COVID-19 AND WATER

Tracking COVID-19 in sewers and in patients to help halt the pandemic

Wastewater-based epidemiological surveillance (WBE) offers an opportunity for the near real-time collection of data on tracking COVID-19 infections. In addition, it can provide early warning on the increases in infections, as well as the emergence of new variants. Article by Jorisna Bonthuys.

Measuring coronavirus levels in wastewater offers an early warning tool against the rise of COVID-19 infections in South Africa.

This is the finding of health and water experts who have been involved in a national COVID-19 environmental surveillance collaborative initiative since 2020.

During a recent online symposium, these experts highlighted their experiences with employing a WBE approach to track coronavirus infection levels in local communities. The symposium was organised by the Water Research Commission (WRC).

The age of coronaviruses

Since the beginning of the twenty-first century, three types or variants of coronaviruses have crossed the barrier to cause deadly pneumonia in humans, including severe acute respiratory syndrome (SARS-CoV-1), Middle East respiratory syndrome coronavirus (MERS-CoV), and now severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2 or COVID-19).

The SARS-CoV-2 virus is the newest member in the coronavirus family, associated with human infections grouped into the beta-CoV genus, and with a 79% genetic similarity to SARS-CoV-1.

While researchers use genetic changes in SARS-CoV-2 to document and analyse its spread across the globe, the emergence of several SARS-CoV-2 variants has become a significant challenge for COVID-19-related policies and vaccination rollouts. In this context, the design of new epidemiological tools and the refining of existing ones –

including the use of WBE to inform healthcare decision-making – has received much attention.

Wastewater profiling for virus detection

Wastewater-based epidemiology has been a valuable tool for monitoring substance use in communities (for instance, the use of prescription and illicit drugs). This approach employs the analysis of human metabolic excretion products in wastewater. Recently, WBE has been extended to serve as a tool in tracking the prevalence of non-communicable diseases (such as cardiovascular disease) and communicable diseases (including diseases caused by microorganisms that are resistant to antimicrobial agents).

COVID-19 infections too can be traced and monitored in wastewater samples. This is because infected people shed the virus through faeces. While the risk of transmission via contaminated stools is unlikely, wastewater that contains such particles is a marker of infection. Therefore, the presence of SARS-CoV-2 in wastewater treatment plant influent can help determine the presence of infected individuals in a local community.

This is because the detection of SARS-CoV-2 genetic material in wastewater typically precede a rise in diagnosed cases and thus presents a warning that spikes in infections and local hospitalisations should be expected. This information can be used as an early epidemiological indicator of COVID-19, especially where community testing is not possible.

During the pandemic, many studies have shown the value of this approach in tracing and monitoring changes in the prevalence of infections in human populations feeding into wastewater streams. The detection of SARS-CoV-2 RNA in untreated domestic wastewater has, for instance, been reported in the Netherlands, France, China, Israel, Turkey, and Italy.

WBE surveillance during the pandemic

The objective of the WRC-hosted symposium was to share knowledge on the progress that has been made in South Africa in monitoring the spread of COVID-19 using the WBE approach. Since 2020, researchers, healthcare practitioners and epidemiologists have formed a multidisciplinary network to evaluate the spread of the novel coronavirus in local communities.

Initially, it had to be established whether WBE could be successfully applied locally to track this coronavirus, given the high number of households without access to formal sewerage networks. For this reason, the implementation of the wastewater surveillance initiative is following a three-phased approach.

The first phase of this approach entailed a proof-of-concept study to optimise sample design and testing, as well as finetune the sampling protocol. This study included the preliminary sampling and analysis of wastewater samples from metropolitan areas. In the second phase, a collaborative monitoring initiative was set up with what has become known as the SACCESS (South African Collaborative COVID-19 Environmental Surveillance System) network in provincial hotspots (in Gauteng, KwaZulu-Natal and the Western Cape), using the sampling and testing protocols developed in the first phase. The third phase will entail a national wastewater surveillance programme roll-out.

