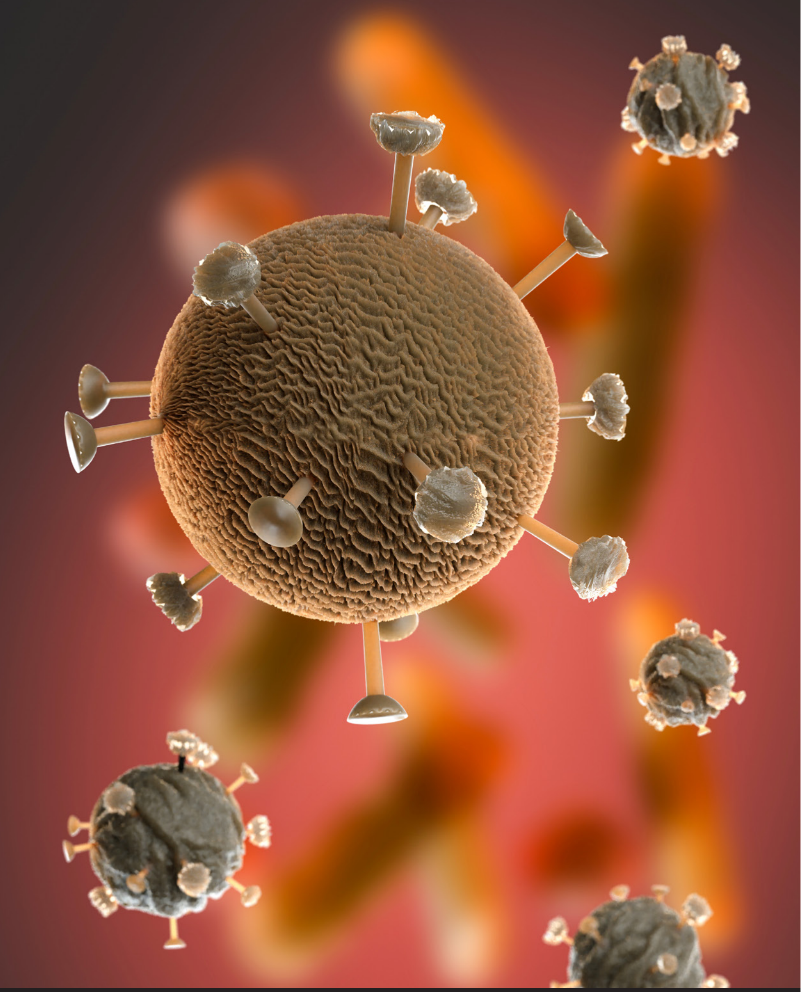

The recent outbreak of novel coronaviruses (COVID-19) in Wuhan City, Hubei Province, China is being closely monitored as it causes acute respiratory illness and has the potential to be fatal (CDC, 2020). The COVID-19 and the 2002 SARS-CoV (severe acute respiratory syndrome coronaviruses) are recent examples of how some coronaviruses that infect animals can evolve to infect humans.

Investigations into the COVID-19 outbreak are ongoing, and the information that we have right now may change as we learn more about this virus (WHO, 2020). As water treatment professionals, we want to inform stakeholders of the current state of knowledge on coronaviruses as it relates to our practice.

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Introduction to Coronaviruses

The purpose of this article is to provide water and wastewater utilities with a summary of some of the relevant issues related to coronaviruses treatment with considerations and recommendations to water and wastewater treatment practitioners with respect to coronaviruses in general.

- *Fate of coronaviruses in sewage and wastewater treatment plants*
- *Fate of coronaviruses in the aquatic environment*
- *Efficacy of water treatment filtration and disinfection processes for coronaviruses removal and inactivation*

It is important to remember that an extensive body of literature on the effectiveness of water and wastewater treatment processes for coronaviruses is not available, and as always, site-specific water-quality and treatment-plant details may result in variation between full-scale effectiveness and research results found in the laboratory.

