National Collaborating Centre for Methods and Tools

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Rapid Review: What is known about using wastewater surveillance to monitor the COVID-19 pandemic in the community?

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Version 2: July 29, 2020

Executive Summary

Background

Water-based epidemiology is an evolving methodology that uses samples collected from municipal wastewater to monitor exposure patterns at the community level. This methodology has been used previously to identify the presence of the Aichi virus in the Netherlands before cases were reported; for polio surveillance; for antimicrobial resistance; and has been proposed as a potential cost-effective method to monitor COVID-19. As a number of jurisdictions around the world begin to lift restrictions put in place to flatten the curve of the pandemic, wastewater surveillance has been proposed as a method to monitor levels of the virus within the community in real time, possibly before individuals start to display symptoms.

This rapid review was produced to support public health decision makers' response to the coronavirus disease 2019 (COVID-19) pandemic. This review seeks to identify, appraise, and summarize emerging research evidence to support evidence-informed decision making.

This rapid review is based on the most recent research evidence available at the time of release. A previous version was completed on May 25, 2020 with evidence available up to May 20, 2020. This updated version includes evidence available up to July 21, 2020.
In this rapid review, we provide the most recent research evidence to answer the question: **What is known about using wastewater surveillance to monitor the COVID-19 pandemic in the community?**

What has changed in this version?

- More single studies have found that the virus that causes COVID-19 has been found in untreated wastewater in numerous jurisdictions. The findings are consistent, although not every sample detects the virus.
- Some of the added studies found that the concentration of viral RNA was correlated with the number of cases in surrounding areas. The findings are consistent.

Key Points

- The virus that causes COVID-19 has been detected in untreated wastewater in a number of jurisdictions worldwide, including the USA, the Netherlands, Spain, Italy, Turkey, Chile, Brazil, Ecuador, Pakistan, India, Japan, Australia and Israel. Viral RNA has been found in wastewater treatment plants and in rivers with direct flow of sewage. In some cases, retrospective analyses of wastewater showed that the presence of the virus could be detected before community transmission had been identified. Variations in methodology may contribute to variability in findings. The quality of the evidence should be confirmed through consultation with a content-area expert.
- In some studies, the concentration of viral RNA was correlated with the known number of cases in the area. Findings are consistent in the most recent studies. The quality of the evidence should be confirmed through consultation with a content-area expert.
- To date, all published studies have demonstrated that wastewater-based surveillance is possible; however, there are no reports of the effectiveness or cost-effectiveness of this method for ongoing surveillance.

Overview of Evidence and Knowledge Gaps

- There was no evidence available on the use of wastewater surveillance as a tool to monitor the status of COVID-19 at a community level or to inform decisions about lifting or imposing lockdown restrictions to slow the spread of the virus.
- One mathematical modelling study predicted that a prevalence between 1 in 114 to 1 in 2 million is needed to detect the virus. Given limited current understanding of the virus that causes COVID-19 and its continuously evolving nature, confidence in this estimate is extremely low (see Warning section).
- Across studies, authors reported inconsistent correlations between levels of the virus detected in the samples and the number of cases identified in the community. It is not known whether this is due to inaccuracy of virus detection methods in wastewater, inaccurate data on the true number of cases in the community, or both. More recent studies appear to be identifying correlations more consistently.
- A variety of methodologies have been used to date, making comparisons across jurisdictions difficult and synthesizing the findings challenging; no best practices for wastewater surveillance have been identified.
- This question should be reviewed again as more data become available.

Methods

Research Question

What is known about using wastewater surveillance to monitor the COVID-19 pandemic in the community?

Search

On May 20, 2020 (for version 1) and again on July 21, 2020 (for version 2), the following databases were searched for evidence for the role of wastewater surveillance in monitoring COVID-19 in the community.

