Introduction to Sewage Epidemiology

Walter Betancourt
Charles P. Gerba
Ian Pepper
Department of Environmental Science

THE UNIVERSITY OF ARIZONA.

WEST CENTER
WATER & ENERGY SUSTAINABLE TECHNOLOGY

Sewage Surveillance

- The virus concentration in sewage is related to the number of cases in a community

- Goes back more than 40 years for detecting poliovirus cases in communities – in use by poliovirus eradication program

- Advantages:
  – Can detect one case of infection in 100,000 persons
  – Can determine success or failures of interventions
  – Can predict the number of cases 7 to 10 days before clinical cases are recognized
  – Can be use to identify facilities with infected individuals
 – Less closely than large numbers of clinical tests

SARS- CoV-2 Studies Underway

- Sewage surveillance of
  – Communities
  – Dormitories
- Determination of infectivity of SARS-CoV-2 in wastewater
- Survival of SARS-CoV-2 in wastewater
- Disinfectant assessment
  – UV light
  – Chloramines
- Persistent anti-viral coatings and fabrics
 – Anti-viral clothing (Masks and protective equipment)

Coronaviruses

- An enveloped virus
- ssRNA
- Survives several days in wastewater/ water
- Excreted in both the urine and feces
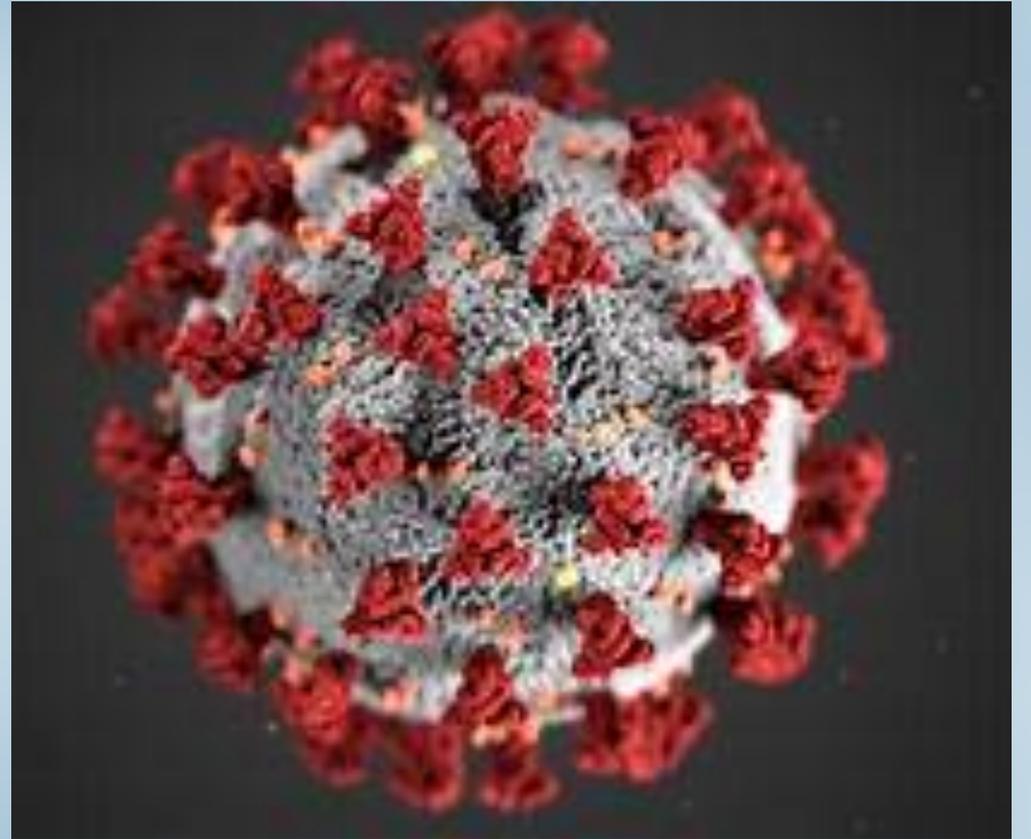
Advantages of Wastewater Epidemiology

|	Diagnose-based	Wastewater-based
Coverage	Individual	Community
Potential bias	High, depending on the testing policy	Low
Operational cost	High	Low
Early warning	Not supported	Supported
Asymptomatic patient detection	Not supported	Supported
Testing capacity requirement	High	Low

