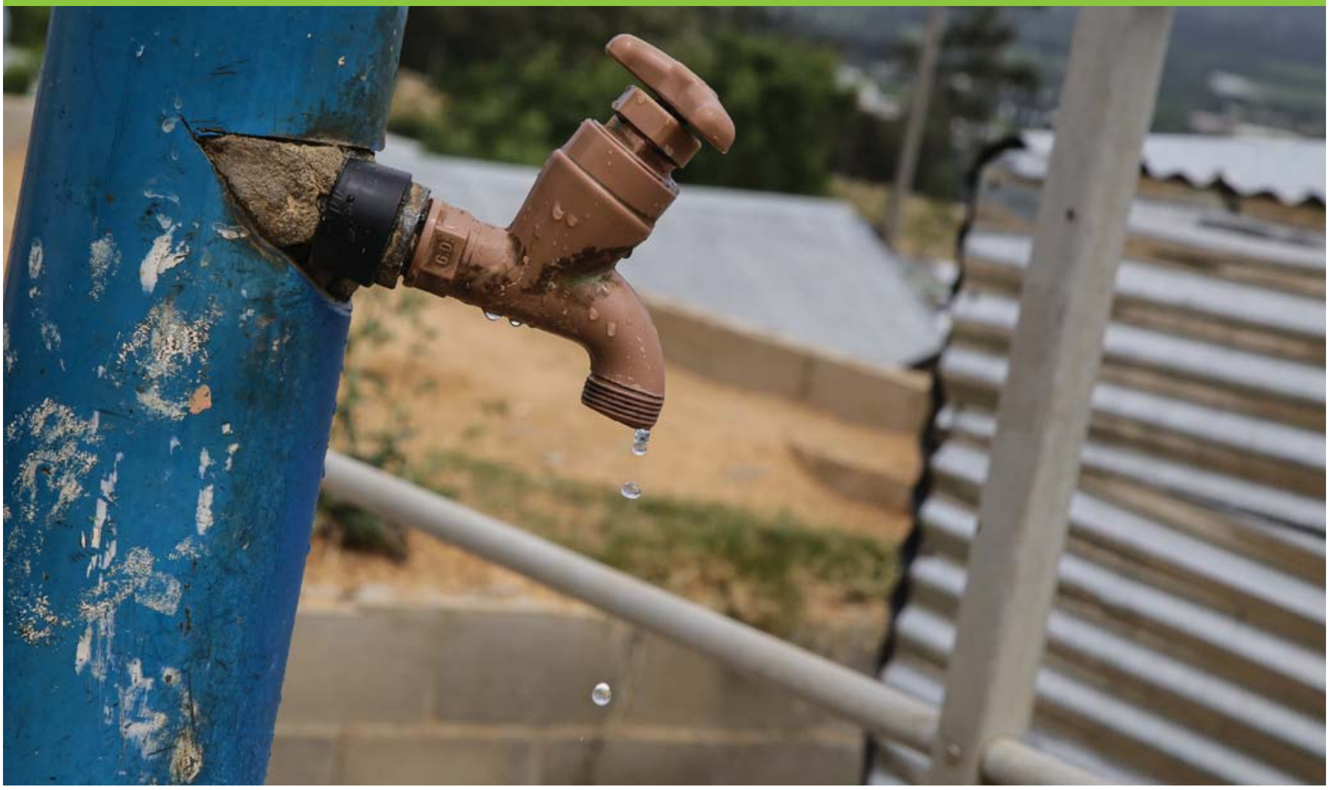
COVID-19

Can the novel coronavirus be transmitted with water? – Researchers investigate

From dirty water, to clean water – what are the risks for Covid-19 transmission? Petro Kotzé took a look at current research being conducted in this space.



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The ongoing Covid-19 pandemic has been closely associated with one of South Africa's most precious resources – water. Water has run like a thin thread alongside the appearance of the virus causing the pandemic; at first, when the importance of hand-washing and basic hygiene became clear and, more recently, followed by questions on whether the virus can be spread via contaminated water.

To understand the capacity of Covid-19 to be transmitted via any water, whether it is sewage, wastewater from homes or hospitals, or leakages from burial sites, the nature of the virus needs to be understood.