- Pubmed's curated COVID-19 literature hub: LitCovid
- Trip Medical Database
- World Health Organization's Global literature on coronavirus disease
- Joanna Briggs Institute COVID-19 Special Collection
- COVID-19 Evidence Alerts from McMaster PLUS™
- Public Health +
- COVID-19 Living Overview of the Evidence (L·OVE)
- Cochrane Coronavirus (COVID-19) Special Collections
- Oxford COVID-19 Evidence Service
- Cochrane Rapid Reviews Question Bank
- Oxford COVID-19 Evidence Service: Current Questions Under Review
- Prospero Registry of Systematic Reviews
- NCCMT COVID-19 Rapid Evidence Reviews
- MedRxiv preprint server
- NCCEH Environmental Health Resources for the COVID-19 Pandemic
- NCCID Disease Debrief
- Institute national d'excellence en santé et en services sociaux (INESSS)
- Uncover (USHER Network for COVID-19 Evidence Reviews)
- Newfoundland & Labrador Centre for Applied Health Research
- Public Health Ontario

A copy of the search strategy is available on request.

Selection Criteria

The search first included recent, high-quality syntheses. If no syntheses were found, single studies were included. English-language, peer-reviewed sources and sources published ahead-of-print before peer review were included. Grey literature, surveillance sources, and reviews with no methods section were excluded.

	Inclusion Criteria	Exclusion Criteria
Population		
Intervention	Wastewater surveillance	
Comparisons		
Outcomes	Detection / monitoring of COVID-19	
Setting	Community setting	

Data Extraction and Synthesis

Data on study design, setting, location, population characteristics, interventions or exposure and outcomes were extracted when reported. We synthesized the results narratively due to the variation in methodology and outcomes for the included studies.

We evaluated the quality of included evidence using critical appraisal tools as indicated by the study design below. Quality assessment was completed by one reviewer and verified by a second reviewer. Conflicts were resolved through discussion.

No suitable quality appraisal tool was found to assess the methodological quality of field-based environmental studies.

Study Design	**Critical Appraisal Tool**
Synthesis	Assessing the Methodological Quality of Systematic Reviews (AMSTAR) AMSTAR 1 Tool

Completed quality assessments for each included study, when appraised, are available on request.

Findings

This second version, updated July 29, 2020, adds 15 new single studies and 3 published versions of previously included preprints, for a total of 24 publications included in this evidence review. The quality of the evidence included in this review is as follows:

		Total	Quality of Evidence
Syntheses	Completed Reviews	1	Moderate
	In Progress Reviews	0	-
Single Studies	Completed	23	Not appraised

Warning

Given the need to make emerging COVID-19 evidence quickly available, many emerging studies have not been peer reviewed. As such, we advise caution when using and interpreting the evidence included in this rapid review. We have provided a summary of the quality of the evidence as low, moderate or high to support the process of decision making. Where possible, make decisions using the highest quality evidence available.

A number of mathematical modelling studies are emerging related to COVID-19. While these studies may provide important estimates, their ultimate usefulness depends on the quality of the data that is entered into the model. Given the constantly evolving nature and changing understanding of COVID-19 around the world, a high degree of caution is warranted when interpreting these studies, and when presented, include the range of confidence intervals rather than single effect estimates.

Important to this question, we did not assess the methodological quality of field-based environmental studies. Due to the highly technical nature of these studies, we highly recommend consulting a content-area expert to inform decision making.

