

CWEA/CASA Presents: Wastewater Based Surveillance:

An update on its use and variant tracking Live Webinar

CASA-CWEA Webinar, October 5, 2022



Greg Kester

MODERATOR DIRECTOR OF RENEWABLE RESOURCE PROGRAMS CASA



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For reporters: all speakers today are off the record.





Alexandria Boehm

Environmental Engineering Stanford University





Wastewater-based epidemiology for COVID-19, MPXV, respiratory syncytial virus (RSV), influenza A, and other respiratory viruses

> Alexandria Boehm Environmental Engineering Stanford University CWEA/CASA meeting 5 October 2022

Overview of talk

- 1. Brief intro to wastewater-based epidemiology (WBE)
- 2. COVID-19 WBE
- 3. Respiratory syncytial virus (RSV) and Influenza A (IAV) WBE
- 4. Emerging pathogen WBE (MPXV)
- 5. Other respiratory pathogens



1. What is wastewater-based epidemiology?







Municipal Wastewater





75% of US population served by municipal wastewater; remaining on septic systems

Typical wastewater treatment plant unit processes



Wastewater consists of liquid and solids



2. COVID-19 wastewater-based epidemiology

Previous work suggests enveloped viruses partition to solids in wastewater



Survivability, Partitioning, and Recovery of Enveloped Viruses in Untreated Municipal Wastewater

Yinyin Ye, Robert M. Ellenberg, Katherine E. Graham, and Krista R. Wigginton*

Cite this: Environ. Sci. Technol. 2016, 50, 10, 5077–5085
Publication Date: April 25, 2016 ~
https://doi.org/10.1021/acs.est.6b00876
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Method testing

- We tested different measurement methods
 - different nucleic-acid extraction methods
 - different matrices (liquid / solids)
 - digital RT-PCR
 - qRT-PCR
- digital RT-PCR with RNA extracted from solids
- Solids have 1000 10,000 times RNA copies of SARS-CoV-2 than liquid wastewater on mass equivalent basis
- Similar experimental results for influenza A and MPXV



Monitoring at Scale: Proof of Concept



wbe.stanford.edu

Sewer Coronavirus Alert Network Implementation Partner: Verily

High-frequency sampling with quick turnaround

- Mid Nov/Dec 2020 present
- 8-12 plants (pop range from ~10,000 1.5 mil)
- Daily samples
- High-throughput analysis with 10 replicates
- Measuring concentrations in the solid fraction of wastewater
- Sample results available within 24 h of sample collection

SARS-CoV-2: N gene, S gene, ORF1a gene Mutation assays: HV69-70, del156-157/R158G, del143-145, LPPA24S, and more Respiratory viruses: IAV, RSV, HMPV Emerging viruses: MPXV Controls: BCoV, PMMoV

Strong correlation between wastewater and case data



Incidence rate highly associated with wastewater measurements



Association: Wastewater and Incidence Rate

- Data collapse onto a single line
- Significant, strong association between wastewater data and incidence rates
- Relationship: $1 \log_{10}$ increase in N/PMMoV = 0.58 log₁₀ increase in incidence rates
- **Detection limit:** D 1.4 cases /100,000 people

Analysis on data from mid-Nov/Dec 2020 – late Sept 22

Variant mutations in wastewater mirror clinical data on variant occurrence

- Assays specific and sensitive for characteristic mutations indicating <u>Alpha</u>, <u>Beta, Gamma</u>, <u>Delta</u>, <u>Mu</u>, and <u>Omicron BA.1</u>
- Measured single mutations in wastewater solids at San Jose RWF WWTP
- Concentration of a single characteristic mutation correlates with state-level data on variants in clinical samples



Replacement of BA.1 with BA.2 and then BA.5



Yellow = S:del143-145 (BA.1) Orange = S:LPPA24S (BA.2 + BA.4 + BA.5) Pink = ORF1a:del141-143 (BA.4) Purple = S:del69-70 (BA.4 + BA.5)

Also have assays for BA.2.75 / BA.2.75.2 Running on daily samples

3. Respiratory syncytial virus (RSV) and Influenza A WBE



Limited data on fecal shedding of RSV and influenza A

- Only <u>two studies</u> have looked at RSV RNA shed in feces (not quantitative, reported it can be present)
- Only a <u>handful of studies</u> have examined influenza A shedding in feces and found 10⁴-10⁶ gene copies per gram of stool (gc/g)
- RSV and influenza A are shed in sputum and mucus which can also enter wastewater