Although WBE surveillance is not yet fully integrated into the national COVID-19 surveillance programme, researchers have made huge strides with this approach since 2020, presenters indicated.

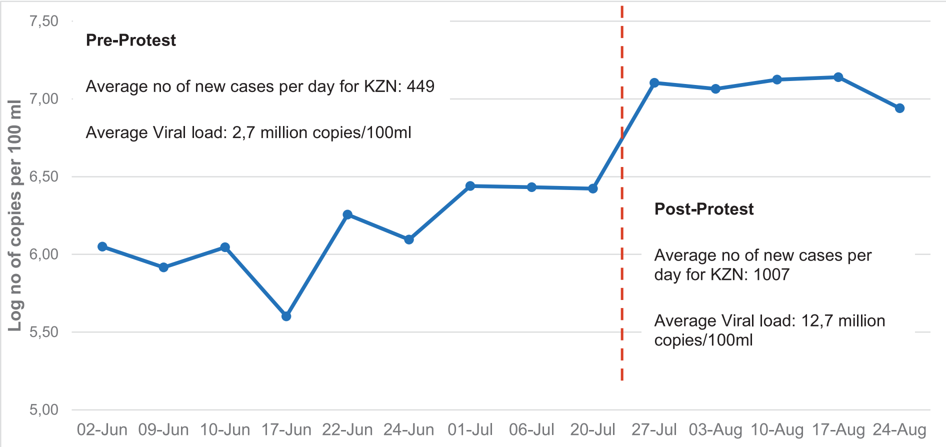
Collaborating partners provide new insights

Notable regional and national efforts are underway towards the early detection of COVID-19 cases by looking for the viral signature of SARS-CoV-2 in wastewater. This was highlighted by Lynn Bust, a public health professional from the University of Cape Town. She said there is scope for both informal and formal surveillance networks to ensure public health responsiveness to the pandemic.

In the Western Cape, the South African Medical Research Council — together with scientists from the City of Cape Town, the Western Cape Provincial Government, and universities — perform routine wastewater surveillance for the metropolitan area and beyond. Viral genome detection in wastewater is reported routinely by the provincial health authority. Since early December 2020, ongoing surges in COVID-19 infections in parts of the province have been confirmed by using WBE. Although most of the data collection includes samples from influent wastewater at wastewater treatment plants, communities without access to formal sewerage networks are also being tracked. In addition, primary sludge and grab samples are collected from industry sewage treatment plants, prisons, student residences, and hospitals.

Ultimately, one of the most significant development to date in terms of WBE surveillance in South Africa has been the establishment of the SACCESS network, noted WRC Executive Manager for water use, wastewater resources and sanitation futures, Jay Bhagwan. This network facilitates knowledge sharing and capacity building amongst its members, who collaborated to standardise the methodology and sampling methods for the national wastewater surveillance initiative.

South Africa was one of the first countries in the world to investigate COVID-19 monitoring of wastewater in non-sewered areas.



The effects of civil unrest on SARS-CoV-2 viral loads in wastewater. (Source: DUT)

The SACCESS list of partners includes researchers from the National Institute for Communicable Diseases (NICD), the Council for Scientific and Industrial Research (CSIR), the South African Medical Research Council (SAMRC), the National Institute for Occupational Health (NIOH), Lumegen Laboratories, Greenhill Laboratories, Waterlab, and several other institutions providing higher education or doing health and water research.

The science and research community under the auspices of the SACCESS network has made significant progress in detecting and quantifying the SARS COV-2 virus and its emerging variants.

Dr Nkosenhle Ndlovu, a medical scientist at the NICD's Centre for Vaccines and Immunology, said the surveillance of defined communities can help direct community screening efforts and alert medical facilities to potential increases in patient numbers.

Ndlovu said what started out with 18 treatment sites monitored by the NICD in five provinces (Gauteng, the Western Cape, Free State, Eastern Cape and KwaZulu-Natal) soon expanded to 49 sites across all nine provinces. As a result, the SACCESS network collectively investigated 798 cases from early in 2020 to August 2021, with the bulk of these handled by NICD researchers. In total, 72% of the samples tested during this period were positive.

