included cultural separation; quarantine; hygiene procedures such as cultural separation; quarantine; hygiene procedures like when manual cleaning and sanitization; symptom monitoring; coughing and just a well as a cotton scarf labels; examination, quarantine, segregation, also touch locating; then routine environmental scrubbing as well as infestation were all part of this plan. These include social distancing. COVID-19 contains no immunization as well as treatment, as mentioned earlier, and its mortality charges remain increasing rapidly. As a result, precautionary measures must be taken to protect the entire population. According to a recent report that the COVID-19 is a spray that may linger inside the air lasting greater than 8 h, so it is very important to wear masks.
3 | ENVIRONMENTAL AND HEALTH CONSEQUENCES OF POLLUTED WASTEWATER FROM COVID-19

In several nations, because of the shortage of water supplies, wastewater is used to irrigate agricultural land. Moreover, sludge from processed wastewater is outstanding nourishment; this is becoming more prevalent being utilized now unindustrialized modifications. As a result, viruses present in wastewater and sludge are accumulated onto crops as well as soil, wherein they have a good chance of survival. A danger to population wellbeing is then generated as possibly a consequence of water pollution sources using virus movement through the soil or the intake of a gardening product tainted on the market.

In agriculture, the recycling of pretreated and untreated sewerage is a trend that is gradually growing. Therefore that one is essential to more about the fate of such infections, especially about undergrowth. It could need to become achieved on cell cultures of enteric viruses that can multiply. The existence of a here is nothing infectious gene implies the existence of virulent pathogenic fragments. Research happening writings show in, depending on circumstances, pathogens could live just about foliage arid through sewerage aimed at varying periods spanning from several days to a few weeks to almost 4 weeks. Two factors tend to have a basic effect on the infections’ survival period on crops following watering, in addition to the existence of the taters under consideration. Both the original quantity of pollution, as well as the temperatures corresponding to sunlight are significant. It must be conscious that achieving a viral decrease of two logs of infection takes more than 6 h, even in regions with a very hot environment. For example, this means that if there is a golf course irrigated Enterococcus infections are probable to show up just on the track throughout that daytime because sewerage is used in the early. On arid lawns in public parks, the same condition can be identified. In these circumstances, athletes and youngsters involved may be affected by enteric viruses. Regarding vegetables, on the contrary, it is obvious, and this has been well confirmed, that plants irrigated with polluted water during cultivation maintain large quantities of malware on the exterior of the computer. Moreover, holding at +4°C not alone serves nothing to accelerate rather significantly delays bacterial deactivation. Consequently, having vegetable crops that are malware during yield is extremely significant. Figure 3 shows the possible benefits of reusing cleansed sewerage during agricultural watering.

Moreover, the COVID-19 epidemic’s influence on its climate has grown accustomed since the onset of the crisis, through examination and review of current impacts and projections relating to long-term changes. Qualitative assumptions prevail, through appropriate data sets and additional information must be awaited for consistent quantitative analysis. Most elements of the COVID-19 pandemic’s environmental impacts are not caused solely by the virus. Economic sectors that have experienced unexpected bans or closures (along with thick manufacturing, conveyance companies, before hotels) have used to have a powerful effect on its climate. The pandemic can lead to a more prosperous future from the standpoint of anthropocentrism, and in particular, toward further robust social-economic structures or limited manufacturing networks, both of these are encouraging signs.

However, by promoting fast economic growth and reducing environmental issues, countries can still opt for less sustainability. Though the COVID-19 crisis will have a large general detrimental economic as well as social consequences, the slowdown in global economic activity is likely to trigger significant changes in the efficiency of environmental and climate service schemes. Nevertheless, hardly any of the economic implications of a situation were and might prove favorable. The majority of those point to a rise in terms of quasi garbage, the enormous quantity of solid unwanted produced as a result of declining exports from agriculture and fisheries, and the lack of protection and
monitoring of natural habitats. Anecdotal evidence suggests decreased demand for waterway metabolic oxygenation versus coliform concentrations, enhanced air excellence due to the lower level of nitrous oxide, particulate matter, also ozone formation (O$_3$) in conjunction alongside additional contaminants (UNCTAD, n.d).

Either minor agriculturalists, small and medium-sized enterprises, or micro, small as well as medium-sized enterprises engaged in such development of biological commerce, jungle, also fishery goods, as well as eco-tourism amenities, several coastal and rural communities depend on the local environment and natural resources being used sustainably. Because the recession has interrupted their requirement ties to domestic and foreign arcades, manufacturers in remote areas (many of whom are supporting females’ whole families) were never again in the position to perform completely sustain development plans but also livelihood services. Considering hazards represented by the coronavirus outbreak to the ecosystem including environmental supplies, and also the cultural-financial ramifications must be considered.

