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# Enteric Viruses in Surface Water: Large Volume Automated Sample Collection and Filtration

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## Summary

- Viruses are thought to be a cause of many waterborne diseases contracted from fecal-contaminated waters.
- Collection of samples that properly represent virus concentrations throughout relevant hydrologic periods has historically been difficult due to complexity of the sampling process.
- An automated process control system was developed to allow for unattended virus sample collection over extended duration sampling periods.


## Objectives

- Define the relative magnitude of selected human gastero-intestinal waterborne viruses in Milwaukee area surface waters
  - Overall occurrence and variability
  - Seasonality
  - Year to year variation
  - Climatic/hydrologic variation
- Develop an automated sampling system to collect large volume (100 to 3000 liters) flow-proportional samples over entire storm runoff events

## Approach

- Sampler design
  - Automated sampler for large volume water filtration
    Filter capacity from 100 to ~3000 liters depending on sample matrix
  - Event-mean virus concentrations determined from flow-weighted composite samples
  - Telemetry: remote access for sample control and data recovery
  - Optimize recovery of viruses through system control
    Flow rate regulation (~1.0 L/min)
    pH regulation (6.5 < pH < 7.0)
    Internal System Pressure was monitored and used to switch filters when clogged.
  - Glass wool filter for virus capture; prefilter to remove larger particles
- Sampling plan
  - 2-year study duration
  - Sampling locations in the Milwaukee River Watershed
    Underwood Creek (Urban)
    Cedar Creek (Rural)
    Milwaukee River at Jones Island (Integration of Urban and Rural)
  - Sampling Frequency
    High-flow samples
    Two flow-weighted composites per season
    Low-flow samples
    One 24-hour composite sample every other month

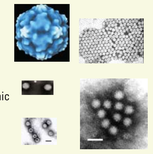
## Results

- Samples were successfully collected to cover a representation of long-term hydrographs (up to two weeks in duration)
- Up to 2,800 liters of water have been filtered through an individual filter
- Results from virus analyses provide event-mean concentrations of:
  - adenoviruses, enteroviruses, rotavirus, hepatitis-A virus, and noroviruses.
- Preliminary data after 1-year of data collection:
  - Viruses have been detected in 53.4% of 54 samples collected in the first year of data collection
  - Concentrations have been detected up to 519 viruses/L
  - Each of the viruses has been detected at least one time

## Virus Analysis

Samples will be analyzed for five types of human gastrointestinal viruses.

- Enterovirus
- Adenovirus
- Rotavirus
- Hepatitis A
- Norovirus



Analytical Method by Marshfield Clinic Research Foundation

- Quantitative Real-time PCR

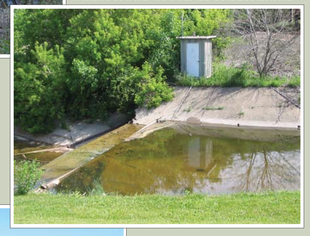
## Why Monitor for these Viruses? (CDC)

Viral gastroenteritis affects people in all parts of the world. Each virus has its own seasonal activity. For example, in the United States, rotavirus infections occur during the cooler months of the year (October to April), whereas adenovirus infections occur throughout the year. Norovirus outbreaks can occur in institutional settings, such as schools, child care facilities, and nursing homes, and can occur in other group settings, such as banquet halls, cruise ships, dormitories, and campgrounds.

