

Water Reuse System Sampling Results Summary

February 2018

Introduction

The Minnesota Department of Health (MDH) contracted with the University of Minnesota (U of M) to study the microbial populations in a stormwater irrigation system in a city park and a toilet flushing system in a building.

The objectives of this study were to:

- Determine if common microbes that can make people sick (human pathogens, also known as “germs”) were in the water of these reuse systems.
- If human pathogens were found:
 - Estimate the concentration of the human pathogens in the water (i.e., how many pathogens per liter of water).
 - Estimate the risk to human health posed by the pathogens.
- Use the findings of the study to help inform possible recommendations for regulatory and/or non-regulatory approaches to water reuse in Minnesota.

The study, funded by the Clean Water Fund, involved collection of samples from the two systems from February 2015 to November 2015. In addition, another researcher sampled the air in the city park while the irrigation system was operating in the fall of 2016.

Water sample locations and analysis

In the stormwater irrigation pond that supplies water to the irrigation system, samples were collected at depths of one foot and eight feet below the surface. For comparison, additional samples were collected from a nearby lake and from a campground water spigot.

For the building toilet flushing system, samples of collected rainwater and stormwater that are used to supply the toilets were taken from 1) an outside overflow cistern (storage tank), 2) an outside primary cistern (storage tank), 3) inside storage tanks, and 4) from a stormwater-supplied toilet bowl. The water supply for the building toilets could be switched to municipally-supplied water when stormwater was not available. Additional samples were taken from the toilets when the municipal water served as the source water.

Samples were analyzed in a laboratory using techniques called quantitative polymerase chain reaction (qPCR) and microfluidic qPCR. Both of these methods provide information about the

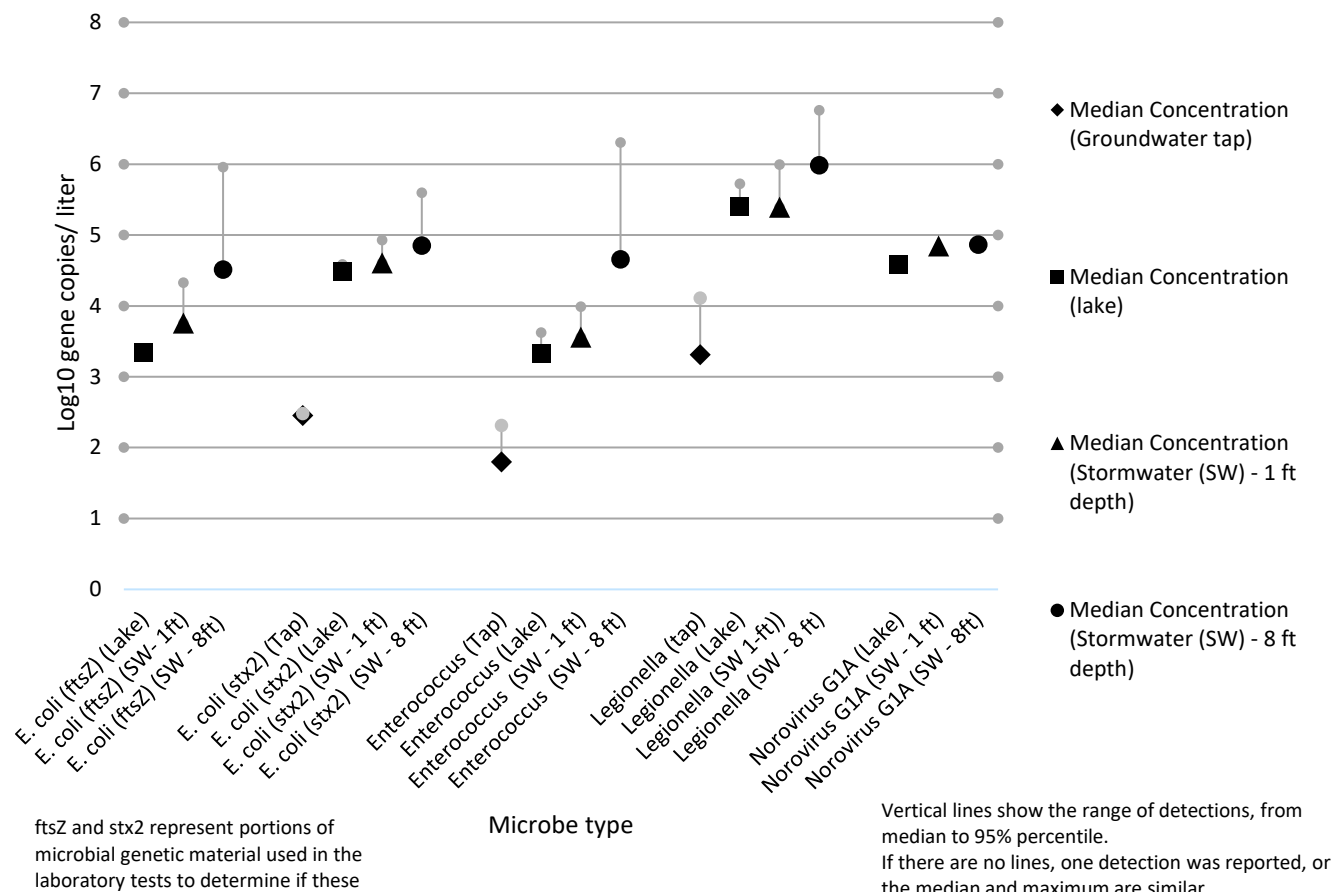
presence of microbes in the sample by counting the number of the microbe's genetic copies per liter in the sampled water.