Like in many countries around the world, sewage provides an acceptable method to Morocco as a result of the increased demand for groundwater, especially as a result of frequent shortages, is steadily rising sewerage recycling in the country is primarily used in industry, especially for phosphate washing, but it is also used to irrigate golf courses. A request sent to the local authorities from the Ministry of the Interior bans the use of wastewater before its treatment due to the potential existence of genome traces from the stools of both the injured populations (https://www.leconomiste.com/article/1061485-les-eaux-usees-unc-moyen-de-tracage-du-covid-19). Those request notes in which these laws and regulations in force determine the use of this wastewater.

4 | SARS-COV-2 POTENTIAL TREATMENT TECHNOLOGIES IN WASTEWATER

Wastewater handling units and WWTPs remain the ultimate destinations intended for disinfection steps, COVID-19 patient excretion, and other COVID-19 administrative requirements. This persuaded the United States Occupational Safety and Health Administration en route to publishing innovative wastewater but instead, sewerage personnel must follow tight laws and norms depending upon evidence collected earlier this year from healthcare settings. 36–38 Ahmed et al. 4 stated that in sewage and drinking water, coronaviruses, such as SARS-COV-2, which caused the COVID-19 outbreak, can be contagious lasting days or weeks. Now addition, washing and disinfection procedures are applied in clinics and hospitals, including ultraviolet (UV) radiation sterilization, peracetic acid, or hypochlorous acid chlorination. This segment presents potential technologies for wastewater treatment and SARS-COV-2 identification strategies in sewage situations.

4.1 | SARS-COV-2 probable approaches for diagnosis

4.1.1 | Electromagnetic nanotechnology

Magnetic nanoparticles (ferromagnetite) have been discovered to be effective platforms for major element desorption into aquatic systems. 8,34 The chemistry overdue this process may be traced back to four electrons that are stranded with a strong magnetic moment in an iron atom in the third shell. Fe$^{2+}$ ions have four valence electrons in their 3D orbit, while Fe$^{3+}$ ions possess five valence electrons in their 3D shell. Magnetite nanoparticles were vulnerable to the oxidation process in aquatic settings and can rapidly agglomerate. These additional surfactants are used as a means of interface alteration desired to stabilize the iron oxide nanoparticles. In this case, the continued magnetostrictive nanostructures for sewage applications, including such elimination by attractive separation of nonmagnetic water contaminants such as it may very well be a highly effective technique for removing contaminants, algae, including viruses. 8

Aimed at an example, Mao et al. 34 demonstrated that aptamer-conjugated magnetic nanoparticles were successful in extracting HCV fragments extracted through individual serum specimens. Compelling
It is achieved through linking particular ligands on the outside of MBs and isolating the MB-bound reagents utilizing some external magnetic field guide. In addition, MBs might formerly work through various sensitive clusters with requirements, such as tosyls, epoxy, carboxyls, as well as amines, that may be used just before disabling high-affinity ligands, together with antibodies, proteins, aptamers, depending upon, along with many numerous things approved implementation.

In biotechnology, magnetic separation applications for analytical purposes, cell separation, sewage treatment, protein digestion, and purification have recently been developed. In addition, the combination of MBs by aptamers gives us new possibilities for fashionable different presentations, together with biosensor-based ailment detection, cell imaging, as well as labeling and magnetic resonance imaging, illness treatments, water cleansing, waste management, wastewater management, and specimen processing are all examples of applications. In aptamer-modified MB-based assays, aptamers areas previously stipulated, used as MBs and binding ligands, typically used to distinguish the analysis from complex matrices. Surface-enhanced Raman scattering (SERS) sensing in aptamer-modified MBs is used for the analytical purpose of different sensor designs.

4.1.2 | Biosensing applications

Biosensors have become used in multiple prospective fields, including drug discovery, diagnostics, biomedicine, food protection, environmental monitoring, and safety, as strong and creative analytical instruments with biological sensing elements. A lactose biosensor is also a convenient device for the study of enzymatic immunoassays with PCR amplification reactions, for example, the words ‘contour’ for determining glucose with “OneTouch” when determining glucose as well as lipids. It stands claimed that Clark also Lyons invented the first biosensor. In addition, the invention of biologically encoding or modified radioactive biosensors in the study of molecular pathways of biological processes is a scientific revolution in biosensors. The production of biological detectors is restricted because of their limited durability as well as fast deterioration while preservation but also usage of biological components. It creates it hard to calibrate and reduces reliability. Their synthetic counterparts, unlike biological materials, are chemically and thermally stable. In addition, with that area of medication development, nourishment quality values, biomedicine, protection, safety, also conservation watching, the use of biosensors has acquired paramount importance. Biological sensing devices, such as biosensors, have been used to build accurate and effective analytical instruments for decades.