Developed a new digital RT-PCR assay for RSV

- Targets the N gene of RSV
- Detects RSV A and RSV B
- Highly specific when tested against a respiratory virus panel
- Applied retrospective to wastewater solids samples from 2 bay area wastewater treatment plants



- High correlation between wastewater to state-wide RSV positivity at sentinel laboratories
- There is not easily accessible aggregated data on RSV cases in the sewersheds



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Letter

pubs.acs.org/journal/estlcu

Respiratory Syncytial Virus (RSV) RNA in Wastewater Settled Solids Reflects RSV Clinical Positivity Rates

Bridgette Hughes, Dorothea Duong, Bradley J. White, Krista R. Wigginton, Elana M. G. Chan, Marlene K. Wolfe, and Alexandria B. Boehm $\!\!\!*$





Influenza A

- Outbreak at Stanford University in Spring 2022
 - Samples collected from large sewer main containing wastewater from 10,000 residents on campus (staff, UGs, grad students)
 - Excellent surveillance data for athletes (Dr. Calvin Huang)
- Quantified influenza RNA using the Influenza A M1 gene assay from CDC using digital droplet RT-PCR



- Strong correlation between M1 gene concentration and positivity rate and incident athlete cases
- Athletes live dispersed through campus, so true number of cases ~ athlete cases
- We also have data for a similar outbreak at Univ Michigan



<u>≥</u>©()§∋

Letter

Wastewater-Based Detection of Two Influenza Outbreaks

Marlene K. Wolfe, Dorothea Duong, Kevin M. Bakker, Michelle Ammerman, Lindsey Mortenson, Bridgette Hughes, Peter Arts, Adam S. Lauring, William J. Fitzsimmons, Emily Bendall, Calvin E. Hwang, Emily T. Martin, Bradley J. White, Alexandria B. Boehm,* and Krista R. Wigginton*

RSV and Influenza A RNA on our website in daily samples





4. Emerging pathogens (MPXV)



- Double stranded DNA, enveloped virus
- Shed in feces, urine, sputum, skin lesions
- G2R_G QPCR assay from Li et al. 2010 (CDC)
- Targets TNF (tumor necrosis factor) receptor gene
- Daily measurements starting June 19 2022 at our sites



Emergence of MPXV DNA shedding



Trends over time in an area with high incidence





Episode Date Report Date

Other respiratory viruses

- SJ RWF WWTP
- 3 d per week between 2/1/21 and 6/21/22
- RSV A, RSV B
- Season coronaviruses
- Parainfluenza 1-4
- Rhinovirus
- Metapneumovirus
- Influenza A, Influenza B
- State-, and weekly-aggregated sentinel lab positivity rates

https://www.medrxiv.org/content/10.1101/2022.09.22.22280218v1



Vision for use of wastewater data



Currently preparing to expand our work to 300 wastewater plants nationally



Thank you for your attention! aboehm@stanford.edu

Pls

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SCAN SEWER CORONAVIRUS ALERT NETWORK



Naoko Munakata

Supervising Engineer, Wastewater Research Section

Los Angeles County Sanitation Districts





Wastewater Surveillance:

A Utility Perspective on Implementation

Naoko Munakata

October 5, 2022



Background
The wastewater surveillance team



take action

Infrastructure: National Wastewater Surveillance System



LACSD: Lessons Learned

- LACSD work on wastewater surveillance



Things to consider: logistics



- Sampling
 - Frequency: How often? Which days?
 - Type: influent, solids
 - Volume
- Integrate into existing sampling if possible

Meta-data



Shipping: all couriers have occasional issues

- Things to consider: data sharing



- Who can access the data?
 - Utility
 - Health department
 - CDC
 - Public





Turnaround time

- Output to the second second
 - Lab to utility
 - Lab to health department
 - Lab to CDC's DCIPHER database
 - Public dashboard

Things to consider: data limitations

- Data noise
- Solution: averaging, trimming



- Things to consider: data limitations

- Data noise
- Solution: averaging







Things to consider: resources



Nwbe.org \bigcirc **NWSS** Utilities Community of Practice



August September

Or email us or explore

the other dashboard

navigation buttons

topics using the

below!

