Short Communication:
Presence of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2),
the virus causing coronavirus disease 2019 (COVID-19), in raw and in partially-
treated sewage

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Summary
This WRI briefing explores the possible presence and transmission of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), the virus causing coronavirus disease 2019 (COVID-19), in raw (untreated) or partially-treated sewage.\textsuperscript{Note 1} The key question we pose here is: \textbf{is there scientific evidence to support SARS-CoV-2 transmission and infection through raw or partially-treated sewage?} We do not address the risks associated with treated sewage that has been disinfected since evidence suggests that SARS-CoV-2 cannot survive the disinfection process of water and wastewater treatment\textsuperscript{1}. As of June 10, 2020, scientists have shown that the virus has been detected in stool and rectal samples of infected individuals, with one study suggesting that the virus was viable in stool samples. Consequently, SARS-CoV-2 has been detected in wastewaters all over the world. However, there is little information on the viability of the virus in the sampled wastewaters. Based on our best effort to review the science, there is currently no evidence to suggest infection through contact recreation and professional interaction (sampling, monitoring, etc.). Regardless of the possible risk of exposure to SARS-CoV-2, however, caution is warranted any time there is possible exposure to untreated wastewater. For stakeholders concerned about the risk of COVID-19 infection associated with their personal and professional activities, and for people handling wastewater or coming in contact with surface water that might reasonably contain raw or partially treated sewage, we refer to existing guidance from public health experts and water professional organizations.

\textbf{Key Definitions:}

- \textbf{SARS-CoV-2:} severe acute respiratory syndrome coronavirus 2 (referred to here as “the virus”)
- \textbf{Transmission:} the passing of a pathogen causing a communicable disease from an infected host individual or group to another individual or group
- \textbf{Infection:} likely transmission of a pathogen to people and other organisms through the environment
- \textbf{Risk (of exposure/infection):} the likelihood of exposure/infection to occur during a specified period of time
- \textbf{Virus is detected:} specific genetic material of the virus is detected using molecular diagnostic tests
- \textbf{Virus is viable (active):} capable of reproducing, especially under particular environmental conditions

\textsuperscript{Note 1:} The terms “sewage” and “wastewater” are used interchangeably.
Scope & Findings

Starting January 2020, the scientific and medical community started mobilizing to understand the modes of transmission of SARS-CoV-2. The two primary modes of transmission identified were: respiratory and contact. However, early reports have cautioned that the virus might also be transmitted through the fecal-oral route\(^2\). This preliminary notion is based on studies of previous coronaviruses (e.g., SARS-CoV and MERS-CoV) that have shown that in the absence of disinfection, the viruses can survive in sewage for a period of time under varying environmental conditions\(^3\).\(^9\).

To answer our key question of whether there is scientific evidence to support a route to infection of COVID-19 through raw or partially-treated wastewater, we provide a diagram below of the possible pathway of infection (Figure 1). Based on our understanding, for SARS-CoV-2 to be transmitted from one person to another through wastewater, the following must occur: 1) the virus is detected \textbf{and} viable in the stools of patients, 2) the virus is detected \textbf{and} viable in raw sewage, and 3) the virus is detected \textbf{and} viable in surface waters that receive raw or partially treated (not disinfected) sewage. We will now review the available literature on the matter.

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**Figure 1.** Diagram of possible viral transmission pathways and infection end points associated with untreated or partially treated sewage. The yellow, grey, and blue boxes indicate that this statement has been supported, refuted, or not yet established with scientific evidence, respectively.

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SARS-CoV-2 in Raw or Partially Treated Sewage. R. Sayess, K.C. Hychka, and B.G. Rahm, NYS Water Resources Institute (http://wri.cals.cornell.edu)

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1. **Do individuals with COVID-19 shed the virus in their stool?**

Numerous studies have shown that stool and rectal samples of infected individuals tested positive for the virus. The positive results for some individuals came at a later stage of infection and often persisted even after the nasopharyngeal testing was negative. This suggests the possibility of fecal-oral transmission and of extended viral shedding in feces of infected individuals, even after being cleared by nasopharyngeal testing. However, there are no reports of infection through the fecal-oral route to date.

