Detection of COVID-19 in Wastewater

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Overview

This brief will provide an introduction to the use of SARS CoV-2 monitoring in wastewater as an early warning system for increased infections in communities. Wastewater-based epidemiology (WBE) is a relatively new but quickly evolving surveillance tool that can detect the presence of certain viruses in community water systems, including SARS-CoV-2, the virus that causes COVID-19. This non-invasive method can measure the presence of COVID-19 genetic material (ribonucleic acid [RNA]) in fecal matter in a sewershed, the area that drains into a community's wastewater collection system. Studies have shown correlations between the amount of viral material in sewage and the number of cases within a given sewershed, thereby offering insight into trends and changes in occurrence, distribution of exposure, and viral evolution for source tracking.

While there is no single validated method for detecting genetic material in wastewater, WBE has been shown to effectively detect polio and norovirus, as well as track opioid use. To detect early signs of COVID-19 occurrence and reemergence, scientists look for trends in specific use cases, as well as the baseline community rates of infection. Scientists can also use samples to monitor the wastewater treatment process and determine the effectiveness of the treatment in removing or damaging the viral genetic material. While there remain significant research gaps, WBE can provide a tool for evaluating mitigation efforts, assessing risk levels, and helping public health and environmental officials assess patterns of occurrence.

Early State Studies

Over 40 states have initiated programs with partners to collect wastewater samples for COVID-19 research to determine the presence of infected individuals and to estimate the extent of community spread. Below is a summary of activities and results in three states.

The Utah Department of Environmental Quality (DEQ) began sampling in spring 2020 to evaluate whether sewage monitoring was a useful tool for assessing community infection trends. DEQ collected samples from sewage entering 10 treatment plants that serve approximately 40% of Utah's population. These plants were selected for the pilot study to capture data from communities of various types and sizes across the state. In early studies, the virus was not detected in water leaving the treatment facility. In late May, sampling detected large increases that mirrored increases in active case counts in the area.

The Ohio Department of Health and Ohio Environmental Protection Agency are coordinating with the EPA Cincinnati laboratory and the Ohio Water Resources Center at The Ohio State University to monitor the state's municipal sewage and wastewater treatment systems. The study aims to determine the presence of RNA fragments in the feces of people who are both symptomatic and asymptomatic for COVID-19. Similarly, the Missouri Department of Health and Senior Services, Department of Natural Resources, and the University of Missouri – Columbia are coordinating on a statewide project to test domestic wastewater for genetic markers of SARS-CoV-2. These studies suggest that monitoring a virus in sewage systems offers a tool for early detection of rising infections and tracking of community infection trends.

Research Gaps

Studies have shown that the long half-life of SARS-CoV-2 may lead to further transmission due to the likelihood for it to remain stable on household surfaces for anywhere from a few hours to a few days. The virus is likely able to survive in wastewater for three to four days. Currently, critical data gaps prevent full understanding of fecal shedding of RNA and its fate in wastewater collection systems. Although the literature is growing, there is a significant need for additional investments in expanding infrastructure for testing capacity and data storage, and developing technology to improve virus detection, quantification, validation, and consistency.

Researchers hope that WBE will support monitoring and surveillance of COVID-19 in communities across the United States. There is currently limited data to support correlations between RNA detection in wastewater and confirmed COVID-19 case counts in a watershed. Without knowing precisely how much RNA is shed by infected individuals, it is challenging to reliably predict localized outbreaks and assess the prevalence of COVID-19 in a community. Other factors, such as the role of industrial discharges and storm water inputs, as well as potential variations in RNA shedding, require further research before data can reliably be used for predictive modeling. In the meantime, data can be used to observe trends in the occurrence of disease.

Risk Communication

While wastewater monitoring provides an opportunity to help inform jurisdictions of possible changes in COVID-19 rates, it also poses risk communication challenges. As with other complex topics, state health and environmental agency leaders need to follow basic communication guiding principles: understand the audience; build trust; define roles; draw from past experience; provide unified messaging; and ensure transparency. Messaging should also be tailored to specific audiences, including the public, water utilities, other state agencies, policymakers, and the media.

Sampling Methodology

Scientists follow strict guidelines when collecting wastewater samples for SARS-CoV-2 detection. Standard practices include:

- Implementing proper personal protective equipment (e.g., safety gloves, glasses, masks), training, and "safe handling" to ensure worker safety, data consistency, and adaptable recommendations that do not inhibit utility operations.
- Making educated decisions about whether to sample in specific areas of concern (e.g., hospitals, airports) or across an entire sewershed.
- Using centralized wastewater treatment plants for baseline assumptions.
- Collecting at least 500 mL per sample for analysis in deoxyribonucleic acid and RNA-free collection bottles (i.e., polycarbonate), and storing and shipping samples using sterilization protocols and at controlled temperatures not exceeding 39.2 degrees Fahrenheit (4 degrees Celsius).