Advance warning about outbreaks

In KwaZulu-Natal, since July 2020, WBE monitoring has been carried out by the Institute for Water and Wastewater Technology, with the assistance of the eThekwini Municipality and Umgeni Water in Durban and Pietermaritzburg. This year, WBE-related research efforts in this province focused on collecting data from Durban's main wastewater treatment plants.

Dr Leanne Pillay from Durban University of Technology's Institute for Water and Wastewater Technology said their monitoring data showed a good correlation between the number of active clinical cases of SARS-CoV-2 in the eThekwini Municipality and those in the province of KwaZulu-Natal. Data collected using the WBE approach enabled researchers to predict the surge in clinical cases in April in KwaZulu-Natal three weeks before it happened. Likewise, the second surge in clinical cases in the province (reported on 9 June) was also predicted three weeks prior (on 18 May).

Pillay also highlighted the effect of the large-scale civil unrest in KwaZulu-Natal in July this year on COVID-19 infections in the province. The unrest turned out to be a superspreader event.

Viral loads in wastewater are dynamic and respond to changes in lockdown levels, Pillay said. In addition, research findings suggest that there may be more infected individuals than what is clinically reported. WBE data, therefore, provided a more accurate representation of infections at the community level than clinical data at this time, as clinical testing came to a halt during the unrest while WBE testing did not.

Understanding the risks

Dr Noncy Gomba, a senior research scientist at the National Institute for Occupational Health's Immunology and Microbiology Department (in the National Health Laboratory Service), discussed the health risks for wastewater workers or in the reuse of treated effluents. Gomba and others assessed the presence, prevalence and removal of SARS-CoV-2 genetic fragments in wastewater at three wastewater treatment plants in Gauteng. They also considered the viability of SARS-CoV-2 in wastewater. She said that positive detection of viral RNA alone does not point to a health risk for wastewater workers or in the reuse of treated effluents.

Research to develop a framework for WBE surveillance in non-sewered communities also came under the spotlight.
Dr Gina Pocock from the Waterlab and Dr Bettina Genthe, a CSIR researcher focusing on water-related health issues, outlined efforts to refine sampling methods in polluted rivers and water run-off from within communities, and in on-site sanitation systems. Their presentation, 'Development of a framework for wastewater-based COVID-19 epidemiology surveillance for non-sewered communities', highlighted that WBE could also be applied in communities without access to formal sewerage systems.

In South Africa, more than 40% of the population does not have access to a municipal sewage system. These communities are usually the most vulnerable, lacking healthcare and financial resources. About 81.9% of households in metropolitan areas live in formal dwellings, while 16.8% live in informal dwellings. In communities lacking sewerage networks or with non-functional or poorly performing wastewater treatment plants, raw or poorly treated sewage and greywater are disposed of on the ground or into a nearby stormwater channel. In most cases, it ultimately enters rivers and streams.

Nearly all municipalities in South Africa have informal and low-income settlements that do not have access to sewage or stormwater systems. Many developing countries share a similar challenge.

Since 2020, researchers have been developing and optimising the methodology for SARS-CoV-2 detection, quantification and monitoring in different types of samples from non-sewered environments. Sampling sites were selected in Gauteng (including the Jukskei River and Kaalspruit), the Western Cape (including the Plankenbrug River near Stellenbosch), KwaZulu-Natal (including the Quarry Road informal settlement and Palmiet River in the eThekwini Municipality), and in Mpumalanga.

Data was collected using grab samples (from, among other sources, surface water, greywater run-off, and chemical and portable toilets) and passive samples (from rivers, run-off channels in informal settlements, and emptying tankers that collect waste from portable toilets).