Topical developments in scientific procedures but also instruments of nanomaterial tagged radiance have been found would thus raise the sensitivity border of biological detectors. The adoption of imprinted polymers of aptamers or nucleotides, peptide collections, antibodies, also molecules could deliver resources for the creation of novel biological detectors above conventional approaches. These combined methodologies make available an enhanced viewpoint aimed at the production of high regenerative capacity, and precise and responsive biosensors. Wider possible applications could be provided by various biological detectors fluctuating after nonmaterials, organisms with polymeric. The integrated strategies often include various technologies optoelectronic immuno sensors including biologically manipulated microorganisms having electrochemical, electromechanical, and luminescence properties. The majority of these biosensors have a lot of promise in terms of clinical recognition as well as therapy. The mission as well as some essential to take advantage of immuno sensors for cost-effective quick evaluation necessitates biofabrication, which will prepare that approach. For the identification of microscopic to entire species behavior having a low identification threshold of molecules as well as a high precision measurement level. According to preceding research, in most cases, early detection of contagious disorders, as well as the effective beginning of correct therapy, are the norm allocated to facilitate medical excellence with welfare services. Various researches provide shown this traditional in utero treatments are time-consuming going to contagious illnesses that need a centralized laboratory, specialized personnel, and heavy infrastructure.

Biosensor technology advancements can include the moment in time monitoring met before surpassing the typical time, quality, also payment criteria. Notwithstanding the therapeutic requirement, nano-sensor conversion between laboratory into medical use is restricted to a handful of famous instances, like the sensing element. Immunosensors have been used to solve therapeutic issues such as collection pretreatment, inhomogeneity, as well as systems engineering. The large variety of sewage microbial diseases in the world has been shown to cause extraordinary morbidity and mortality. Sewage offers a great state of production for different kinds of yeasts, fungus, algae, protozoa, viruses, as well as bacteria, which are all examples of organisms. The proportions of mixotrophic, blue-green algae, symbiotic, quasi, and dangerous microorganisms differ according to their origins, according to Mishra et al. Tobore projected that the concentration in the wastewater of certain bacterial pathogens viruses and parasites like Giardia but also cryptosporidium are intimately involved related to those population’s sickness amount. Other nonpathogenic faunal bacteria, such as bacteriophages of RNA, complete coliforms, and Escherichia coli, may be less troublesome as a result of this. The majority of coli are found in wastewater and have only a small impact on
people's lives. As a result, using biosensors in the sewage system to detect SARS-CoV-2 in wastewater purification facilities is beneficial. Li et al. also added that it is important to classify waterborne infections as pathogens that should eliminate as well as reduce their noxious impacts. Essentially, with magnetic nanomaterials, the latest development of biosensors can be used to enhance the accuracy and efficacy of the detection of many pollutants, including viruses.

Classification of COVID-19 probable biosensors

At point-of-care (POC) treatment of various ailments, new varieties of COVID-19 possible immuno sensors had already been identified and recently recognized. These include biosensors based on specimen chips, papyrus, and even nanomaterials are all used. Chip-based immuno sensors for the detection of pathogens being manufactured from polyethylene glycol methacrylate. Since these biosensors are automated that improve the movement of the fluid using a tiny amount of specimens that can be changed precisely, they have a high analysis throughput. Moreover, very minimal rates, great transparency, and excellent cytocompatibility characteristics ought to draw attracted people's interest in progressive scientists. An interactive technology different sampling hardware nucleotide detector, for example, should always be tailored for the probable detection of COVID-19 in sewers.

Parchment nanosensors have gotten increasing consideration toward POC usage than hardware immuno sensors. Because of its minimal price, ease of application, and high good biocompatibility, they can be utilized on and for POC screening in distant situations to obtain quick efficiency. The following are the components of these test strips: (i) a sample pad to be used to apply samples to patients; (ii) an allergen COVID-19 conjugation device comprising non-nanoparticles (gold-COVID-19); (iii) a membrane made of polyurethane resin consisting of a control line (goat-coated IgG antirabbit, antihuman IgG coated IgG test line, antihuman IgM coated IgM test line); and (iv) an absorbent IgM coated IgM test line; an absorbing cushion for absorbing garbage.

The preamble of nanomaterial-fabric, movie, magnetic nanoparticles (gold, iron, zinc), graphite, but also nanoparticles (nanowire) biosensing enabling COVID-19 identification in sewerage environments has led to further developments in biosensors. The production of the article aims to enhance the overall usefulness as well as the accuracy of identification of traditional immuno sensors to commercialize and reduce COVID-19’s socioeconomic danger enhancing both adjustable hydrophilic nature as well as associations among integrating nanostructured antibodies (AuNP-Ab) as well as the experimental substrate, in particular.