Summary

Sampling

Safety

Public Health

Utilities Community of Practice: nwbe.org

- Monthly virtual meetings with presentations, discussions, and updates from CDC
- Answers to Frequently Asked Questions
- Cost calculator and budgeting guidance
- Online library with templates, videos, other resources
- Oiscussion board
- Regular email updates
- All free

NWSS Sequence Data Visualization Dashboard



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Future of Wastewater Surveillance

Core Endemic or common diseases





SARS-CoV-2





Norovirus



Candida Auris



Antibiotic Resistance



Drugs

Emergency Sporadic but expected diseases



Monkeypox



Poliovirus

Pandemic Preparedness

Rare, unexpected diseases



Ebola

WEF recommendation on polio: wait for better guidance, expected in ~a few weeks



• Utilities play a key role in wastewater surveillance

- Help protect public health: CDC, CDPH and/or local health departments are actively using the data
- Data are another resource to "recover" from wastewater
- For implementation: consider logistics, data sharing and limitations
- Resources are available to help utilities
 - CDPH: shipping/handling, analysis, data interpretation, etc.
 - NWSS Utilities Community of Practice (nwbe.org): information
- Wastewater surveillance can be used for a variety of public health issues and will continue for the long-term

What are some advantages of wastewater surveillance over clinical testing?



More complete

Independent of:

- Symptoms
- Test kit availability
- Access to health care
- Care/test-seeking behavior



Faster

- No need to collate individual data
- SARS-CoV-2 variants have been observed up to weeks earlier



Less expensive

One sample can:

- Provide broader coverage
- Give community level information

Photo credits: (1) iStockphoto.com (2) https://pngimg.com/download/15430 licensed under <u>CC BY-NC</u>.

• What are some disadvantages, compared to clinical samples?



Complex matrix

- Results have more variability/noise
- Interferences with analysis
- Harder to identify variants in a mixture from many people



Angela Rabe

Wastewater Surveillance Epidemiologist California Department of Public Health



California Surveillance of Wastewaters (Cal-SuWers)

CWEA/CASA: Wastewater Based Surveillance Webinar October 5, 2022



Angela Rabe

Wastewater Surveillance Epidemiologist California Department of Public Health Coronavirus Science Branch, Surveillance Section <u>angela.rabe@cdph.ca.gov</u>



Outline

- Wastewater Surveillance for SARS-CoV-2 in CA
- Clinical surveillance vs. Wastewater surveillance data
- Wastewater surveillance based public health action(s)
- CDPH Drinking Water & Radiation Lab
- What's next?
- Opportunities for collaboration and support

The New York Times

The Lost Month: How a Failure to Test Blinded the U.S. to Covid-19

Aggressive screening might have helped contain the coronavirus in the United States. But technical flaws, regulatory hurdles and lapses in leadership let it spread undetected for weeks.



Wastewater Surveillance



- First used for public health almost 70 years ago
 - Poliovirus
- Look for concentration of SARS-CoV-2 RNA fragments

California Surveillance of Wastewaters (Cal-SuWers) Network



- CDPH, CDC/Biobot and Network
- 70 participating sites
- 26 Counties
- ~ 25.5 million people
- 60 % of CA's population covered
 - 70% of the reachable population

*Network sites include sites conducting wastewater surveillance independently of CDPH or CDC, but submitting data to CDPH/CDC including SCAN, Verily, HCVT, and City/County sponsored sites

Wastewater trends mirror case count trends





Wastewater as leading indicator?



- Varies by sewershed and surge
- Likely dependent on many things:
 - Community test utilization
 - Case test result delays
 - Symptom incubation period
 - Screening programs
 - Environmental factors



Strong correlation between cases & wastewater



Wastewater Concentration, N1 (rolling avg 10d)

Correlation Coefficients (R2) range from 0.7-0.95



What is Public Health Disease Surveillance?

- Counting cases for Situational Awareness
 - Burden / extent of disease
 - Outbreaks
 - Evaluate effectiveness of interventions
 - Understand disease severity, vaccine effectiveness, etc
- Important for
 - Public health preparedness
 - Medical and health care decision making and planning
 - Personal risk assessment
- Reliant on testing and reporting of test results
- What happens when cases aren't tested?
 - Can't access a test (no tests available)
 - Don't want to get a test testing fatigue
 - Use a test that doesn't get reported? at home antigen test





TIME

HEALTH • COVID-19

COVID-19 Could Be Surging in the U.S. Right Now and We Might Not Even Know It

BY MADISON MULLER / BLOOMBERG APRIL 11, 2022 10:10 AM EDT

he rise of Covid cases in some regions of the U.S., just as testing efforts wane, has raised the specter that the next major wave of the virus may be difficult to detect. In fact, the country could be in the midst of a surge right now and we might not even know it.

