Implications of COVID-19 for Water, Wastewater, and Water Reuse

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What is COVID-19?

Coronavirus disease 2019 (COVID-19) is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), or simply the 2019 novel coronavirus (2019-nCoV). In terms of its genome, this virus is closely related to the viruses responsible for SARS in 2003 and Middle East Respiratory Syndrome (MERS) in 2012. However, there are important differences affecting the global spread of SARS-CoV-2 and the unprecedented actions that have been taken to mitigate public health impacts and ensure continuity of critical infrastructure.

In late 2019, the first cases of COVID-19 were identified, and by March 11th, the World Health Organization (WHO) had classified COVID-19 as a global pandemic. The rapid progression of the disease was caused by a number of factors:

- The ***case fatality rate*** for COVID-19 is still uncertain and is dependent on age, underlying health conditions, and other variables, but current estimates put the rate at ~1-3%, while SARS and MERS had case fatality rates of 11% and 34%, respectively.[1-3]
- The virus responsible for COVID-19 has a ***reproduction number***—or the number of additional cases caused by an infected individual—of between 1.5 and 3.5. This is higher than that of seasonal influenza (0.9 to 2.1), SARS (<1 to 2.75), and MERS (~1), but considerably lower than that of measles (12-18).[4]
- COVID-19 has an estimated ***asymptomatic ratio***—the proportion of infected individuals showing no significant symptoms—of 1 in 3, which is slightly higher than SARS (1 in 10) and significantly higher than MERS (1 in 1,000).[5-7]

Collectively, these characteristics make SARS-CoV-2 a 'superbug' because of its relatively high infectivity, its ability to be transmitted undetected in many cases, and the severe outcomes that are overwhelming medical resources in many regions.

What does this mean for water/wastewater/water reuse?

SARS-CoV-2 is primarily respiratory in nature, but studies have confirmed the presence of its genetic material in the feces of infected individuals, possibly due to co-infection of cells within the gastrointestinal tract.[8] This secondary infection may explain why the genetic material can be detected in feces after it is no longer detected in oral and nasal swabs.[9] During the previous SARS outbreak and also the current COVID-19 outbreak, transmission via sewage was implicated but never confirmed.[10]

Common enteric viruses such as adenovirus and norovirus essentially consist of nucleic acid—DNA or RNA—surrounded by a protein coat. SARS-CoV-2 consists of RNA surrounded by a protein coat, but similar to other respiratory coronaviruses, SARS-CoV-2 also has a lipid envelope that affects its 'survival' and partitioning. Enveloped viruses are often thought to be more fragile, but studies indicate that coronaviruses can persist on surfaces[11] and in water/wastewater[12] for days. However, research also suggests that coronaviruses are ***more likely to partition to solids*** and are ***more susceptible to water and wastewater treatment*** processes than their non-enveloped enteric counterparts.[13] Therefore, multi-barrier water and wastewater treatment processes likely provide adequate protection against coronaviruses[13], so the associated public health risks for drinking water, treated wastewater, and water reuse are likely negligible. Recent CDC guidance[14] supports these conclusions:

https://www.cdc.gov/coronavirus/2019-ncov/php/water.html

What are the implications of wastewater detection of SARS-CoV-2?

Because SARS-CoV-2 genetic material has been detected in feces, many researchers and wastewater agencies throughout the world are collaborating to document its occurrence in wastewater. One published study has already confirmed detection of the viral RNA in wastewater at multiple sites in the Netherlands,[15] and there are ongoing studies in Nevada, Washington, and Arizona (likely others as well) observing similar results. It is important to note that there have not been any detections in drinking water.[14] Given the intense interest and time-sensitive nature of this issue, researchers are now developing collaborative networks to share protocols and coordinate monitoring efforts.