2. **Is the virus viable in stools of COVID-19 patients?**

As of June 10, 2020, one peer-reviewed study detected live SARS-CoV-2 virus in the stool samples of two COVID-19 patients. There are no other reports on the viability of the virus in stools.

3. **Has the virus been detected in untreated wastewater?**

SARS-CoV-2 has been detected in untreated wastewater collected in the USA, Spain, the Netherlands, France, Australia, and Italy. The samples tested positive for virus RNA using quantitative reverse transcription-polymerase chain reaction (RT-qPCR), a method that does not assess virus viability or infectivity. As of June 10, 2020, there is no information on how long detectable virus can last in wastewater or under what environmental conditions.

4. **Is the virus viable in untreated wastewater?**

The authors of one preprint (not-peer reviewed) study evaluated the vitality of SARS-CoV-2 in wastewater using non-human cells and concluded that the ability of the virus to infect was insignificant. As of June 10, 2020, there is no other information yet on whether or not the virus is viable in wastewater. However, previous coronaviruses were known to be readily inactivated in water and wastewater at ambient temperatures compared to other groups of human enteric viruses.

5. **Has the virus been detected in surface water that receives untreated or partially-treated sewage?**

In one preprint (not-peer reviewed) study, SARS-CoV-2 was detected in 3 out of 4 samples taken from two rivers in Italy that were sampled on two different dates. The authors associated this detection with non-treated discharges into the rivers and with combined sewer overflow (CSO) events.

6. **Is the virus viable in surface water that receives untreated or partially-treated sewage?**

The authors of the same preprint study referenced in Question 5 reported that the ability of the virus to infect was negligible. As of June 10, 2020, there is no other information on the presence or the viability of the virus in surface waters.

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**Note 2:** References 12, 26, and 29 are preprints, i.e., they are preliminary reports that have not been peer-reviewed.
Untreated, or partially treated, sewage can enter waterbodies from several pathways. It can be discharged by a wastewater treatment plant that: 1) experiences a CSO event in which stormwater and rainwater inputs overwhelm treatment capacity, or 2) malfunctions or has failing infrastructure, such as clogs or leaky sanitary sewer pipes. Treated effluent that has not been disinfected can be legally discharged when a plant 3) disinfects only seasonally or 4) is not required to treat the effluent prior to release. Untreated wastewater can also enter a waterbody through pathways not related to wastewater treatment plants, including illegal sewage discharges and leaky septic systems.

In New York State, the Sewage Pollution Right to Know Law\textsuperscript{32} requires that publicly owned treatment works (POTW) must notify the public within two hours of discovery of a discharge of untreated or partially treated sewage. However, this law does not cover discharges from privately owned treatment works or POTWs that are in compliance with a NYSDEC (New York State Department of Environmental Conservation) approved plan or permit. Due to these exemptions, and the non-POTW pathways laid out above, public knowledge of untreated wastewater in waterways and of the risk of exposure due to contact water uses is complex and incomplete.

**Concluding Remarks**

Given that the viability of SARS-CoV-2 in wastewater has not been demonstrated, there is currently no evidence to suggest infection through contact recreation and professional interaction (sampling, monitoring, etc.). However, given the rapidly evolving body of knowledge on this virus, and the public health implications of infection, it seems prudent to take a conservative approach. For people handling wastewater, or for those coming in contact with surface water that might reasonably contain raw or partially treated sewage, there are existing guidelines in place for doing so safely (see Current Guidance below). These guidelines prescribe a combination of best sanitation and hygienic practices, as well as personal protective equipment (PPE). A reasonable response to stakeholders interested in the questions addressed here could reference these existing guidelines, and act as a reminder that conservative approaches to protection are appropriate given the state of knowledge and the risks associated with COVID-19 infection. This document aims to increase dialogue and provide reference points regarding the current research on the presence of the virus in raw or partially treated sewage. For medical advice or other recommendations, please consult a medical professional or the Center for Disease Control and Prevention (CDC – see Current Guidance below).

**Current Guidance:**

- For specific guidelines for wastewater management workers and employers, visit the Occupational Safety and Health Administration (OSHA) website at: [https://www.osha.gov/SLTC/covid-19/solid-waste-wastewater-mgmt.html](https://www.osha.gov/SLTC/covid-19/solid-waste-wastewater-mgmt.html).
References