Comparison to reported case data



Public Health Uses of Wastewater

Situational Awareness

- Data when testing is low
- Confirm or refute epi data trends
- Early indicator
- Variant detection
- Other pathogens, antimicrobial resistance
- Understanding virus epidemiology
- Predictive models

Inform



- Messaging, Public Awareness
- Testing
- Resource Allocation
 - Testing, Contact Tracing, Vaccination, Sequencing
 - Hospital / PPE planning
- Inform PH Decision Making (e.g., masking, etc)

Local level uses

- Understand community disease activity, variants
- Messaging (e.g., Wear a mask? Need booster?)
- Resource Allocation
 - Testing availability, screening
 - Staffing
 - Hospital ICU beds, supplies
- Understand what diseases are circulating (e.g., flu vs covid)
- Therapeutic choices (e.g., monoclonals, antimicrobials)





Public Health Uses of Wastewater in CA

COVIDPoops19 Summary of Global SARS-CoV-2 Wastewater Monitoring Efforts by UC Merced Researchers



- Wastewater integrated in metrics to inform masking recommendations
- Increased vigilance or monitoring of cases and other metrics
- Community outreach/messaging
- Awareness messaging to visitors in Yosemite National Park
- Proxy for cases when testing low
- Redirecting resources (test, vaccines, etc)
- Preparing/notifying hospitals
- Notifying student/parents
- Altering NPIs (e.g. masking, face covering, etc.)

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Wastewater surveillance milestones & roadmap





California Surveillance of Wastewaters (Cal-SuWers) Network

CDPH Expansion Goals

- ✓ Represent 50% of CA population
- At least one site in 50% of counties of each HO region (Northern CA, Greater Sac and San Joaquin Valley)
- □ Improve equity
- □ Transition all sites to state lab by Spring 2023
- Add sequencing
- □ Add Influenza /RSV surveillance by Fall/Winter 2022
 - Other pathogens (e.g.,MPXV)



High-throughput wastewater SARS-CoV-2 viral detection pipeline

CDPH Drinking Water & Radiation Laboratory (DWRL)



- Richmond CDPH Campus, CA
- Led by Dr. Chad Crain
- Started in December 2021
- Monitoring at 14 sites and 6 sub sewersheds
- High-throughput pipeline
- Expanding lab space, capacity, equipment and staffing now

Opportunities to join

CDPH

- Expansion especially in Northern CA, Greater Sacramento area, and San Joaquin Valley
- Building out capacity at state laboratory (DWRL)
- Free for utilities to participate (CDPH covers laboratory testing, shipping and handling, etc)

Local Public Health, Private Labs, & Academic groups

• Include some free or subsidized programs

Contact <u>WWS@cdph.ca.gov</u> for more information


Wastewater as long-term sustainable Public Health system

- Support wastewater utilities:
 - Covering cost of sample collection materials, shipping and lab analysis
 - Provide logistic support for sample pick up and shipping
 - Flexible & alternative sampling schedules
 - Monthly office hours for local partners (health departments and utilities)
 - Teams channel & forum
 - Resource repository (utility safety documents, protocols, talking points, articles/journals)
 - Financial support (stipend, auto-sampler)

Ideas for other ways CDPH can support wastewater treatment plants?

wws@cdph.ca.gov

Dashboards and Resources

- CDPH Wastewater Surveillance Dashboard
 https://www.cdph.ca.gov/Programs/CID/DCDC/
 Pages/COVID-19/CalSuWers-Dashboard.aspx
- CDC COVID Data Tracker (CDT)
 <u>https://covid.cdc.gov/covid-data-</u>
 tracker/#wastewater-surveillance



CA Wastewater Surveillance Forum and Office Hours – Email <u>wws@cdph.ca.gov</u> to join!



COVID-19 WASTEWATER SURVEILLANCE

Return to the COVID-19 Wastewater Surveillance Overview webpage

CDPH Wastewater Surveillance Network Dashboard

California Surveillance of Wastewater Systems (Cal-SuWers)





Acknowledgements

CDPH

- Cal-SuWers (Wastewater Team)
 - Duc Vugia, MD, MPH
 - Angela Rabe, MS
 - Andrew Abram, MPH
 - Kelvin Wong, PhD
 - Madhura Rane, PhD
 - Elisabeth Burnor, MS
 - Joel Rojas, MS
 - Caroline Collins, MPH
 - Marisa Donnelly, PhD
- Epi, Data and Surveillance Teams
- Modeling
- Genomic Epidemiology
- VRDL
- Leadership

State Water Resources Control Board

Academic Partners

- SCAN/Stanford/Emory/Umich
- UC Berkeley
- UC Davis, UC Merced
- UC San Diego

Local Health Departments

Utilities

• Many, many thanks to the hard work of many

CDC

- Epidemiology and Laboratory Capacity Grant
- NWSS



QUESTIONS & ANSWERS



CASA CWEA

Thank You!

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