Table 1: Syntheses

Reference	Date Released	Description of included studies	Summary of Findings	Quality Rating: Synthesis	Quality Rating: Included Studies
Evidence previously reported May 25, 2020					
Carducci, A., Federigi, I., Liu, D., Thompson, J., & Verani, M. (2020). Making Waves: Coronavirus detection, presence and persistence in the water environment: State of the art and knowledge needs for public health *Water Research*, 179:115907 Epub ahead of print	May 5, 2020 (Search completed Apr 20, 2020)	22 studies published between 1978 and 2020, including 6 studies analyzing the virus causing COVID-19. • 5 studies focused on community wastewater surveillance of the virus • All environmental surveillance studies were from Australia, the Netherlands, USA (2) and France	Detection of the virus causing COVID-19 in wastewater challenges previous knowledge that enveloped viruses are not viable in water. Five field studies, including 4 pre-prints, tested wastewater for the virus for the purpose of surveillance at the community level. Each study positively identified the virus causing COVID-19 in samples with varying viral loads. Various methods were used, limiting comparability across studies. The correlations between results and the number of known cases in their respective communities was inconsistent across studies. Current knowledge on the potential for surveillance or transmission of the virus causing COVID-19 through wastewater is extremely limited.	Moderate	Not reported (4/5 studies are pre-prints that have not been peer reviewed)

Table 2: Single Studies

Reference	Date Released	Study Design	Setting	Summary of findings	Quality Rating:
New evidence reported July 29, 2020					
Ahmed, W., Bertsch, P.M., Angel, N., Bibby, K., Bivins, A… Mueller, J.F. (2020). Detection of SARS-CoV-2 RNA in commercial passenger aircraft and cruise ship wastewater: a surveillance tool for assessing the presence of COVID-19 infected travelers. *Journal of Travel Medicine*. Epub ahead of print.	Jul 14, 2020	Environmental surveillance	Passenger aircrafts and cruise ships	Samples were collected from 2 cruise ships and 3 aircraft wastewater systems in April and May 2020. RNA from the virus causing COVID-19 was detected in samples from both cruise ships and in 1 of 3 aircraft. Concentrations of RNA were higher in the cruise ship samples.	Not appraised
Rimoldi, S. G., Stefani, F., Gigantiello, A., Polesello, S., Comandatore, F., Mileto, D… Salerno, F. (2020). Presence and infectivity of SARS-CoV-2 virus in wastewaters and rivers. *Science of The Total Environment 744*: 140911.	Jul 14, 2020	Environmental surveillance	Milan, Italy	Three wastewater treatment plants and two rivers in Milan, Italy were sampled from April 14 to April 22, 2020. RNA from the virus causing COVID-19 was detected in 4 of 6 raw wastewater samples, not detected in any of the treated samples, and detected in 3 of 4 river samples. The concentration of the virus' RNA in samples decreased over time, correlating with a decrease in COVID-19 cases in the surrounding region.	Not appraised
Guerrero-Latorre, L., Ballesteros, I., Villacrés-Granda, I., Granda, M.G., Freire-Paspuel, B., & Ríos-Touma, B. (2020). SARS-CoV-2 in river water: Implications in low sanitation countries. *Science of The Total Environment 743*: 140832.	Jul 9, 2020	Environmental surveillance	Quito, Ecuador	Three urban river locations were sampled on June 5, 2020. RNA from the virus causing COVID-19 was detected in samples from all 3 sampling locations.	Not appraised