The SARS-CoV-2 virus

A virus is a collection of genetic material; consisting of **deoxyribonucleic acid** (DNA) or **ribonucleic acid** (RNA) inside a protein shell. To cause infection, it must copy itself inside a living host's cells. In this way the virus can cause a disease. Examples are polio, Ebola and hepatitis.

Viruses are non-enveloped or enveloped. The first (non-enveloped viruses) consists of the genetic material inside its protein capsid. These are often responsible for waterborne diseases. Examples are the norovirus and rotavirus. In comparison, enveloped viruses consist of the genetic material covered in a thin membrane called a lipid layer. The Spanish Flu in 1918 as well as Swine Flu in 2009 were both pandemics caused by enveloped viruses (H1N1 Influenza A subtypes). Ebola is another enveloped virus.

The group of coronaviruses are enveloped viruses. The Severe Acute Respiratory Syndrome epidemic (SARS-CoV) and the Middle East Respiratory Syndrome (MERS-CoV) are examples, as is SARS-CoV-2, the virus responsible for the current ongoing Covid-19 pandemic.

The group of coronaviruses get their name from the Latin word for crown (***corona)*** because the proteins on its surface are in the form of projecting spikes, which attach to the host's' cells. This virus mainly targets the tissue that lines the outer surfaces of organs and blood vessels and the inner surfaces of cavities in many internal organs. Once attached, the RNA genome enters the host cell and starts to multiply.

The virus is able to transfer when an infected person coughs or sneezes in close contact with an uninfected person, and this person inhales the droplets. The virus can also be transferred when a person picks up such a droplet from a surface, and transfers it to themselves by touching their mouth, nose or eyes with their contaminated hands.

How long can SARS-CoV-2 survive outside a host?

Outside of the host body, the virus cannot replicate, although there is evidence to suggest that coronaviruses can persist on surfaces, says microbiologist and senior researcher with the CSIR, Lisa Schaefer. The amount of virus deposited, temperature, humidity and UV light can determine how long viruses stay active outside the body. Virus particles that are expelled when an infected person coughs or sneezes may have a protective layer of mucous that helps them survive. The spiked envelope of the coronaviruses is vulnerable and easily destroyed by soap, disinfectants, low pH, heat, and detergents. When a pair of infected hands is washed with soap, for example, the lipid envelope is destroyed, and the virus cannot attach to a cell and cause infection any longer.

A study published in the ***Journal of Hospital Infection*** reviewed the literature on all available information about the persistence of human and veterinary coronaviruses on inanimate surfaces. Because the morphology and chemical structure of SARS-CoV-2 are similar to those of other coronaviruses for which there are data about both survival in the environment and how to effectively inactivate it, this information provided insight into the potential reaction of SARS-CoV-2.

An analysis of 22 studies revealed that human coronaviruses such as SARS coronavirus, MERS coronavirus or endemic human coronaviruses can persist and remain infectious on inanimate surfaces like metal, glass or plastic, at room temperature, for up to nine days. At a temperature of 30˚C or more the duration of persistence is shorter. Veterinary coronaviruses have been shown to persist even longer, for 28 days. The study also found that the viruses can be efficiently inactivated by disinfection within one minute.

More recently, researchers from the National Institutes of Health, Centers for Disease Control and Prevention, the University of California, Los Angeles (UCLA) and Princeton University examined how long the virus SARS-CoV-2 survived in the air as well as on copper, cardboard, plastic and stainless steel. They found the virus to be detectable in aerosols for up to three hours, up to four hours on copper and up to 24 hours on cardboard under the right environmental conditions. This coronavirus can last up to three days on plastic and stainless steel, though the amount of the virus left on those surfaces decreases over time.

Still, says Schaefer, it is important to note that viruses persisting on surfaces may not necessarily still infect other people.

As for the virus' survival in drinking water or sewage, the CSIR advises that we do not yet have all the answers about SARS-CoV-2 in water and the perseverance of infectious viral particles in the environment. However, there is sufficient knowledge about similar viruses and viruses more resistant than the SARS-CoV-2 virus to have some certainties.