4.2 | SARS-COV-2 realistic developments for wastewater management

4.2.1 | Bioreactor membrane

Membrane manufacturing has advanced and materialized as a favored method on behalf of recovering water for reuse on or after various sewage sources. Membrane technology provides many opportunities for wastewater treatment, with a substantial decrease in terms of instrument size, resource requirements, as well as an inexpensive initial investment. Membrane manufacturing can bridge the economic as well as the sustainable disparity between minimal or no pharmaceutical usage options, renewability, as well as easy availability that consumers, according to Obotey Ezugbe and Rathilal. Therefore in recent times, membrane manufacturing has proved to be a better desirable choice during the sewage remediation procedure. The schematic representation of the various membrane process paths is revealed in Figure 4.

MBRs have gained a large advertise apportion happening water also wastewater environments over the past decades, that projected to rise with a cumulative annualized growth ratio of 13.2%. According to current studies, a demonstrator plant requires a significant energy utilization of 0.45–0.65 kWh/m³ for maximal ideal functioning, is the main drawback of their widespread implementation.

Previous research papers have reported that while MBR technology was not used when Smith et al. implemented it earlier that had a major influence during the latter 1960s, since the mid-1990s in effluent recycling processing. The key factors behind these humankind’s present extensive adoption across the universe could be attributed to stringent effluent discharge legislation and lower membrane initial costs. The recent advent of the presence of biological management inside the sewage therapeutic industry reflects the level of stability attained by this innovation. A 9.0% yearly development percentage percent is recorded in the most cited market research report and forecasts by 2023, the worldwide industry will be worth USD 3.7 billion. China and some European regions, having implementation rates of more than 50% and 20%, correspondingly, are primarily outstanding in this situation. Technological development in this sewage water enterprise is often indicated in two major classifications: increasing diversity of equipment providers as well as the increase in based data. The quantity of MBRs has been found to have risen exponentially since 1990, by the end of 2009, it is expected that there will be over 50 different providers. MBR systems use their microbiological and metabolic capacities to handle wastewater. MBR developments stand similar to traditional operations involving activated sludge (CAS) about this. These are planned and controlled with retention times of solids (SRT) much longer than that of CAS processes. Different care performance and other related circumstances arise from longer SRT operations. The benefits and drawbacks of MBR over CAS are shown in Table 2.

Confines of MBR

Microbiome, thermodynamics, composition, and mass balance are all topics covered in this section are the basic frameworks associated with an MBR, which vary significantly derived using CAS plants biocatalysts in terms of conception as well as implementation. MBR developments are used to isolate treated water from activated sludge using microfiltration or ultrafiltration membranes, in CAS procedures, downhill suspension containers (or supplementary deposition containers) are replaced. MBRs have many advantages, including simplicity, minimalism, improved
discharge efficiency, quicker biodegradability, and the potential to transfer between preexisting traditionally activated sewage treatment filtration systems. The disadvantages include limited oxygenation, sediment pressure in outside MBRs, contamination, and therefore higher price expenses. Popular addition, it is important to consider microbial development as another process in moderate development circumstances, as necessary for MBRs. That is understood to be a need for preservation capability, spontaneous respiration, then future enigmatic expansion.

Traditionally, this involves handling activated sludge and filtration of processes via a membrane with hole sizes ranging from 10 nm to 0.4 microns (micro/ultrafiltration), improving sediment extraction. To ensure that all particulates, micelles, bacterium, or infections are retained, the outer layer acts as a barrier, retaining all atoms, colloids, bacteria, and viruses.

In addition, there is little knowledge in terms of the shape but also the processing of extracellular polymeric substances on behalf of the complete withholding of sludge and low ratios. In addition, membrane separation technology could overcome the restriction of gravitational deposition, which creates approximately particulate-cleanse effluents for cheap. However, cases of extreme membrane fouling have been recorded. Continuous improvement in membrane modules and membrane components is needed to minimize membrane clogging is a significant problem for cell wall technology. In many WWTPs, the ability to combine two or more transmembrane technologies with related technologies, such as anticoagulation, is continuously explored, improved, and introduced.