## STUDY LOCATION

Cedar Creek near Cedarburg

Underwood Creek at Wauwatosa

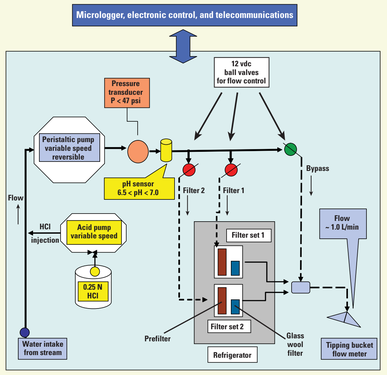


Milwaukee River

## AUTOMATIC SAMPLING METHODS

- System components and capabilities
  - Peristaltic pump for delivery of stream water
  - Flow regulation to ~1-L/min
  - pH regulation to 6.5-7.0 by HCl injection into flow stream
  - Pressure monitoring within system
  - Large volume filtration (100-3000 L)
    Pre-filter for large particles
    Glass-wool filter for primary virus capture
    Less expensive than previous (<$25)
  - Capability of extended duration samples (days to weeks)
  - Datalogger for electronic process control
    Control of autosampling system
    Control of streamflow-weighted composite sampling
    Automatic sample trigger based on streamflow
  - Telemetry for remote communication
    Control sampling parameters remotely
    Real-time monitoring of process
    Remote data capture

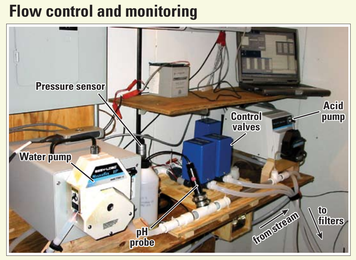
### Filtration system schematic




### Refrigerated filters

### Electronic system control

### Flow control and monitoring




### Tipping bucket sampler

## Conclusions

- Automated sampling for viruses in water allows for successful collection of samples representing long-term hydrograph conditions
- Large volumes of stormwater (up to 2,800 liters to date) can be filtered for an individual sample
- The system is successful in capturing numerous different viruses for analytical determination
- All viruses included in study periodically exist in surface waters within the Milwaukee River Watershed

## Future Work

- Current 3 sites will be monitored through September 2008
- Study will continue at 6 sites for evaluation of the Menomonee River Watershed
  - Define relative locations of virus loading contributions throughout the entire watershed
  - Chemical tracers of wastewater: co-occurrence with viruses?
  - Partitioning: Sediment sampling vs water sampling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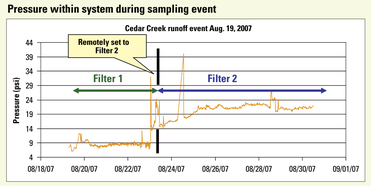
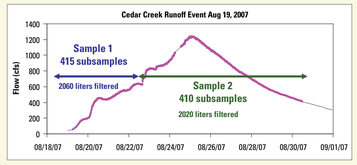
## SAMPLING PROCESS RESULTS

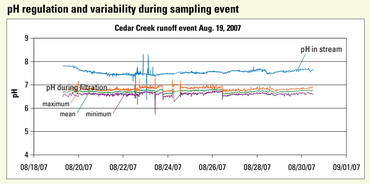
### Pressure within system during sampling event




### Hydrograph coverage during sampling event




### pH regulation and variability during sampling event




## PRELIMINARY ANALYTICAL RESULTS: VIRUS OCCURRENCE IN 2007–08

### Runoff events

| Virus | Concentrations (n = 43) Max (v/L) | Mean (v/L) | Percent occurrence |
|---|---|---|---|
| Adenovirus | 344 | 52.1 | 54 |
| Enterovirus | 426 | 11.8 | 12 |
| G1 Norovirus | 339 | 9.56 | 9.3 |
| G2 Norovirus | ND | ND | 0.3 |
| Hepatitis-A | 16.2 | 0.37 | 2.3 |
| Rotavirus | 98.3 | 2.33 | 7.0 |
| Sum of viruses | 519 | 76.2 | 63 |

### Baseflow periods

| Virus | Concentrations (n = 20) Max (v/L) | Mean (v/L) | Percent occurrence |
|---|---|---|---|
| Adenovirus | 130 | 9.6 | 10 |
| Enterovirus | ND | ND | 0 |
| G1 Norovirus | 12.1 | 0.9 | 10 |
| G2 Norovirus | 9.4 | 0.5 | 5 |
| Hepatitis-A | ND | ND | 0 |
| Rotavirus | 41.1 | 2.0 | 5 |
| Sum of viruses | 130 | 13.1 | 20 |