Early warning

Time lag

— Reported cases
— Viral titers

Time

Asymptomatic patient detection

— Newly infected
— Reported cases

Time

COVID-19 prevalence

Virus concentration
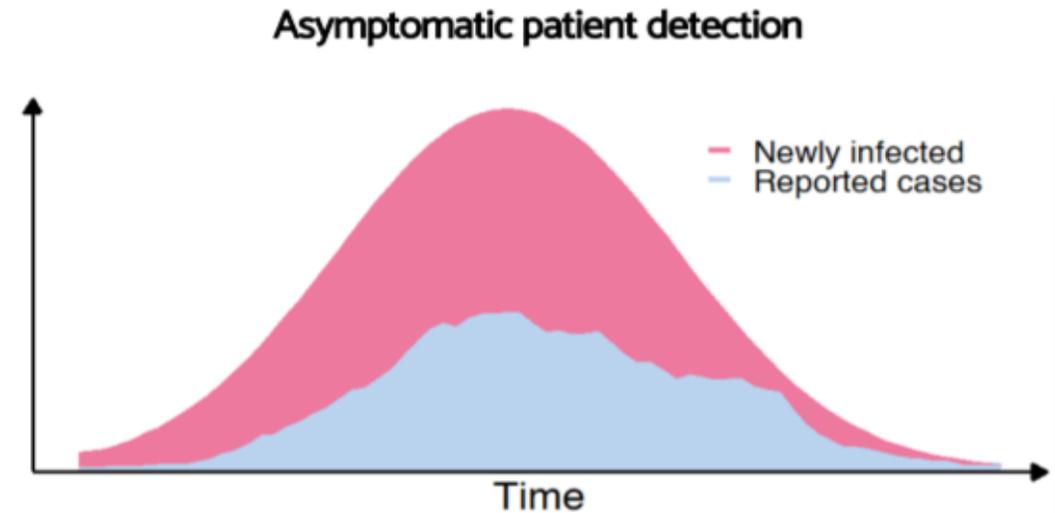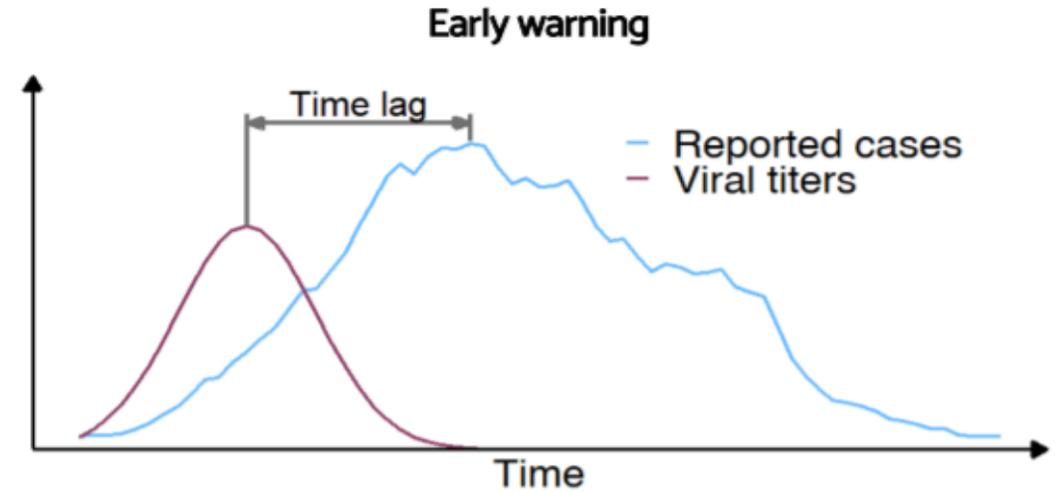
Viral RNA extraction
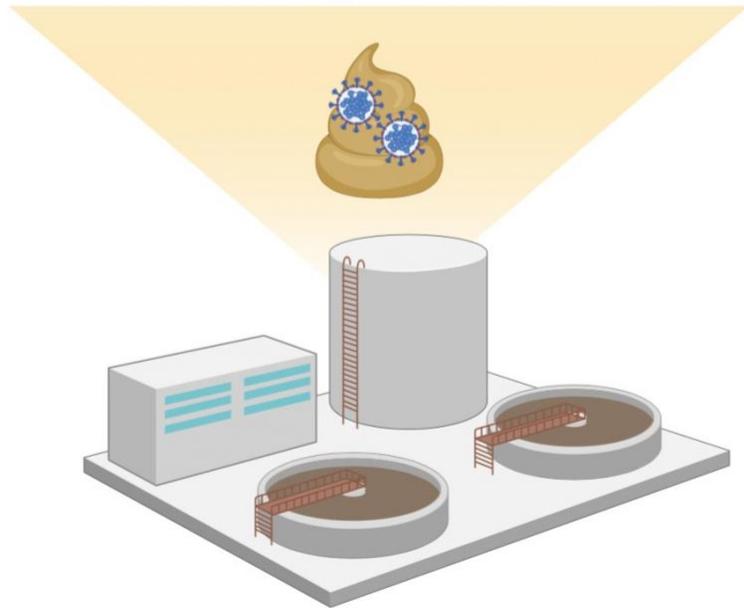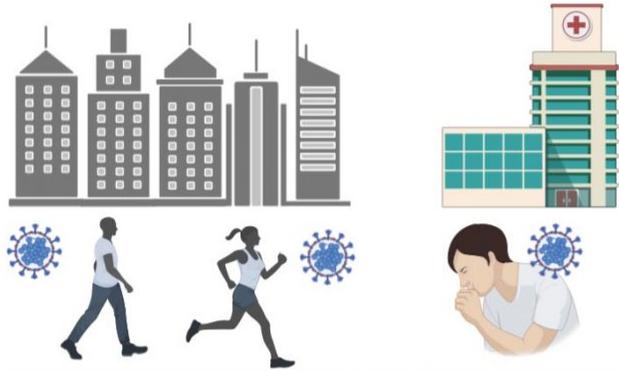
Wastewater treatment plant