Wu, F., Xiao, A., Zhang, J., Moniz, K., Endo, N., Armas, F… Thompson, J. (2020). SARS-CoV-2 titers in wastewater foreshadow dynamics and clinical presentation of new COVID-19 cases. *Preprint.*	Jul 6, 2020	Environmental surveillance	Massachusetts, USA	Samples were collected from a municipal wastewater treatment plant from January to March 2020. RNA from the virus causing COVID-19 was detected in samples. Concentrations of RNA were correlated with the COVID-19 caseload in the surrounding area.	Not appraised
Nemudryi, A., Nemudraia, A., Surya, K., Wiegand, T., Buyukyoruk, M., Wilkinson, R., & Wiedenheft, B. (2020). Temporal detection and phylogenetic assessment of SARS-CoV-2 in municipal wastewater. *Preprint*.	Jul 5, 2020	Environmental surveillance	Bozeman, Montana, USA	Samples were collected from a municipal wastewater treatment plant at 12 timepoints in a 52-day period. RNA from the virus causing COVID-19 was detected in samples. Concentrations of RNA correlated with the COVID-19 caseload in the surrounding area.	Not appraised
Ampuero, M., Valenzuela, S., Valiente-Echeverria, F., Soto-Rifo, R., Barriga, G. P., Chnaiderman, J… Gaggero, A. (2020). SARS-CoV-2 Detection in Sewage in Santiago, Chile - Preliminary results. *Preprint*.	Jul 3, 2020	Environmental surveillance	Santiago, Chile	Two wastewater treatment plants were sampled from March to June 2020. RNA from the virus causing COVID-19 was detected in samples from both treatment plants taken in May and June 2020, correlating with the caseloads in the surrounding area.	Not appraised
Fongaro, G., Stoco, P.H., Souza, D.S. M., Grisard, E.C., Magri, M.E., Rogovski, P… Rodriguez-Lazaro, D. (2020). SARS-CoV-2 in human sewage in Santa Catalina, Brazil, November 2019. *Preprint*.	Jun 29, 2020	Environmental surveillance	Santa Catalina, Brazil	Samples collected from a municipal wastewater treatment plant from October 2019 to March 2020 were tested. RNA from the virus causing COVID-19 was detected in samples collected as early as November 27, 2020, earlier than the first reported case of COVID-19 in the Americas on January 21, 2020.	Not appraised

La Rosa, G., Mancini, P., Bonanno Ferraro, G., Veneri, C., Iaconelli, M… Suffredini, E. (2020). SARS-CoV-2 has been circulating in northern Italy since December 2019: evidence from environmental monitoring. *Preprint*.	Jun 26, 2020	Environmental surveillance	Milan, Turin and Bologna, Italy	Samples collected at 5 wastewater plants in 3 cities from October 2019 to February 2020 were analyzed. RNA from the virus causing COVID-19 was detected at various levels in 15 of 62 samples. RNA of the virus causing COVID-19 was detected in untreated water before the first cases were reported in the surrounding regions.	Not appraised
Sharif, S., Ikram, A., Khurshid, A., Salman, M., Mehmood, N., Arshad, Y… Ali, N. (2020). Detection of SARS-CoV-2 in wastewater, using the existing environmental surveillance network: An epidemiological gateway to an early warning for COVID-19 in communities. *Preprint*.	Jun 24, 2020	Environmental surveillance	Pakistan	Samples were collected from 38 districts across Pakistan, mostly from existing polio surveillance drain sites. Collection dates were not reported. RNA from the virus causing COVID-19 was detected in 21 of 78 samples, from 13 different districts.	Not appraised
Arora, S., Nag, A., Sethi, J., Rajvanshi, J., Saxena, S., Shrivastava, S.K., & Gupta, A.B. (2020). Sewage surveillance for the presence of SARS-CoV-2 genome as a useful wastewater based epidemiology (WBE) tracking tool in India. *Preprint*.	Jun 20, 2020	Environmental surveillance	Jaipur, India	Samples were collected from 6 municipal wastewater treatment plants and 2 hospital wastewater treatment plants in May and June 2020. RNA from the virus causing COVID-19 was detected in samples from 2 municipal wastewater treatment plants.	Not appraised
Haramoto, E., Malla, B., Thakali, O., & Kitajima, M. (2020). First environmental surveillance for the presence of SARS-CoV-2 RNA in wastewater and river water in Japan. *Science of The Total Environment*, *737*, 140405.	Jun 20, 2020	Environmental surveillance	Yamanashi Prefecture, Japan	Samples were collected from a municipal wastewater treatment plant and a river in March and May 2020. RNA from the virus causing COVID-19 was detected in a sample of secondary-treated wastewater. RNA was not detected in samples of the influent or samples of river water.	Not appraised