The risk to drinking water supplies

According to the World Health Organisation (WHO), there has been no evidence of SARS-CoV-2 survival in water of any kind to date and, according to a guidance document updated in

The highly polluted Jukskei River flows through the back alleys of Johannesburg

Can coronaviruses enter groundwater through burial sites? The likelihood is very low.

The likelihood of the SARS-Covid-2 virus to survive in any wastewater is thought to be low, but yet to be confirmed.

May, the risk of coronaviruses to water supplies is low. Though the presence of the SARS-CoV-2 in untreated drinking-water is possible, it has not been detected in any drinking-water supplies yet. Other coronaviruses have also not been detected in surface or groundwater sources. The CSIR also announced that drinking water and groundwater pose a very low risk of SARS-CoV-2, as has international bodies such as the United States Environmental Protection Agency (EPA), which has recommended that people continue to drink tap water as usual.

Schaefer explains that waterborne viruses tend to have a much sturdier casing (non-enveloped viruses with protein capsids) than that of the casing surrounding SARS-CoV-2 (enveloped viruses) that enables them to persist in water for longer periods of time. This suggests that enveloped viruses, such as SARS Cov-2, are unlikely to survive as long in the water system.

The virus has also been detected in stool samples of some of the small percentage of patients with Covid-19 that develop diarrhoea, which has raised questions about the potential spread of the virus via stool and sewerage systems.

The risk due to contaminated sewage

During a presentation for the Water Research Commission (WRC) on coronaviruses in water and risk of infection, Prof Natasha Potgieter, Head for Environmental Health at the Domestic Hygiene and Microbial Pathogens Group, explained that for the virus to be transferred via stool, it must have the ability to survive in human waste, retain its infectivity and come in contact with another person, which can most likely happen via aerosols.

This could be the case, for example, if water droplets infected with stool is inhaled by another person – such as when a toilet is flushed with the lid open. Schaefer adds that in cases such as these, the highest risk remains to householders living in a home with an infected person.

Once the infected water leaves the home via the sewerage system, the chances of infection seem to become smaller. The RNA remnants of the virus have been found in untreated sewage, first by microbiologists at the KWR Water Research Institute in the Netherlands. They analysed wastewater from treatment plants in the Netherlands, including Schiphol airport and Amersfoort. In this way, their data told them the virus was present in the population before the first patients appeared.

This was later verified by the National Institute for Public Health and the Environment (RIVM), who also took samples. The two studies concluded that RNA traces of the virus were present in untreated wastewater. No traces were found in treated wastewater.

This knowledge is now put to the test in different countries in attempts to monitor the spread of the virus, including South Africa (see box on the WRC new project on page 21).

The Dutch researchers also tested treated effluent from wastewater plants that was discharged into surface water, and found no trace of the coronavirus.

Yet, questions remain. Though there have been no reports of faecal-oral transmission of COVID-19, it is not known whether the virus in sewage is able to infect a person. Schaefer explains that the technique to detect the virus in wastewater picks up fragments of the RNA nucleic acids, but is not able to determine if the virus is intact and infectious. The presence of viral RNA is not necessarily a transmission risk; however, the presence of infectious virus is a transmission risk, she explains.

The amount of virus released from the body (shed) in stool and how long the virus is shed are also not known. These are all questions that limit our capacity to understand the risk of transmission of Covid-19 from the faeces of an infected person.

Potgieter said that until we have more answers, it's impossible to say what the risk of the virus is to a community without functioning wastewater treatment systems in place. According to Schaefer, due to the state of some of the wastewater treatment systems in South Africa, infection via contaminated wastewater is a possibility but, in her opinion, unlikely because of the virus' anticipated short survival time in the environment. "The question remains whether any viral RNA detected is actually infectious virus."

What about water contamination from mass burial sites?

According to Prof Matthys Dippenaar, Associate Professor at the University of Pretoria's Department of Engineering Geology and Hydrogeology, the bigger concern is the handling of the body, rather than the actual burial process. "If cemeteries: are cited and managed appropriately are appropriate, we are not altering the load of possible contamination," he said during a recent presentation on the topic for the WRC. Dippenaar was team leader for the project 'State-of-the-Art Cemetery Guidelines: Impacts of Interments on Water Resources and subsequently, terms of reference for the investigation, management and monitoring of new and existing cemeteries in South Africa' (**WRC Report no. 2449/1/28**).