**TABLE 2 Benefits and drawbacks of MBR over CAS**

| Advantages | Disadvantages |
|------------|--------------|
| 1. Demand for large treated wastewater that in addition to the elimination of most bacterial infections and certain viruses, is renewable. | 1. More difficulty with procedure and mechanism |
| 2. Small impact due to a supplementary sedimentation tank obviation and smaller scale of the bioreactor | 2. Lower cost of capital and operations |
| 3. Reduces the amount that WAS generated | 3. Greater tendency for foaming. |
| 4. SRT regulation in its Finest Form | |

**FIGURE 4** Schematic representation of the various membrane process paths

**FIGURE 5** MBR configurations

**Configuration of MBR**

There are currently two major MBR configurations in use: MBRs on the lateral flow but also submerged MBRs (Figure 5). Cranking mechanism typically transports feedstock for filtering but also residues through the purification system returned toward the tank an MBR lateral streaming and the earliest to be employed in previous generations. It is vital to recall that the barriers inside this secondary fluid MBR are typically located just outside of the fermenter, requiring another intermediary phase. Such an approach is useful since the membranes component is readily available for regular
Microorganisms are historically categorized, perhaps more than anything, based on their size and shape. Prokaryotic microorganisms are generally identified as miniature shapes of life that the naked eye cannot easily recognize, but are examined using the use of a magnification. Microorganisms are historically categorized, predicated just on the existence of a spindle that is lattice, into prokaryotic and microbes that are multicellular. There is a surface nuclear within the body of unicellular microorganisms containing nuclear technology, unicellular lifeforms microbes disseminate their chromosomal components in the cytoplasmic, whereas eukaryotic pathogens do not (e.g., no membrane-bound nucleus). Table 3 illustrates the differences between these microorganisms. Cell potential, lattice structures, cell wall, cell proliferation, as well as procreation are also factors to consider in the selection are specific characteristics that distinguish them. Prokaryotic microorganisms comprise bacteria and archaea, although unicellular microbes include fungus, algae, protozoa, and even mammals.

In bioreactors, those microbes are important in the oxidation of organic contaminants becoming carbon dioxide as well as water, whereas nitrogen (an inorganic pollutant) is oxidized into nitrogen. In bioreactors, different kinds of microscopic life forms may be present. One of the most important aspects of microbiology in ecological system architectures, such as MBR, is that they are organized into communities with different species in an independent process where diverse creatures are continually fed from the atmosphere and through powerful wastewater into a bioreactor. Nevertheless, by imposing particular reactor designs and operating requirements, particular species can be enhanced for use in bioprocesses. The organization of the microbial community is regarded to be critical in defining the overall functionality, effectiveness, and quality durability of bioprocesses.

**TABLE 3 Comparison between Prokaryotic and Eukaryotic microorganisms**

| Microorganisms                  | Prokaryotes | Eukaryotes                        |
|--------------------------------|-------------|-----------------------------------|
| Membrane-bound nucleus         | Absent      | Present                            |
| Cell size                       | 0.1–2 μm    | 10–100 μm                          |
| Membrane-bound organelles       | Absent      | Present (e.g., mitochondria, chloroplast, and Golgi complex) |
| Cell wall                       | Present     | Not all                            |
| Pili                            | Present     | Absent                             |
| Cell division                   | Binary fission | Mitosis, meiosis                   |
| Sexual reproduction             | Asexual     | Sexual, asexual                     |

**4.2.2 | Method of advanced oxidation**

The latest emerging contaminants of micropollutants (COVID-19 RNA, insecticides, antibiotics, and endocrine disruptors) in WWTPs affect such possibility of recycling after treatment of these waters. When aquatic animals inject toxins containing micropollutants, their endocrine system is altered by endocrine-disrupting compounds. As an advanced oxidation process, hydrogen peroxide (H₂O₂)/UV (AOPs) is a potential possibility besides eliminating contaminants from intermediate WWTPs. This process was recently used in Edmonton, Canada, belong with a result of the Gold Bar Sewage Management Unit to treat secondary sewage. Since that time, much attention has been paid to the system since it makes more use of hydroxyl radical (•OH), which is extremely responsive in the direction of the degradation of uncontrollable substances contained in effluents. It is...
understood that hydroxyl radicals bombard organic molecules nonselectively and quickly. In addition, the system offers another diverse strategy for the development of hydroxyl radicals that makes it more flexible and thus provides a strong strategy to comply with strict guidance during the wastewater treatment process in treating effluents, AOPs such as photocatalysis, ultrasonic processes, Fenton and photo-Fenton processes (Fe\(^{2+}/\)UV/H\(_2\)O\(_2\) and Fe\(^{2+}/\)H\(_2\)O\(_2\)), H\(_2\)O\(_2\)/UV, ozone in combination with catalysts (O\(_3/\)catalysts), UV irradiation (O\(_3/\)UV), and ozone in combination with hydrogen peroxide (O\(_3/\)H\(_2\)O\(_2\)) or both (UV/H\(_2\)O\(_2\)/O) (Table 4).