Some of the challenges in doing this kind of research included sampling logistics, the cost of transporting large volumes of water, and maintaining the cold chain in rural areas. During the rainy season, the dilution of samples may also hinder the detection of the novel coronavirus. Sampling from on-site sanitation systems is costly and impractical. It is also challenging to correlate viral loads with clinical cases. One of the main issues is that there are gaps in the reporting of data for the province regarding situational reports.

However, researchers can still successfully monitor trends in viral loads to implement an early warning system and assess community infections. Passive sampling methods may overcome issues of low yield during high-dilution periods, allow for the easier and cheaper transport of samples, and improve the consistency of the data generated.

Future applications

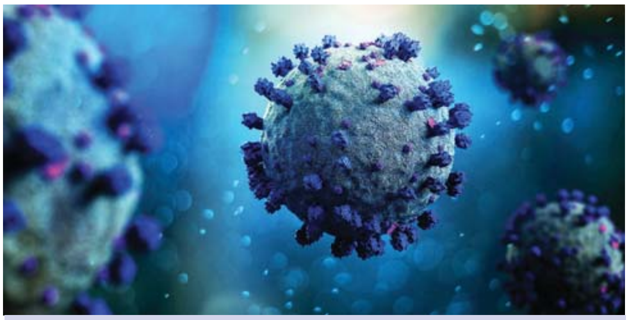
The detection of SARS-CoV-2 RNA in 98% of the wastewater samples collected has demonstrated the proof of concept for using WBE surveillance to track COVID-19. Continued WBE sampling at priority sites will allow for the expansion of pandemic trend monitoring. In terms of the impact on public health decision-making, only the City of Cape Town and the Western Cape Provincial Department of Health have incorporated WBE into their local responses. This is helping the City and province understand the emergence and patterns of infections. Efforts are also underway to get municipalities that are considered COVID-19 hotspots to incorporate the WBE approach into their actions to manage the pandemic.

Many of the presenters indicated that sampling in defined populations could provide a cost-effective and less invasive means of continuous screening. Where an increase in viral load is detected — signalling an early warning — additional clinical test methods could be rolled out. Bhagwan said the WBE monitoring systems that have been established offers the future potential to transition to monitor environmental water quality in the country. In addition, as the water and health sector is learning and looking beyond the pandemic, opportunities are emerging for researchers to help improve the provision of water and sanitation services in the country.

Monitoring of COVID-19 infections within communities using WBE could provide a cost-effective alternative to clinical testing. This approach, however, still requires improvement if it is to be applied efficiently.

Bhagwan concluded that COVID-19 and its surveillance responses offer the water sector "an opportunity to organise itself for a robust water quality compliance future".

Visit www www.wrc.org.za/corona-virus for information and regular updates on the WBE programme.



More about coronavirus

- Authorities have reported about 241.17 million COVID-19 cases and 4.9 million deaths since December 2019.
- The term 'coronavirus' refers to a family of viruses that causes many different types of illnesess, including the common cold, Sars, and Mers.
- The virus spreads by respiratory droplets released when someone with the virus coughs, sneezes, breathes, sings or talks. These droplets can be inhaled or land in the mouth, nose or eyes of a person nearby.
- In some situations, the COVID-19 virus can spread by a person being exposed to small droplets or aerosols that stay in the air for several minutes or hours — called airborne transmission. It's not yet known how common it is for the virus to spread this way. It can also spread if a person touches a surface or object with the virus on it and then touches his or her mouth, nose or eyes, but the risk is low.
- A SARS-CoV-2 virus particle is about 100 nanometers in diameter – visible only with an electron microscope. It is a near sphere of protein inside a fatty membrane that protects a twisting strand of RNA (a molecule that holds the virus's genetic code). Coronaviruses are a type of enveloped virus encased within a lipid (fatty) membrane that is susceptible to heat.
- Most people infected with the COVID-19 virus will experience mild to moderate respiratory illness and recover without requiring special treatment. Older people and those with underlying medical problems like cardiovascular disease, diabetes, and cancer are more likely to develop serious illnesses.

Source: John Hopkins Coronavirus Resource Centre; www.who.int; www.scientificamerica.com