COVID-19 Surveillance using Wastewater-Based Epidemiology

September 17, 2020

HRSD’s Pathogen Program

• Core Focus Area
  – Microbial Source Tracking
  – Quantitative Microbial Risk Assessment
  – Pathogen Quantification
  – Environmental Surveillance

• Matrices
  – Stormwater, Biosolids, Wastewater, Drinking Water, Shellfish

• Capabilities
  – Digital PCR
  – Quantitative PCR
  – Next generation sequencing
    ▪ Illumina iSeq 100
    ▪ Nanopore MinION
  – Culture:
    ▪ Traditional FIB
    ▪ Coliphage
    ▪ GB-124
HRSD provides service to 18 cities and counties of southeast Virginia, an area of over 3,087 square miles with a population of 1.7 million.
We operate nine major treatment plants and seven smaller plants in eastern Virginia, with a combined treatment capacity of 249 million gallons per day.
Mission
We protect public health and the waters of Hampton Roads by treating wastewater effectively.

Vision
Future generations will inherit clean waterways and be able to keep them clean.

Portsmouth, Virginia before HRSD was created in 1940. Raw sewage was discharged to open area waterways and ditches.
COVID-19

• Novel Coronavirus disease 2019

• Viral agent: severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)

• high infectivity, relatively high asymptomatic ratio in the population, and potential to result in serious health complications

Source: NIAID
COVID-19 in Water

• More susceptible to disinfection and environmental stressors than enteric viruses

• Unlikely to be viable in wastewater
  – Not a risk to operators
  – Not a risk to lab personnel

• Unlikely to make it through WWTP

Source: https://commons.wikimedia.org/wiki/File:3D醫療動畫_冠狀病毒.jpg
Dec 8
First patient develops symptoms

Jan 30
Public Health Emergency of International Concern

Feb 29
US reports first COVID-19 death

Mar 11
COVID-19 declared pandemic

May 15
Phase 1 Safer at home

July 1
Phase 3

Jan 11
1st known death due to new coronavirus

Feb 17
HRSD decides to monitor wastewater

Mar 9
1st HRSD sample

Mar 30
Stay at Home Order

June 12
Phase 2

COVID-19 Timeline
Wastewater-Based Epidemiology

- Observe community-level trends through biomarkers in raw wastewater

- Past studies:
  - Pharmaceuticals
  - Illicit drugs
  - Industrial chemicals
  - Emerging contaminants
  - Population health markers
Monitoring human enteric viruses in wastewater and relevance to infections encountered in the clinical setting: a one-year experiment in central France, 2014 to 2015

Detection of Pathogenic Viruses in Sewage Provided Early Warnings of Hepatitis A Virus and Norovirus Outbreaks

Environmental Microbiology

REVIEW ARTICLE
Role of environmental poliovirus surveillance in global polio eradication and beyond

T. HOVI¹, L. M. SHULMAN², H. VAN DER AVOORT³, J. DESHPANDE⁴, M. ROIVAINEN⁴ AND E. M. DE GOURVILLE⁵
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
Gertjan Medema,* Leo Heijnen, Goffe Elsinga, Ronald Italiaander, and Anke Brouwer

First detection of SARS-CoV-2 RNA in wastewater in North America: A study in Louisiana, USA
Samendra P. Sherchan 1,2,3, Shalina Shahin 4, Lauren M. Ward 3, Sarmila Tandukar 5, Tiong G. Aw 4, Bradley Schmitz 6, Warish Ahmed 6, Masaaki Kitajima 6

Wastewater-Based Epidemiology: Global Collaborative to Maximize Contributions in the Fight Against COVID-19
Aaron Bivins, Devin North, Arslan Ahmad, Warish Ahmed, Eric Alm, Frederic Been, Prosun Bhattacharya, Lubertus Bijlsma, Alexandria B. Boehm, Joe Brown, Gianluigi Buttiglieri,

First confirmed detection of SARS-CoV-2 in untreated wastewater in Australia: A proof of concept for the wastewater surveillance of COVID-19 in the community
Culture-based Method
- Determines infectivity
- Requires BSL3
- VERO E6 cells (a monkey kidney cell line)

PCR-based Method
- Does not differentiate between viable and non-viable virus
- ‘scent of a virus’
- BSL2+ recommended
- RT-qPCR, RT-dPCR

Goal:
Regional study to describe the rise and fall of COVID-19 cases in the community

Specific Objectives:
1. detect SARS-CoV-2 in wastewater
2. describe the trends in SARS-CoV-2 in wastewater
3. determine if wastewater is a leading indicator of new clinical COVID-19 cases
HRSD Monitoring

- Weekly monitoring of 9 major facilities
- 24-hr composite and grab samples
- 100 mL wastewater volumes
- RT-ddPCR quantification of CDC’s clinical COVID-19 panel (N1, N2, N3 assays)
COVID-19 Cases in Hampton Roads
Regional Viral Load

Daily New Clinical Cases and Viral Load in HRSD Treatment Facilities

- **New Clinical Cases by Date**
  - Y-axis: 0 to 1000
  - Grid lines: 500, 1000

- **Viral Load in Wastewater (copies)**
  - Y-axis: 0 to 1.5e+13
  - Grid lines: 5.0e+12, 1.0e+13, 1.5e+13

- **Timeline**
  - Apr to Sep
  - Phases:
    - Stay at Home Order
    - Phase 1 Reopening
    - Phase 2 Reopening
    - Phase 3 Reopening
    - Hampton Roads Restrictions
    - Phase 3 Reopening

- **Trend lines**
  - Trend lines created using lowess smoothing function

*Note: The graph shows the trend of daily new clinical cases and viral load in HRSD treatment facilities over the timeline from April to September.*
Population Normalized SARS-CoV-2 Loading
A Spatial Look at SARS-CoV-2 Loads

Population Normalized SARS-CoV-2 Loading
Date: 2020-03-11

Log$_{10}$ Viral Load

[Color scale from 5.5 to 7.5]

[Map showing population normalized SARS-CoV-2 loading across different areas]
• Special studies
  – Epidemiological modeling
  – Infrastructure modeling
  – SARS-CoV-2 strain sequencing
• University WW monitoring
• Targeted high-priority monitoring
  – Bases, hotels, high density residential areas, hospitals
• Multi-lab validations
Questions?

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