Considerations for Water and Wastewater Treatment

Infectious human coronaviruses may be present in raw wastewater that is collected from a population where an infection is occurring. About 20-40% of SARS-CoV infections presented symptoms of diarrhea and the virus is capable of binding to receptors in the intestines as well as in the lungs (Leung et al. 2003). These viruses may be detected in urine and stools from infected individuals for more than 100 days after initial infection (Liu et al., 2003). The persistence of coronaviruses in hospital wastewater and domestic sewage is estimated to be 2-3 days (Wang et al., 2005).

Wastewater treatment plants that are receiving sewage from hospitals and isolation centers treating patients for coronaviruses may have elevated concentrations of viruses in the wastewater influent. Further, if wastewater treatment is insufficient to remove or inactivate coronaviruses, or combined sewer overflows/bypasses are operational, the viruses may be released into the environment (Casanova et al., 2009).

Coronaviruses have not been found to be more resistant to water treatment than other microorganisms such as *E. coli*, phage, or human viruses such as poliovirus, which are commonly used as surrogates for treatment performance evaluations (Gundy et al., 2009). Results from bench-scale studies suggest that the survival of coronaviruses is temperature dependent; with greater survival at lower temperatures. Therefore, the persistence of coronaviruses are expected to be reduced in raw wastewater and surface waters in warmer seasons.

Common disinfection methods used in water and wastewater treatment are expected to be effective for inactivation of coronaviruses when executed properly

Wastewater Treatment

In general, secondary wastewater treatment may be credited with removing 1 log (90%) of viruses, though broad studies suggest the level of virus removal is highly variable between insignificant removal to greater than 2 log removal (99%) (Hewitt et al., 2011; USEPA, 1986). Because of this variability, the primary process for the inactivation of viruses in wastewater treatment is chemical disinfection (i.e. chlorination) and/or disinfection by ultraviolet (UV) light.

The efficacy of chlorination for inactivating viruses in wastewater is dependent upon numerous water quality factors. Of particular importance is the presence of disinfectant-demanding substances and in particular, ammonia, which reacts with chlorine to form chloramines. In general, chloramines are much poorer virucides as compared to free available chlorine. Thus, it is important to consider the level of ammonia before the disinfection process to adequately determine its virucidal efficiency. Chemical disinfection of wastewater with free available chlorine is expected to be effective for coronaviruses when applied at adequate levels. In one published research study, chlorination of domestic wastewater using a dose of 10 mg/L sodium hypochlorite, a contact time of 30 minutes, and a free chlorine residual of >0.4 mg/L was found to inactivate 5 log of coronaviruses (Wang et al., 2005). This level of chlorination is often applied in full-scale WWTPs. For example, the Ontario (Canada) Ministry of the Environment typically requires WWTPs to have a free chlorine residual of 0.5 mg/L after 30 minutes of contact time at the design average daily flow (Ministry of the Environment, 2008). The efficacy of UV disinfection of viruses in wastewater is highly dependent upon the fluence achieved by a particular system and it is, therefore not possible to estimate for general systems. For UV disinfection systems that were not designed specifically for virus inactivation, only low-levels of coronaviruses inactivation are expected.

The World Health Organization has found that risk communication and community engagement (RCCE) has been integral to the success of response to health emergencies.

RCCE action items related to coronaviruses include communicating about preparedness measures at all levels and establishing a system for listening to public perceptions to prevent misinformation.

Sludge Management

The survival of coronaviruses in wastewater sludge has not been reported but is expected to vary significantly depending on site-specific sludge handling and treatment procedures. Based on a study examining survival of coronaviruses in water and wastewater (Gundy et al., 2009), coronaviruses survival in primary wastewater effluent at temperatures greater than 20°C is expected to be very low - within a period of 4 days. However, this same study reported that the survival time increases (e.g. more than 4 weeks) at cold temperatures (near 4°C) in clean water. At all temperatures studied, coronaviruses showed lower survival rates in wastewater than other viruses. Sludge handling and disposal practices should be reviewed on a case-by-case basis to prevent contamination of ground and surface waters.

The U.S. Environmental Protection Agency's (EPA's) Part 503 rule provides comprehensive requirements for the management of biosolids generated during the process of treating municipal wastewater.