Dippenaar explained that, in general, the body is not the contaminant at cemeteries. Rather, the bigger concern is the metals, nutrients, organics and pathogens from medical implants, jewelry, the metals attached to the coffin and so forth. The pathogens, bacteria and viruses that are the actual cause of

According to recent information, the risk of coronaviruses to water supplies is low.

death tend to die off in an oxygenated environment, such as a coffin.

We have good guidelines in South Africa that comply with international guidelines, noted Dippenaar and, as long as we choose the locations for the graveyards well, we will be safe. He added that though we still need to confirm the persistence rate of the virus in all environmental conditions, the locations of cemeteries are chosen because the geography is such that the rate of the water that moves through substrata is retarded. By the time it reaches any groundwater table the pathogens would probably have died off.

In an online presentation on the topic for the WRC, Dr Eunice Ubomba-Jaswa (WRC Research Manager for Water Resources Quality and Management) added that as soon as a host dies, the virus will also start dying and, the timespan for survival in a dead body is relatively low. Rather, she said, the danger could lie in the time between dying and handling of the body, or when an autopsy is conducted, in case an organ is punctured, for example. When attending a funeral, she maintained, you are more likely to be infected from another person that is alive and infected.

According to a fact sheet recently released by the WRC more research, including the development of better techniques for studying this type of virus is necessary to better assess the risks associated with wastewater.

"We don't know if the remnants in wastewater are infective; it's highly unlikely, but we don't know for sure," says Schaefer. More questions that need answering is whether the pandemic can be monitored through a sewerage system in South Africa, as has been proven in a developed country such as the Netherlands.

In the interim, cautions the WRC, the best way forward is to take due care at all times.

Boxed: Sources:

- *Aerosol and surface stability of HCoV-19 (SARS-CoV-2) compared to SARS-CoV-1.* van Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN, Tamin A, Harcourt JL, Thornburg NJ, Gerber SI, Lloyd-Smith JO, de Wit E and Munster VJ.
- *Survival of surrogate coronaviruses in water* by Lisa Casanova, William A. Rutala, David J. Weber, Mark D. Sobsey
- *Persistence of coronaviruses on inanimate surfaces and their inactivation with biological agents* by G. Kampf, D. Todt, S. Pfaender and E. Steinman
- *Water, sanitation, hygiene, and waste management for the COVID-19 virus*, Interim guidance 23 April 2020 by the WHO and UNICEF
- KWR, 2020. Update COVID-19 Sewage Research (https://bit.ly/382OYm9) csir.co.za

National programme on monitoring COVID-19

The WRC recently launched the national programme on monitoring COVID-19 spread in communities using a water- and sanitation-based approach. Sue Matthews reports.

Research teams around the world are investigating the potential of wastewater surveillance as a monitoring tool for COVID-19, and on 20 May 2020 the Water Research Commission launched a national programme to do the same. The launch took place via a two-hour Zoom webinar, with a number of presentations or talks by representatives of the WRC and partner organisations, as well as a brief address by the Minister of Human Settlements, Water and Sanitation, Lindiwe Sisulu.

"Part of what we're wanting to do is develop a South African chapter of the wastewater surveillance programme, and hopefully expand this into an African chapter," explained WRC CEO, Dhesigen Naidoo, in his introduction. He added that it could also provide a platform for building a much stronger surveillance system to address the wide array of emerging pollutants that are an increasing concern around the world.

The keynote speaker for the launch was Dr Peter Grevatt, CEO of the Water Research Foundation (WRF), a global organisation based in the United States. In April, the WRF convened an online international summit, 'Environmental surveillance of Covid-19 indicators in sewersheds', with discussions focused on four topics: interpretation of data, communication, sample collection (the where, when and how) and sample analysis. Typically, samples are taken from sewage at the point where it enters a wastewater treatment works (WWTW), and these are analysed using polymerase chain reaction (PCR) techniques to detect fragments of RNA, which serve as the 'genetic fingerprint' of SARS-CoV-2, the virus responsible for Covid-19.