SARS-CoV-2 in wastewater

Quantitative PCR

Fluoresent signal

PCR cycle
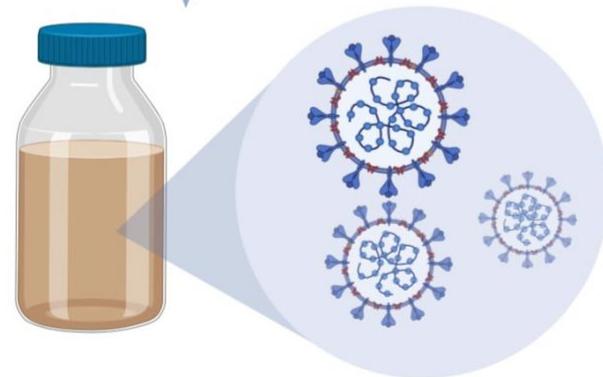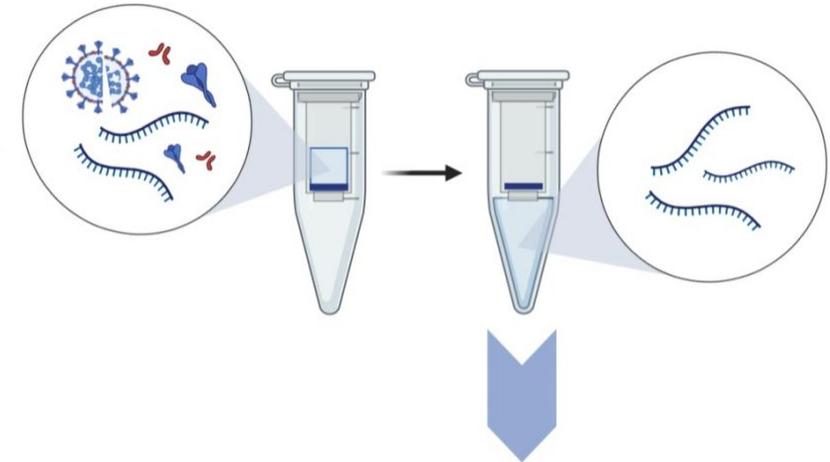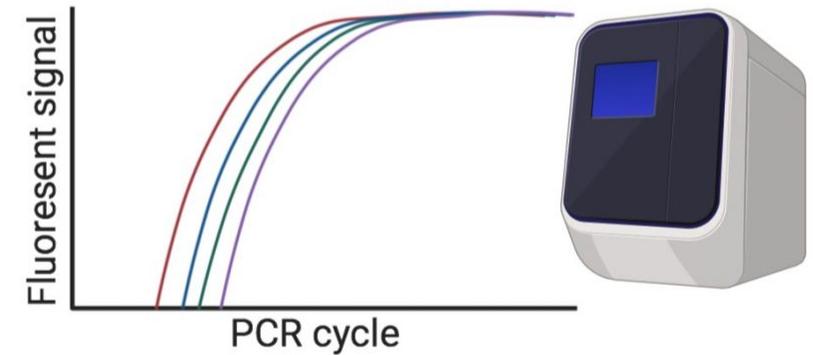
Detection & quantification of SARS-CoV-2 RNA

