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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

SARS-CoV-2 and Wastewater

The Water Research Commission has compiled a review on the state of knowledge of the coronavirus SARS-CoV-2, responsible for COVID-19, as it pertains to wastewater management. The following is a summary of key findings.

The virus known as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which has caused the global pandemic of the coronavirus disease COVID-19, is transmitted primarily via respiratory droplets. The disease is spread through inhalation of droplets that have been expelled from the nose and mouth of infected people during coughing, sneezing and speaking. In addition, contact with surfaces onto which the droplets have settled may cause infection in people who touch their mouth, nose or eyes with contaminated hands or materials. Studies have shown that the virus remains viable for up to three days on hard surfaces such as plastic and stainless steel.

Furthermore, SARS-CoV-2 genetic material can be detected in stool samples of COVID-19 patients, and cell culture from such samples has allowed the virus to be isolated. However, it is not yet known to what extent the virus survives in a viable and infective state in faecal matter.

The virus's genetic material has also been detected in sewage wastewater, raising concerns that wastewater could be a potential transmission route.

Viruses in wastewater

Wastewater treatment processes are designed to significantly reduce or inactivate pathogens such as bacteria, viruses and protozoa, which cause a variety of human diseases. Inadequate treatment may mean that the final effluent poses a health risk, particularly if used to irrigate agricultural fields or sportsgrounds, or the receiving waters are used for recreational activities or as a source of drinking water.

To date, studies on the presence of viruses in wastewater, and their survival through the various stages of treatment, have focused primarily on enteric viruses, which occur in the gastrointestinal tract and are transmitted via the faecal-oral route. They include viruses that cause gastroenteritis, such as norovirus and rotovirus, or other diseases, such as aseptic meningitis and/or hand, foot and mouth disease in the case of echovirus and coxsackievirus respectively.

Most enteric viruses are non-enveloped, consisting only of nucleic acids (DNA or RNA) enclosed in a protein capsid.

By contrast, enveloped viruses have an outer membrane comprised of lipids and proteins. The membrane is relatively fragile, however, and if it is destroyed the virus is no longer infective. This is because the membrane must fuse with that of a host cell to allow entry of the virus. The membrane is sensitive to low pH, heat, desiccation, detergents and disinfectants, so enveloped viruses are generally considered unable to withstand stomach acids, or to survive outside the host for long periods.

As a result, enveloped viruses have been assumed to be absent in wastewater, or rapidly inactivated when released to wastewater. Some anecdotal evidence and research has suggested that this assumption may be erroneous, but there have been relatively few studies on the issue. This is partly because of a lack of appropriate methods for isolating enveloped viruses in water, as opposed to simply detecting their genetic material, which does not imply virus viability.

Enveloped viruses have been responsible for several high-profile disease outbreaks in the past, including the 1918 'Spanish Flu' and 2009 'Swine Flu' pandemics (both due to H1N1 Influenza A subtypes), the 2003 Severe Acute Respiratory Syndrome epidemic (SARS-CoV), and multiple outbreaks of Middle East Respiratory Syndrome (MERS-CoV) and Ebola (various strains of Ebalovirus). The SARS-CoV-2 virus responsible for the COVID-19 pandemic is likewise an enveloped virus.

The risks of faecal-oral transmission

Although some studies have shown that certain coronaviruses and other enveloped viruses can survive for days or weeks in water and sewage wastewater, these were laboratory studies. To cause infection, viruses present in wastewater must retain their infectivity until they encounter the next host. Once subjected to disinfection at a wastewater treatment works (WWTW), SARS-CoV-2 and other enveloped viruses should be rendered inactive, being considered more sensitive than non-enveloped viruses to both chlorination and ultraviolet (UV) radiation.

The optimum UV wavelength range for disinfection ('germicidal effects') is 245–285 nm. Most studies on UV disinfection of viruses have made use of low-pressure mercury lamps, which emit UVC (100-290 nm) radiation at 254 nm (UV_{254}). This disinfection technology is rarely used at municipal WWTW in South Africa, where tertiary treatment relies on chlorination followed by an optional 'polishing step' in maturation ponds. Exposure to UV radiation in the form of sunlight further reduces pathogens in the maturation ponds before discharge to the receiving environment.

Given that much of South Africa's wastewater infrastructure is aged or overburdened, and that poor operation and management practices result in inadequate treatment and disinfection at some WWTW, there is nevertheless concern about the potential for SARS-CoV-2 transmission via wastewater. Currently, there is no indication that WWTW workers are at greater risk than the general population, and existing protective protocols are considered adequate.