Operators of Wastewater Treatment

Respiratory illnesses can be spread by contact with aerosols and by hand-to-mouth transmission. Therefore, it is recommended that wastewater treatment operators and sludge handlers use barriers such as face masks and disposable gloves to prevent exposure to aerosols. Further, strict sanitation practices should be implemented to encourage frequent handwashing, the separation of eating areas from work areas, and minimization of contact between hands and face. Communications should be sent to plant operators and staff to inform them of best sanitation practices.

Do's and Don'ts of general sanitation practices that prevent the spread of respiratory viruses are listed below.

Do's:

- *Do wash hand with soap and water for at least 20 seconds, especially after using the bathroom, before eating, after blowing your nose, coughing or sneezing.*
- *Do stay home when you are ill.*
- *Do cover your cough or sneeze with a tissue and dispose of the tissue in the trash.*
- *Do disinfect frequently touched objects and surfaces such as door knobs.*

Don'ts:

- *Don't touch your eyes, nose and mouth with unwashed hands.*
- *Don't have close contact with people who are ill.*

Drinking Water Treatment

Surface water treatment plants with upstream wastewater impacts are the most susceptible to having coronaviruses contamination in the raw water supply during, and after, an outbreak. Conventional treatment with free available chlorine designed to provide 0.5 log inactivation of Giardia can achieve at least 8 log inactivation of viruses in general (Health Canada, 2019a). Note that it is important to ensure that disinfection performance is continuously monitored (e.g. turbidity, disinfectant dose, residual, pH, temperature, and flow). Optimized conventional filtration can achieve 2 (99%) log virus removal (Health Canada, 2019b). A UV fluence of 44 mJ/cm^2 can achieve up to 3 log (99.9%) inactivation of poliovirus 1 and rotaviruses, while a dose of 40-199 mJ/cm^2 can inactivate up to 3 log (99.9%) of adenoviruses; the most UV resistant viruses (Health Canada, 2019b; USEPA 2006). Based on published research, water treatment processes that meet virus removal/inactivation regulations are expected to be effective for coronaviruses control. Further details of the efficacy of various treatment processes for the removal/inactivation of human viruses was recently updated in the Guidelines for Canadian Drinking Water Quality (Health Canada, 2019b).

Potential response actions

Here are some response actions to potential risks from coronaviruses in water and wastewater treatment:

Critical Control Point	Potential Risk	Risk Response
Wastewater treatment - open basins	*Aerosols created during wastewater treatment process*	■ *Communicate risks, provide signage, and PPE barriers to wastewater treatment operators regarding the potential transmission of coronaviruses and precautionary sanitation practices*
Wastewater disinfection	*Infectious coronaviruses persisting in domestic sewage*	■ *Ensure optimal contact time for chemical disinfection*
Drinking water treatment	*Infectious coronaviruses in water supplies impacted by wastewater effluent*	■ *Ensure continuous monitoring and performance of drinking water disinfection processes for systems with upstream wastewater impacts during, and after, an outbreak*

Contact us with questions

Stantec is pleased to provide this information on coronaviruses as it relates to water treatment. We can be reached at your convenience to answer questions. We hope this factual content will assist with the communication of risk within your organization.

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Further Reading:

1. **Centers for Disease Control Updates:** https://www.cdc.gov/coronavirus/2019-ncov/index.html
2. **World Health Organization Updates:** https://www.who.int/emergencies/diseases/novel-coronaviruses-2019
3. **WHO Risk Communication and Community Engagement (RCCE) Rediness and Response to COVID-19:** https://www.who.int/publications-detail/risk-communication-and-community-engagement-readiness-and-initial-response-for-novel-coronaviruses-(-ncov)
4. **USEPA Surface Water Treatment Rules:** https://www.epa.gov/dwreginfo/surface-water-treatment-rules
5. **Health Canada – Guidelines for Canadian Drinking Water Quality – Enteric Viruses:** https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidelines-canadian-drinking-water-quality-guideline-technical-document-enteric-viruses.html

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- *WHO. (2020). Novel Coronaviruses 2019. World Health Organization. Accessed on February 4, 2020 at <https://www.who.int/emergencies/diseases/novel-coronaviruses-2019>.*