Results

In the stormwater pond, bacteria, viruses, and protozoa that can be human pathogens were detected in the water used for irrigation. One of the pathogens, *Norovirus*, is a human virus that causes gastrointestinal symptoms (such as diarrhea and vomiting) and is often found in human sewage. Additional pathogens that can come from human or animal waste were also found. These pathogens included bacteria (*Campylobacter*, *Clostridium*, *Enterococcus*, and *Escherichia (E. coli species)*) and protozoa (*Giardia* and *Cryptosporidium*). Further, *Legionella* species, which are commonly found in the environment, were also detected. However, the specific *Legionella* subtype often connected to outbreaks of Legionnaires' disease, *Legionella pneumophila* serogroup 1, was not found. In general, the concentration of pathogens detected eight feet below the surface, where the irrigation water is drawn, was higher than at one foot below the surface. This was particularly true for *Enterococcus* and *Legionella* species.

The median concentrations of detected pathogens in the groundwater tap, the lake, and the stormwater pond at depths of one foot and eight feet below the surface are shown in Figure 1. The concentrations shown are the microbes' genetic copies per liter of water.

Figure 1. Comparison of concentrations of detected microbes in an outdoor tap, a lake, and stormwater



Access Figure 1 chart data in [Supplemental Information \(PDF\)](https://www.health.state.mn.us/communities/environment/risk/docs/guidance/dwec/qmra/chartdata.pdf) (<https://www.health.state.mn.us/communities/environment/risk/docs/guidance/dwec/qmra/chartdata.pdf>)

The air sampling also revealed that pathogens can be transmitted through the air via the irrigation spray. The genetic material of viruses (Avian Flu virus and *Adenovirus*) and bacteria (*Escherichia* and *Legionella*) were detected by the air samplers. In addition, a bacterium that is often a marker for human sewage, *Bacteroidales*-like Hum M2, was also detected by the air samplers. This bacterium is not usually associated with illness, however.