How University of Arizona aimed to control spread among 7,600 students

Population

- 7,600 on-campus students
- 23 dorm buildings
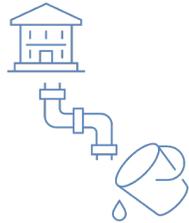
Collection

- Weekly collection for each building
- Anomalous results trigger additional sampling
- Anonymous nature of sampling alleviates CLIA requirements

Lab processing

- Existing BSL 2 lab
- Filters and centrifuges for simple sample prep
- CDC panel assay
- Roche and Biorad RT-PCR analyzers

Structured decision tree based on results

- **10^1 to 10^2 viral copies**: increased wastewater screening of target building
- **10^3 to 10^4 viral copies**: increased wastewater screening and initial individual screening
- **10^5 to 10^9 viral copies**: intensive response with antigen testing of all individuals and follow-on molecular tests

Collecting Wastewater from Dorms

From 100 samples/year to 100 samples/Week

Wastewater-Based Epidemiology at the University of Arizona WEST Center
The Likins Dorm Case Study - Timeline

Date	Time	Event
August 25	8:30am	Likins Dorm wastewater sampled
	8:30am – 5:00pm	Sample analyzed
	6:00pm	positive for SARS-CV-2 and announced to UA Task Force
	11:00pm	Emergency meeting, Dr. Pepper with Task Force including President Robbins
August 26	8:00am	Emergency meeting – decision made to test students in Likins Hall
	8:30am	5 samples, one every 5 minutes, collected from Likins Dorm sewage
	11:00am	Antigen and PCR tests of students in Likins Dorm
	5:30pm	All 5 samples positive for SARS-CoV-2. Concentrations virtually identical in all 5 samples. Two students positive for antigen test and removed from Likins Dorm
August 27	8:30am	Wastewater sample collected from Likins Dorm
	12:30pm	Additional sample collected from Likins Dorm
	5:00pm	All samples found to be negative
August 28	8:30am	Likins Hall sample collected
	5:00pm	Sample found to be negative
August 30		Plans made to double WBE testing capacity - Originally 10 locations twice weekly - New projection 24 locations 3x a week

Effectiveness of the COVID-19 Containment Strategy at the University of Arizona

Clinical Cases in Monitored Dorms

No new cases from 10/17 To 11/30

SARS-CoV-2 Virus - Update

- No infectious virus detected yet detected in wastewater
- By RT-qPCR as high as 10,000,000/liter detected in wastewater
- By RT-qPCR high a 100,000,000/liter detected in primary sludge

What have we learned – sewage monitoring for SARS-CoV-2 at the University of Arizona and Tucson

- Grab samples collected in the morning works in identifying cases

- Can identify as few as 2 infected students in a in dorms of ~327

- No viruses detected in sewage after infected students removed

- Four-day lead on identifying cases before positive clinical test by student health center

- Concentration of virus increases in community sewage after Memorial day, 4th of July, Labor, Thanksgiving and New Year day before increase seen in clinical cases

- Social distancing, use of masks, and stay in place decreased concentration of virus in sewage

- Virus concentrations in dorm sewage with infected individuals range from 1e3 to 1e9 per liter

What is needed

- Development of standard methods
  - Several companies are producing SARS-CoV-2 test kits for wastewater testing
- Tools for data analyses
- Education and training
  - Most health departments do not know how to use the data
  - Many potentional applications
    - – quantifying successes of interventions
    - -targeting interventions to greatest number of cases with a region
- National network data collection
  - 100 treatment systems will be in a nationwide network in the U.S. (NIH/CDC)