- Ensuring that a sample is detecting SARS-CoV-2 and not a byproduct of the wastewater matrix, as well as not detecting SARS-CoV-2 when it is present due to signal loss in the collection system (e.g., dilution and decay) or during sample processing and analysis (e.g., matrix recovery and polymerase chain reaction inhibition).
- Reporting on all factors or sewershed characteristics that could impact results (e.g., sewage may travel to a different city; people can be asymptomatic; rate per person varies based on symptoms, age, or gender).
- Using methods that are reproducible, reliable, and contain quantitative information.

Minimally acceptable criteria for sample collection, processing, and analysis include:

- **Sample type:** It is important to obtain and report a representative sample. Composite samples (e.g., samples collected at the same site over 24 hours) are generally preferred over non-composite "grab" samples in sewersheds, except when monitoring more rural communities or multiple locations (e.g., hospitals) within a service area.
- **Frequency:** Sampling frequency can vary but should capture critical epidemiological points. Researchers recommend collecting samples at least once weekly per location until there is a significant change in the signal. Sampling frequency can then be adjusted based on an increase or decrease in the signal, the objectives of a particular study, and available resources.
- **Documentation:** Should include time sampled, sampler, location, weather, flow, population served, storage temperature, and other sample characteristics (e.g., pH, temperature, ammonia levels).
- **Analytical methods:** Methods will vary, and researchers have not determined the most effective method for quantifying SARS-CoV-2 in wastewater, but methods typically should include sample concentration followed by extraction of genetic material to amplify, detect, and quantify target gene sequences (see Table 3 of the Water Research Foundation's [WRF] *Wastewater Surveillance of the COVID-19 Signal in Sewersheds* report for SARS-CoV-2 gene targets).

Recommendations and Looking Ahead

As state public health and environmental officials move forward with their research and collect more data in the coming months, ERIS and ASTHO will highlight more findings and trends, with an emphasis on risk communication.

Other partners are engaged in related activities. For example, WRF has enlisted national and international experts to survey literature, conduct surveys, and develop minimally acceptable criteria. This work emphasizes the importance of establishing sound methodologies for collection, analysis, and quality assurance and control. ERIS and ASTHO will continue to monitor this work.

Scientists must translate COVID-19 research into steps for practical pandemic preparedness. Environmental wastewater surveillance is just one tool for assessing COVID-19 prevalence around the country. To encourage timely assessments, public health and environmental agencies, laboratory testing facilities, and utilities should embrace opportunities for partnerships that tackle challenges with data and privacy, sampling and analysis, and risk communication.

In addition to addressing research gaps, officials must understand how to interpret and report data. Given that COVID-19 wastewater detection is an emerging area of research, WBE may offer public health and environmental practitioners an opportunity to enhance their ongoing risk assessment and risk communication activities to help slow the spread of COVID-19.

References and Resources:

- American Water Works Association Coronavirus Resources
- CDC Information for Sanitation and Wastewater Workers on COVID-19
- CDC National Wastewater Surveillance System
- Colorado Department of Public Health and Environment COVID-19 Resources for Water and Wastewater Utilities
- Elsevier Public Health Emergency Collection COVID-19 pandemic: Considerations for the waste and wastewater services sector
- Florida Department of Health COVID-19 Onsite Sewage
- Massachusetts Department of Environmental Protection COVID-19 Resources for Water Suppliers and Wastewater Operators
- Mathematica COVID-19 Wastewater Testing
- New Jersey Department of Environmental Protection Guidance for Wastewater Utilities Engaging in Wastewater Collection and Analysis for SARS-CoV-2
- OSHA COVID-19 Control and Prevention
- University of Minnesota Wastewater and COVID-19: What are the risks?
- U.S. EPA Coronavirus and Drinking Water and Wastewater
- Utah Department of Environmental Quality's Division of Water Quality Wastewater-Virus Dashboard
- Vermont Department of Environmental Conservation COVID-19 Basics for Water and Wastewater Systems
- Water Research Foundation COVID-19 Guidance and Resources
- World Health Organization Water, Sanitation, Hygiene, and Waste Management for the COVID-19 Virus: Interim Guidance