| Advantages and disadvantages of AOPs in WWTPs | Advantages | Disadvantages |
|-----------------------------------------------|------------|---------------|
| Advantages | Treat almost all organic compounds and remove some poisonous substances by converting natural substances into inorganic stable compounds. | It could be important to consider the removal of residual peroxide. |
|          | It is possible that new toxic substances will not enter the water. | Complicated chemistry customized for particular pollutants. |
|          | No sludge is generated, unlike biological or chemical processes. | Maintenance and relatively large money. |
|          | Does not seem to collect sewage for later use in any way. Bacterium decontamination, for example, with UV R | Energy-intensive rate. |

The environmental friendliness of the end product was a notable characteristic discovered throughout the procedure, giving it a more successful perspective for mineralizing a wide diapason of organic contaminants, like COVID-19. The approach is environmentally friendly since it uses solar energy rather than hazardous and inefficient artificial light sources. •OH’s extraordinarily sensitive composition allows it to strike practically any biological substance beyond distinction. Tables 3 and 4 lists the benefits and drawbacks of AOPs in WWTPs.

Relevance of AOP on infection rates in wastewater

Because AOP produces hydroxide (OH–), a balanced antioxidant factor, is a very important antioxidant representative, the hydroxyl radical (•OH) variant is more specifically produced. In essence, the oxidation capacity of AOP is two times that of chlorine (the widely used sanitizer), so it is useful to use AOP as a polishing stage in WWTPs. The primary impetus behind many AOPs is hydroxyl radicals. In various combinations, UV, H\(_2\)O\(_2\), and O\(_3\) are routinely used to generate •OH in appropriate amounts and efficiently break down contaminants. The method will reduce those deliberations of contaminants, possibly ranging from thousands many nanometers to just a few parts per billion. The above molecules have zero selectivity also all organic materials are thus essentially targeted. Then with the •OH radical, they form intermediates. After reacting in conjunction with said reactive oxygen species, the intermediates mineralize into stable compounds. Microorganisms-loaded particulates were used to charge photoanode substrates with hepatitis A (H\(_3\)N\(_2\)). live attenuated viruses, *Bacillus thuringiensis*, and mycobacterium smegmatis were investigated with platinized sulfated TiO\(_2\) (TiO\(_2/Pt\)) and undoped TiO\(_2\). \(4\) The study found that 30 min of UVA irradiation on TiO\(_2\) achieved 90% inactivation and 99.8% on TiO\(_2/Pt\) achieved 99.9% inactivation. Inside the anodized photocatalyst, TiO\(_2/Pt\) exhibited a higher degradation frequency, which deactivation would have been the most feedback controller to charged transport dissociation. And for its quasi character and strong oxidizing capability, the OH molecule does have the fastest rate of the response of the overall superoxide anion employed to remediate effluent (Table 5).

The rapid reactions have resulted in significantly shorter recollection durations compared with similar conventional processes of management. The extremely poisonous byproducts (DPBs) that can be produced from therapy are one of the problems with chlorine disinfection. A further dechlorination step is often needed to predict these outcomes. To produce water, the •OH molecule can integrate. The most critical problem will be the formation of excess peroxide and bromated, although issues are manageable in a well-structured AOP system. Some of the aforementioned research data concerning SARS-COV-2 and additional CoV variants in WWTPs are given in Tables 4 and 5 concerning SARS-COV-2 or other CoV compounds in WWTPs. Wurtzer et al. \(6\) discovered assuming an infectious concentration of 5.40 logarithmic 10 copies/L was appropriate for wastewater treatment.

### 5 | RESULT

Various technologies in consequence of COVID-19 occurrences in wastewater were reviewed and their results are depicted in this section.

- **COVID-19 Wastewater-Based Epidemiology Tracking**—2.1 billion people might be affected globally, with roughly 105,600 waste disposal facilities that can be controlled. COVID-19 has been reported in over 27,609,408 cases, according to the ECDCPC.
- **Observation of the Social Virus Module**—This translates to infectious replication levels in the effluent ranging from 0.15 million to 14.15 million per liter.
- **Electromagnetic Nanotechnology**—SERS sensing in aptamer-modified MBs is used to test alternative sensor architectures for analytical purposes.
- **Applications of Biosensing**—Essentially, magnetic nanoparticles may be used to improve the accuracy and efficacy of biosensors, which can be used to detect a variety of contaminants, including viruses.
- **COVID-19 Probable Biosensors Classification**—The article’s creation aims to improve the overall usefulness as well as the accuracy of traditional immuno sensor identification to commercialize and reduce COVID-19’s socioeconomic risk by enhancing both adjustable hydrophilic nature as well as associations among integrating
nanostructured antibodies and the experimental substrate, in particular.