Kumar, M., Patel, A. K., Shah, A. V., Raval, J., Rajpara, N., Joshi, M., & Joshi, C. G. (2020). First proof of the capability of wastewater surveillance for COVID-19 in India through detection of genetic material of SARS-CoV-2. *Preprint*.	Jun 18, 2020	Environmental surveillance	Ahmedabad, Gujarat, India	Samples were collected from a municipal wastewater treatment plant at two different times in May 2020. RNA from the virus causing COVID-19 was detected in samples. RNA concentrations correlated with COVID-19 caseloads in the surrounding area.	Not appraised
Hata, A., Honda, R., Hara-Yamamura, H., & Meuchi, Y. (2020). Detection of SARS-CoV-2 in wastewater in Japan by multiple molecular assays implication for wastewater-based epidemiology (WBE). *Preprint*.	Jun 12, 2020	Environmental surveillance	Ishikawa and Toyama Prefectures, Japan	Samples were collected from 4 wastewater treatment plants in March and April 2020. RNA from the virus causing COVID-19 was detected in 7 of 27 samples. RNA concentrations correlated with COVID-19 caseloads in the surrounding area.	Not appraised
Peccia, J., Zulli, A., Brackney, D.E., Grubaugh, N.D., Kaplan, E.H., Casanovas-Massana, A… Omer, S.B. (2020). SARS-CoV-2 RNA concentrations in primary municipal sewage sludge as a leading indicator of COVID-19 outbreak dynamics. *Preprint*.	Jun 12, 2020	Environmental surveillance	New Haven, Connecticut, USA	Samples were collected from a wastewater treatment plant in March to May 2020. RNA from the virus causing COVID-19 was detected in all samples collected. RNA concentrations correlated with COVID-19 caseloads in the surrounding area.	Not appraised
La Rosa, G., Iaconelli, M., Mancini, P., Bonanno Ferraro, G., Veneri, C., Bonadonna, L… Suffredini, E. (2020). First detection of SARS-CoV-2 in untreated wastewaters in Italy. *Science of the Total Environment 736*: 139652.	May 29, 2020	Environmental surveillance	Milan and Rome, Italy	Twelve wastewater treatment plants in Milan and Rome, Italy, were sampled between February 3 and April 2, 2020. RNA from the virus causing COVID-19 was detected at various levels in 6 of the 12 samples.	Not appraised
Balboa, S., Mauricio-Iglesias, M., Rodríguez, S., Martínez-Lamas, L., Vasallo, F.J., Regueiro, B., & Lema, J.M. (2020). The fate of SARS-COV-2 in WWTPS points out of the sludge line as a suitable spot for monitoring. *Preprint*.	May 26, 2020	Environmental surveillance	Ourense, Spain	Samples were collected from a wastewater treatment plant in April 2020. RNA from the virus causing COVID-19 was detected. RNA concentrations correlated with COVID-19 caseloads in the surrounding area.	Not appraised

Medema, G., Heijnen, L., Elsinga, G., Italiaander, R., & Brouwer, A. (2020). Presence of SARS-Coronavirus-2 RNA in Sewage and Correlation with Reported COVID-19 Prevalence in the Early Stage of the Epidemic in The Netherlands. *Environmental Science & Technology Letters 7*(7): 511-516.	May 20, 2020	Environmental surveillance	Netherlands	Five municipal and one airport's wastewater treatment plants were surveilled from February to March 2020. RNA from the virus causing COVID-19 was detected at various levels in samples from each testing site. At one site, RNA of the virus causing COVID-19 was detected in untreated water before the first cases were reported in the surrounding regions.	Not appraised
Randazzo, W., Truchado, P., Cueves-Ferrando, E., Simón, P., Allende, A., & Sánchez, G. (2020). SARS-CoV-2 RNA in wastewater anticipated COVID-19 occurrence in a low prevalence area. *Water Research 181*: 115942.	May 16, 2020	Environmental surveillance	Murcia Region, Spain	Six wastewater treatment plants in Spain were sampled from March 12 to April 14, 2020. RNA from the virus causing COVID-19 was detected in untreated water before the first cases were reported in low prevalence regions. Discrepancies were noted among assays used.	Not appraised
Evidence previously reported May 25, 2020					
Alpaslan Kocamemi, B., Kurt, H., Sait, A., Sarac, F., Saatci, A. M., & Pakdemirli, B. (2020). SARS-CoV-2 Detection in Istanbul Wastewater Treatment Plant Sludges. *Preprint*.	May 16, 2020	Environmental surveillance	Istanbul, Turkey	Nine wastewater treatment plants in Istanbul, Turkey were sampled on May 7, 2020. RNA from the virus causing COVID-19 was detected at various levels in each sample.	Not appraised