However, sanitation staff, plumbers, health/care workers and members of the public who come into contact with raw sewage or faecal matter should be aware of the uncertainty surrounding the potential risks. Communities without waterborne sewage or with frequent sewage spills may be at increased exposure, particularly as their access to protective gear and disinfectants is likely to be low. Furthermore, the possibility of transmission via aerosolization during toilet flushing, sewer flow and WTWW primary/secondary processes should not be overlooked. A 2003 outbreak of SARS in a Hong Kong apartment complex was linked to a faulty sewage system that allowed high concentrations of virus-laden aerosols in the building's plumbing to be drawn into apartments through floor drains.

Wastewater-based epidemiology

Wastewater-based epidemiology (WBE) or wastewater surveillance has frequently been used over the past decade to provide population-scale information on the use of pharmaceuticals and illicit drugs, or on exposure to endocrine disruptors and other chemicals. However, its potential for monitoring the spread of infectious disease has also been recognised. Environmental surveillance of poliovirus in wastewater samples has been conducted by many countries since the 1980s.

Researchers in The Netherlands recently reported that they had detected SARS-CoV-2 genetic material in samples collected from WWTW less than a week after the country's first case was reported. This resulted in the WBE approach being advocated as a potential early warning system for outbreaks of COVID-19, or the presence of infected individuals in particular areas.

A number of similar studies have since been initiated elsewhere in Europe and on other continents. For example, Massachusetts-based start-up Biobot Analytics has launched a ***pro bono*** programme in collaboration with researchers at MIT, Harvard, and Brigham and Women's Hospital to map COVID-19 across the United States. It outlines the potential benefits of the data as enabling communities to:

- Measure the scope of the outbreak independent from patient testing or hospital reporting, including data on asymptomatic individuals
- Provide decision support for officials determining the timing and severity of public health interventions to mitigate the overall spread of the disease
- Better anticipate the likely impact on hospital capacity in order to inform hospital readiness and the necessity of public health interventions
- Track the effectiveness of interventions and measure the wind-down period of the outbreak, and

- Provide an early warning for re-emergence of the coronavirus, if it does indeed have a seasonal cycle.

Samples are usually collected from influent wastewater at WWTW as these serve communities in defined geographic areas. In South Africa, stormwater systems and urban rivers that are known to be heavily contaminated by discharge from informal settlements could potentially also be monitored.

Currently, WBE studies are making use of reverse transcription polymerase chain reaction (RT-PCR) analysis, which is used to detect fragments of genetic material in the form of RNA. RT-PCR tests are considered the most reliable means of COVID-19 diagnosis worldwide, but sampling and laboratory analyses requires special handling and skilled personnel. A variety of cartridge-based tests are becoming available for point-of-care screening, and there is potential that similar tests could be developed for WBE purposes, although the characteristics of wastewater present challenges in this regard. In addition, a paper-based rapid test kit is being developed for use at WWTW by a team of researchers from the Chinese Academy of Sciences and Cranfield University, United Kingdom. If successful, this would be a cheap and simple method of detecting whether there are potential COVID-19 carriers in local areas. Cell culture would not be recommended for WBE application due to biosafety concerns.

Conclusion

As of mid-April, the World Health Organisation advises that there have not been reports of faecal-oral transmission of COVID-19, nor any evidence of SARS-CoV-2 survival in water or sewage. However, more research, including the development of better techniques for studying infectious enveloped viruses, is clearly needed to better assess the risks associated with wastewater and faecal matter. The precautionary principle dictates that due care should be taken in the interim.

FURTHER READING

- The review drew upon a large number of references in the scientific literature. Readers requiring further information may find the following most relevant.
- Gundy, PM, Gerba, CP, & Pepper, IL 2009. Survival of Coronaviruses in Water and Wastewater. Food Environ. Virol. 1: 10. https://doi.org/10.1007/s12560-008-9001-6.
- Wigginton, KR & Boehm AB 2020. Environmental Engineers and Scientists Have Important Roles to Play in Stemming Outbreaks and Pandemics Caused by Enveloped Viruses. Environ. Sci. Technol. 54: 3736–3739. https://doi.org/10.1021/acs.est.0c01476
- Yeo, C, Kaushal, S & Yeo, D 2020. Enteric involvement of coronaviruses: is faecal–oral transmission of SARS-CoV-2 possible? The Lancet Gastroenterology & Hepatology 5(4). https://doi.org/10.1016/S2468-1253(20)30048-0
- Information for the water sector is also updated regularly at the Centers for Disease Control and Prevention webpage: https://www.cdc.gov/coronavirus/2019-ncov/php/water.html