- The Membrane of a Bioreactor—The counter current design provides an increased discharge, which has traditionally been employed in relatively small instances such as industrial and leachate drainage.
- Microorganisms in Bioreactors—Specific species can be improved for usage in bioprocesses by enforcing specific reactor designs and operational criteria.
- Advanced Oxidation Method—For wastewater treatment, an infectious concentration of 5.40 logarithmic 10 copies/L was found to be adequate.

These are the results that are taken from the proposed methodology which gives a better interpretation of the proposed technique.

6 | OVERALL EVALUATION

In summary, the analysis revealed that sewage treatment systems may be a possible field on behalf of tracking the epidemic of SARS-CoV-2 in societies across the globe from existing fiction scheduled this latest contagion that the world is in an awful state. Nonetheless, in deprived areas, most sewage systems appear oblique and are visible enhancing and enhanced countries because of their established and coordinated sewage systems. Further experiments have shown that now the pathogen will persist in sewerage as well as potable for days, indicating an efficient way to remove the load of the virus should be adopted. Furthermore, insufficient COVID-19 diagnostic testing in poor regions results in high costs, delays, and unrelenting problems; thus, this study identified WBE as a viable approach instead of identifying COVID-19 hotspot areas including both isolated areas as a densely crowded metropolis. Thus by efficient random sample and examining of viral RNA in wastewater to assess the occurrence of viruses, early warning and spread of viral RNA in established populations appears to be very promising and cost-effective. Limited information remains, however the streamlined and standardized procedure for improving, SARS-CoV-2 detection, as well as quantitation in the effluent, requires future work. In addition, it was found that the traditional RT-PCR methods used during statistical analytics were moment, employment, but also unavailable from apart. Biosensors were, as a result, an effective solution to real-time monitoring (RT-PCR) of COVID-19 outbreaks was discovered because of their minimal rates, ease, quickness, and excellent mobility. By combining specimen industrial attachment of an immunoassay, chip, paper mainly, and nanotechnology immuno sensors were employed to recognize pathogenic nucleotides with individual antibodies against the organisms. To enhance the durability of RNA in the specimen, magnetic nano-based elements (gold, iron, graphene, and nanotubes) or protease substances can be used to enhance assessment sensitivities, accessibility, and effectiveness of immuno sensors.

Sidestream MBRs and submerged MBRs are the two most common MBR topologies now in use. In recent decades, the sidestream MBR was the first to be introduced. The membranes for the side stream MBR are located outside the bioreactor, necessitating an intermediary pumping system to convey the biomass for filtration and residue from the filtration set up back to the bioreactor. This approach is useful in that the membrane module is easily accessible for cleaning; nevertheless, side stream MBRs have had limited applicability in recent years compared with submerged MBRs due to the high energy and pressure requirements. Because the method was only used in a few circumstances, such as industrial and leachate wastewater, the side stream arrangement generates particularly high-quality effluent.
The extension of this technique to broad applications such as the treatment of municipal wastewater was hampered by higher energy costs associated with mixed liquor recirculation, membrane fouling, and expensive membrane capital costs. In MBRs with absolute pore sizes of 0.1 m, human norovirus, enterovirus, and adenovirus were reduced by 3.9, 5.1, and 5.5 logs, respectively. To completely inactivate SARS-CoV, chlorine dioxide must have a free residue chlorine concentration of >2.2 mg/L.

Hydrogen peroxide/UV as an enhanced oxidation process might be a viable option for eliminating micropollutants from tertiary WWTPs. Organic compounds are known to be bombarded by hydroxyl radicals in a nonselective and fast manner. Furthermore, the technique provides a variety of methods for creating hydroxyl radicals, making it more adaptable and, as a result, providing a better way to conform to tight wastewater treatment criteria. Photocatalysis, ultrasonic processes, Fenton and photo-Fenton processes, \( \text{H}_2\text{O}_2/\text{UV} \), ozone mixed with catalysts, UV irradiation, and ozone combined with hydrogen peroxide or both have all been shown to be successful in wastewater treatment. The end-eco-friendliness products were a standout quality discovered during the procedure, providing it a better chance to mineralize a wide range of organic contaminants, including COVID-19. The technique is environmentally benign, as it may rely on solar energy rather than dangerous and expensive artificial light sources.

With the immediate need for a breakthrough to create a COVID-19 cure or vaccine, wastewater remediation should not be left out. Thus, WWTPs are the final path for wastewater and human excretion. The WBE method was found in this study as a potential way of tracking the spread of COVID-19. Furthermore, incorporating new magnetostrictive nanomaterials, biological recognition, and transmembrane bioremediation or AOPs in traditional therapy techniques could decrease the danger represented by new pollutants and also the SARS-COV-2 RNA. Some of the advantages of using AOP in WWTP are:

- Organic molecules are converted into stable inorganic chemicals.
- Almost all organic chemicals are treated, and certain heavy metals are removed.
- Do not theoretically put new dangerous chemicals into the water.
- As opposed to biological or chemical processes, there is no sludge produced.
- Does not include concrete for additional pathogen disinfection, particularly when employing UV Rapid and Robust technology.