Hart, O. E., & Halden, R. U. (2020). Computational analysis of SARS-CoV-2/COVID-19 surveillance by wastewater-based epidemiology locally and globally: Feasibility, economy, opportunities and challenges. *Science of the Total Environment*, 730:138875	May 7, 2020	Predictive modelling	City of Tempe, Arizona, USA	Using recently available reports of fecal viral load of infected individuals, wastewater surveillance may detect the presence of COVID-19 in the community. Estimated minimum prevalence needed ranges from 1 in 114 to 1 in 2 million, which may also vary based on environmental conditions. The authors note the wide range of estimates due to limited available data and that the model should be refined as more information is available.	Not appraised
Alpaslan Kocamemi, B., Kurt, H., Hacioglu, S., Yarali, C., Saatci, A. M., & Pakdemirli, B. (2020). First Data-Set on SARS-CoV-2 Detection for Istanbul Wastewaters in Turkey. *Preprint*.	May 6, 2020	Environmental surveillance	Istanbul, Turkey	Seven wastewater treatment plants and two manholes in Istanbul, Turkey were sampled on April 21 and 25, 2020. RNA from the virus causing COVID-19 was detected at various levels in 7 of the 9 samples. Correlation of the virus' RNA concentration and number of COVID-19 cases in the surrounding communities was unclear.	Not appraised
Bar Or, I., Yaniv, K., Shagan, M., Ozer, E., Erster, O., Mendelson, E… Kushmaro, A. (2020). Regressing SARS-CoV-2 sewage measurements onto COVID-19 burden in the population: a proof-of-concept for quantitative environmental surveillance. *Preprint.*	May 1, 2020	Methodological report	Israel	This article reports on novel methods for detection of COVID-19 in wastewater in the community. Sewage samples from a COVID-19 isolation facility were used as positive control samples in the validation of this new test. The authors note extreme caution should be used in application of this method as 1) their previous work showed wide differences by location and 2) this work is preliminary and ongoing.	Not appraised

Randazzo, W., Cuevas-Ferrando, E., Sanjuan, R., Domingo-Calap, P., & Sanchez, G. (2020). Metropolitan Wastewater Analysis for COVID-19 Epidemiological Surveillance. *Preprint.*	Apr 29, 2020	Environmental surveillance	Valencia, Spain	Samples of undertreated wastewater were taken from 22 sites from February to April 2020. Viral load was detectable at a community level at the same time as the first case was reported. This suggests that community transmission was occurring earlier than previously believed.	Not appraised

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Arora, S., Nag, A., Sethi, J., Rajvanshi, J., Saxena, S., Shrivastava, S.K., & Gupta, A.B. (2020). Sewage surveillance for the presence of SARS-CoV-2 genome as a useful wastewater based epidemiology (WBE) tracking tool in India. *Preprint*.

Balboa, S., Mauricio-Iglesias, M., Rodríguez, S., Martínez-Lamas, L., Vasallo, F.J., Regueiro, B., & Lema, J.M. (2020). The fate of SARS-COV-2 in WWTPS points out of the sludge line as a suitable spot for monitoring. *Preprint*.