Dr Grevatt pointed out that the data could be used to track trends and monitor changes in occurrence of Covid-19 in communities, potentially providing an early warning signal of new outbreaks and allowing the impact of interventions to be assessed. But although some indication of the prevalence of the disease in the community is certainly possible, determining the actual number of cases would be far more complicated, as this requires an understanding of the amount of RNA that infected individuals shed in their faeces, and how this differs between asymptomatic and severe cases.

To ensure that credible information can be provided to decision-makers, the WRF is organising an international inter-laboratory comparison to assess which methods produce the most reliable results, and to what extent sample results can be reproduced by the participating labs. Other research priorities are to understand how the virus's RNA fingerprint changes over time in the wastewater matrix (which would have implications for the timing and location of sample collection), and to determine the impact of sample storage and pre-treatment methods on signal strength.

The WRC's Group Executive: Research and Development, Dr Stanley Liphadzi, then gave an introductory overview of South Africa's envisaged surveillance programme. He noted that South Africa has some 900 WWTW and these are concentrated in cities, which is where most of the country's confirmed COVID-19 cases occur, but non-sewered sanitation systems typical of informal settlements and rural areas would not be overlooked. The programme would be conducted in three phases, starting with a 'proof of concept' phase and progressing to pilot-scale monitoring before the full-scale national surveillance programme is implemented.

Research Manager, Dr Nonhlanhla Kalebaila, provided more detail on the WRC initiative, pointing out that it will include projects aimed at establishing the role of water and sanitation environments in the transport and transmission of the virus. One of the projects that has already been commissioned for the first phase is a preliminary study on the wastewater-based epidemiology approach that will test and validate protocols for sampling and analysis. It will also provide an initial interpretation of data, to be published as a State of Knowledge report on SARS-CoV-2 in South Africa's water and sanitation environments. The project builds upon an earlier WRC study that applied the same approach to assess the use and abuse of pharmaceuticals in communities.

A second project, being done in collaboration with the National Institute of Occupational Health, involves the evaluation of health risks associated with occupational exposures to biological and chemical contaminants at WWTWs. The SARS-CoV-2 virus will receive special attention as one such biological contaminant. The project team will examine the virus's occurrence in wastewater, aerosols and sludge, and determine whether it is present in a live and potentially infective state. Currently, it is thought that wastewater treatment processes are adequate for removing the virus, or at least rendering it inactive, but the researchers will investigate this. If the live virus is detected, the implications for WWTW workers' safety and for non-potable water reuse, such as irrigation of crops or sportsfields, will be assessed too.

The WRC had issued an 'expression of interest' call for the programme, seeking experts to serve on a national advisory panel as well as laboratory services for sample analyses, and inviting researchers to submit proposals for projects. Implementation of the programme will rely heavily on partnerships and collaborations, as well as co-funding from different stakeholders.

Kalebaila reported that there are already projects within the WRC portfolio that are looking at human pathogens in water, but efforts will be made to address a number of knowledge gaps relating to SARS-CoV-2. For example, is there any risk of faecal-oral transmission via ingestion of contaminated food or water? And how could South Africa's national building regulations be strengthened to ensure water and sanitation safety, given that a 2003 outbreak of SARS in a Hong Kong apartment complex was linked to a faulty plumbing system that allowed virus-laden aerosols to be drawn into apartments? If such incidents do occur here, protocols for incident management and response will clearly be needed. The large-scale use of disinfectants during such incidents, as well as in routine sanitising of taxi ranks, hospitals, schools and workplaces, might have implications for aquatic ecosystems, so this needs to be investigated too.

During the Q&A session, Kalebaila confirmed that some of the projects would involve taking samples from on-site toilet systems, such as VIP and pour-flush toilets, and testing the methods on these samples. Once there's sufficient confidence in the methods and the results, these systems can be included in the programme's reporting.

"Dealing with the non-sewered environment may be the big contribution that South Africa can make, because that part resembles a lot of the developing world," added Naidoo. "We also want to make a substantial investment in new innovations in this domain – finding cheaper, more accessible techniques."