Due to these advantages, it is more effective in the WWTP system so that there will be no serious issues and the dangerous COVID-19 will not have much impact on the system.

7 | CONCLUSION

This article analyzed relevant material on COVID-19’s presence in wastewater treatment setups as well as changing wastewater handling strategies. While COVID-19 is treating wastewater, magnetic nonmaterial (biomagnetic separation, immunosays, and medical imaging methods) are thought to be useful in targeting developing contaminants that traditional systems fail to eradicate. Thus, leftover chlorine magnetic particles may be swiftly separated from the solution using an applied magnetic field. The use of particles happening in wastewater handling environments might also increase some efficacy in terms of both viral RNA as well as additional biosensor detection pathogens. Comprehensive research on the toxicity of magnetic nanoparticles has shown that there is little to no harmful effect on the environment. Therefore, because of their super-magnetic properties, the incorporation of magnetized nonmaterials into the wastewater treatment settings may promote medication and separation, whereas the remainder of this compound remains intended service supply a significant amount in terms of coverage arena detection and quantification of RNA viruses adsorption. Through WBE, the incorporation of magnetic biosensing examinations is being included in wastewater remediation technologies. As a result, studying the spread of COVID-19 for health policy advancement in communities throughout the world while lowering the cost of investigative research might be a viable option. AOP (\( \text{UV/H}_2\text{O}_2 \)) has also been proven to be economically viable for the breakdown and removal of endocrine-disrupting chemicals in wastewater in the long term, showing that UV/magnetized TiO\(_2\) photocatalysis on the adsorbed sludge surface can inactivate COVID-19 RNA. Human norovirus, enterovirus, and adenovirus were decreased by 3.9, 5.1, and 5.5 logs, respectively, in MBRs with absolute pore diameters of 0.1 m. Chlorine dioxide must have a free residue chlorine content of >2.2 mg/L to inactivate SARS-CoV. As a result, it is easier to meet stringent wastewater treatment standards. In wastewater treatment, photocatalysis, ultrasonic processes, Fenton and photo-Fenton processes, \( \text{H}_2\text{O}_2/\text{UV} \), ozone mixed with catalysts, UV irradiation, and ozone combined with hydrogen peroxide or both have all proven effective. Applications for the proposed technique include hospitals, schools, industries, and so forth, wherever the public or crowded places are available. The future scope has been given in the following section below.

8 | FUTURE SCOPE

The future scope of the proposed study involves:

- When using WBE, which necessitates routine samples for diagnostic testing, all safe work practices, and suitable personal protective equipment should be followed to safeguard employees from SARS-CoV-2 exposure.
- Future work on creating optimal and standardized techniques for the detection and quantification of SARS-CoV-2 in wastewater is critical to eliminating discrepancies in results. To assist develop effective regional reports, this assay must be compared and integrated with centralized hospital laboratories.
- To increase the sensitivity and detection of biosensors with the aforementioned qualities to reduce and safeguard COVID-19's
spread, magnetic nano-based materials should be used. Future research might concentrate on combining biosensors with biosecurity, as well as smartphone apps linked to a centralized hospital database for tracking carrier status.

- Because photocatalysis is widely used for sterilization of clinical devices, protein degradation, and viral RNA degradation, its chances of inactivating SARS-CoV-2 in wastewater settings are quite good. To counteract the COVID-19 pandemic, future research should focus on its safe nanotechnology and bioengineering line.

- These are the future perspectives that can be brought into the proposed method.

**AUTHOR CONTRIBUTIONS**

B. Manimekalai: Conceptualization (equal); formal analysis (equal); funding acquisition (equal); investigation (equal); methodology (equal); writing – original draft (equal); writing – review and editing (equal). R. Arulmozhi: Investigation (equal); methodology (equal); validation (equal); visualization (equal); writing – original draft (equal).

Mariselvam Ammasi Krishnan: Conceptualization (equal); formal analysis (equal); supervision (equal); writing – review and editing (equal).

S. Sivanesan: Data curation (equal); supervision (equal); validation (equal); visualization (equal); writing – review and editing (equal).

**DATA AVAILABILITY STATEMENT**

There is no data available for this article.

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How to cite this article: Manimekalai B, Arulmozhi R, Krishnan MA, Sivanesan S. Consequence of COVID-19 occurrences in wastewater with promising recognition and healing technologies: A review. Environ Prog Sustainable Energy. 2023;42(1):e13937. doi:10.1002/ep.13937.