Bar Or, I., Yaniv, K., Shagan, M., Ozer, E., Erster, O., Mendelson, E… Kushmaro, A. (2020). Regressing SARS-CoV-2 sewage measurements onto COVID-19 burden in the population: a proof-of-concept for quantitative environmental surveillance. *Preprint.*

Carducci, A., Federigi, I., Liu, D., Thompson, J., & Verani, M. (2020). Making Waves: Coronavirus detection, presence and persistence in the water environment: State of the art and knowledge needs for public health *Water Research*, 179:115907. Epub ahead of print.

Fongaro, G., Stoco, P.H., Souza, D.S. M., Grisard, E.C., Magri, M.E., Rogovski, P… Rodriguez-Lazaro, D. (2020). SARS-CoV-2 in human sewage in Santa Catalina, Brazil, November 2019. *Preprint*.

Guerrero-Latorre, L., Ballesteros, I., Villacrés-Granda, I., Granda, M.G., Freire-Paspuel, B., & Ríos-Touma, B. (2020). SARS-CoV-2 in river water: Implications in low sanitation countries. *Science of The Total Environment 743*: 140832.

Haramoto, E., Malla, B., Thakali, O., & Kitajima, M. (2020). First environmental surveillance for the presence of SARS-CoV-2 RNA in wastewater and river water in Japan. *Science of The Total Environment*, *737*, 140405.

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La Rosa, G., Iaconelli, M., Mancini, P., Bonanno Ferraro, G., Veneri, C., Bonadonna, L... Suffredini, E. (2020). First detection of SARS-CoV-2 in untreated wastewaters in Italy. *Science of the Total Environment 736*: 139652.

La Rosa, G., Mancini, P., Bonanno Ferraro, G., Veneri, C., Iaconelli, M... Suffredini, E. (2020). SARS-CoV-2 has been circulating in northern Italy since December 2019: evidence from environmental monitoring. *Preprint*.

Medema, G., Heijnen, L., Elsinga, G., Italiaander, R., & Brouwer, A. (2020). Presence of SARS-Coronavirus-2 RNA in Sewage and Correlation with Reported COVID-19 Prevalence in the Early Stage of the Epidemic in The Netherlands. *Environmental Science & Technology Letters 7*(7): 511-516.

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Randazzo, W., Cuevas-Ferrando, E., Sanjuan, R., Domingo-Calap, P., & Sanchez, G. (2020). Metropolitan Wastewater Analysis for COVID-19 Epidemiological Surveillance. *Preprint.*

Randazzo, W., Truchado, P., Cueves-Ferrando, E., Simón, P., Allende, A., & Sánchez, G. (2020). SARS-CoV-2 RNA in wastewater anticipated COVID-19 occurrence in a low prevalence area. *Water Research 181*: 115942.

Rimoldi, S. G., Stefani, F., Gigantiello, A., Polesello, S., Comandatore, F., Mileto, D... Salerno, F. (2020). Presence and infectivity of SARS-CoV-2 virus in wastewaters and rivers. *Science of The Total Environment 744*: 140911.

Nemudryi, A., Nemudraia, A., Surya, K., Wiegand, T., Buyukyoruk, M., Wilkinson, R., & Wiedenheft, B. (2020). Temporal detection and phylogenetic assessment of SARS-CoV-2 in municipal wastewater. *Preprint*.

Sharif, S., Ikram, A., Khurshid, A., Salman, M., Mehmood, N., Arshad, Y... Ali, N. (2020). Detection of SARS-CoV-2 in wastewater, using the existing environmental surveillance network: An epidemiological gateway to an early warning for COVID-19 in communities. *Preprint*.

Wu, F., Xiao, A., Zhang, J., Moniz, K., Endo, N., Armas, F... Thompson, J. (2020). SARS-CoV-2 titers in wastewater foreshadow dynamics and clinical presentation of new COVID-19 cases. *Preprint.*