Although it is not necessarily surprising for the RNA of SARS-CoV-2 to be detected in wastewater, it creates additional uncertainty for the water/wastewater/water reuse industries. SARS-CoV-2 is not expected to persist through disinfection processes,[13] but the precautionary principle dictates that the industry should consider risks from aerosolization in sewers and during primary or secondary wastewater treatment. In previous research, viruses spiked at high concentrations were detected in aerosols released from model-scale sewers and aeration basins.[16] Here are several additional considerations:

- All wastewater studies to date have used molecular assays targeting the genetic material of SARS-CoV-2 and do not provide any direct evidence of infectivity or even structurally intact viruses. So even though the viral RNA has been detected in wastewater, the presence of the genetic material does not necessarily imply any risk to facility personnel or the general public.
- Cell culture methods are critical for evaluating the infectivity of human viruses. Virus growth in cell culture indicates the potential for the virus to replicate in humans and cause disease. For SARS-CoV-2, cell culture methods require Biosafety Level 3 precautions. This limits such studies to specialized laboratories, which is why many studies include only molecular assays.
- SARS-CoV-2 genetic material is frequently detected in the feces of infected individuals, hence the detection of its RNA in wastewater, but isolation of infectious SARS-CoV-2 from fecal samples has been unsuccessful in many, but not all, cases.[17-18] Previous studies of SARS-CoV-1 (2003 outbreak) showed that diarrhea was a common symptom, but attempts to isolate infectious virus from fecal samples also experienced mixed results.[19-20] For SARS-CoV-2, neither RNA nor infectious virus has been detected in urine,[17] but infectious SARS-CoV-1 was detected in urine in past studies.[20] Therefore, the situation is still uncertain, but it is possible that wastewater contains only non-infectious SARS-CoV-2 or even just its genetic material. ***It is critically important that this conclusion be reevaluated over time as additional research becomes available.***
- Consistent with these findings and past research on other coronaviruses, the CDC published the following guidance for wastewater agencies: “Wastewater treatment plant operations should ensure workers follow routine practices to prevent exposure to wastewater. These include using engineering and administrative controls, safe work practices, and PPE normally required for work tasks when handling untreated wastewater. No additional COVID-19-specific protections are recommended for employees involved in wastewater management operations, including those at wastewater treatment facilities.”[14]

How can water/wastewater/water reuse agencies get involved?

One of the major challenges associated with COVID-19 is developing an accurate estimate of disease prevalence in various communities. This has been hindered by challenges in implementing broad clinical testing and the wide range of symptoms experienced by infected individuals, including those who are completely asymptomatic. This presents a unique opportunity for the water/wastewater/water reuse industry with respect to ‘environmental surveillance’ or ‘wastewater epidemiology’—the study of wastewater-derived constituents as a means of characterizing levels of disease within a community. Widespread monitoring of wastewater across regions and time may ultimately provide critical information related to the actual prevalence of COVID-19, time series comparisons with clinically-confirmed cases, and an early-warning system for reemergence of COVID-19. In fact, some regions where COVID-19 had largely been contained, such as South Korea, are now observing a second wave of infections as society returns to normal.[21]

As a water/wastewater/water reuse agency, there may be opportunities to actively participate in this important research effort. Although standard methods exist for clinical testing,[22-23] there are no standard methods for environmental surveillance of SARS-CoV-2, and given the current 'stay-at-home' directives in many states, research is currently on hold in many places. However, there are still measures that can be adopted now to assist in future research efforts. ***One option is to freeze at least 1 liter of composite influent wastewater/raw sewage each week—or whatever frequency is practical for a given facility.*** If possible, this sampling should continue throughout the duration of the outbreak and beyond to account for unexpected spikes in COVID-19. Once activities resume at universities and other research agencies, there will be considerable demand for these samples so that the industry can learn from the current pandemic and adopt best practices for the future. There will be additional guidance from researchers and/or research foundations on how to participate in these future efforts. The Water Environment Federation (WEF) is also expected to release additional guidance on COVID-19 in the coming weeks.

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