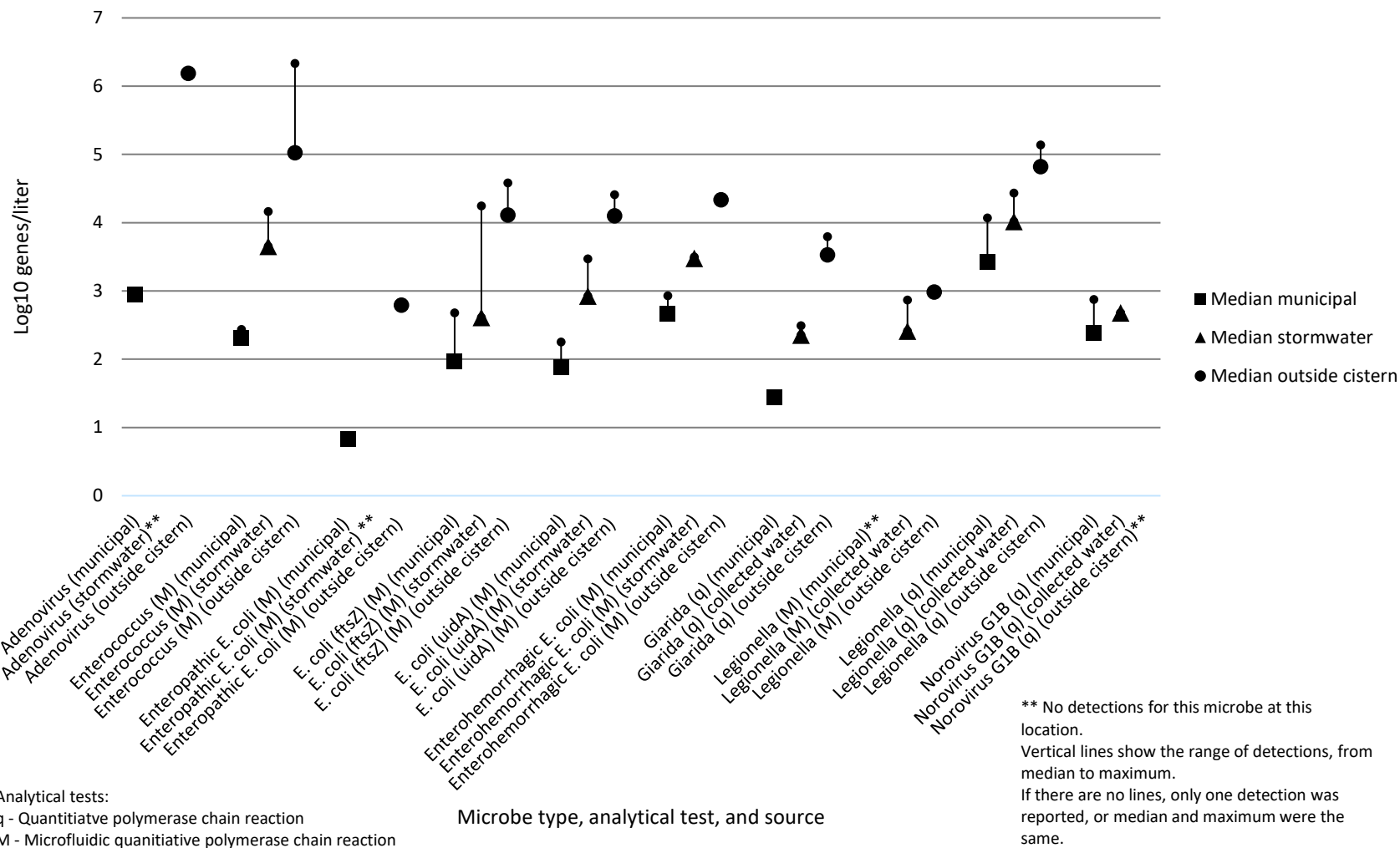
The median concentration for all species detected in the air were less than one genetic copy per liter. The concentrations ranged from less than one genetic copy to more than 18 gc/L for Avian Flu.

For the building toilet flushing system, similar potential human pathogens were found, but at generally lower concentrations than in the city park system. Examples of these pathogens

include bacteria (*Campylobacter*, *Enterococcus*, *Escherichia*, *Legionella*), a protozoan (*Giardia*) and two viruses (*Adenovirus* and *Norovirus*). Again, the species of *Legionella* detected did not include *Legionella pneumophila* serogroup 1.

Median concentrations of detected pathogens in the municipal water flushed toilet, the stormwater flushed toilet, and the outside cistern are shown in Figure 2.

Figure 2. Concentration of microbes in municipal water-flushed toilet and stormwater-flushed toilet and the outside cistern for the building toilet flushing system *



Access Figure 2 chart data in [Supplemental Information \(PDF\)](https://www.health.state.mn.us/communities/environment/risk/docs/guidance/dwec/qmra/chartdata.pdf)
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Risk estimates

MDH estimated the risk of infection from exposure to these pathogens from the two types of systems using up-to-date techniques for quantitative microbial risk assessment (QMRA). Using QMRA estimations, there was a broad range of risk potential calculated for a one-time exposure to reused water. Risk depends on the concentration of the microbes, the strength of the pathogen, and how much water a person is exposed to.

The level of risk that is acceptable often varies by individual. However, some goals have been established. For indoor exposures in the United States, the generally accepted risk level is 1/10,000 infections per year. This is based on the U.S. Environmental Protection Agency's (EPA's) standard for drinking water (Hunter and Fewtrell, 2001). At this level, there will be an estimated one infection for every 10,000 exposed people per year. (Note that an infection will not necessarily result in symptoms.) For voluntary activities (such as swimming), the Water Environment and Research Foundation (WE&RF) uses a rate of 1/100 infections per year (Water Environment and Research Foundation (WE&RF), 2017). This means that about one person of every 100 exposed people will become infected after a year of exposures.

WE&RF assumed that people are exposed to irrigation system water about 50 times per year. For stormwater irrigation, the risk of infection was generally acceptable for a voluntary exposure (less than 1/100 per year) for *Campylobacter* and most *Escherichia* species. The estimated risk of infection after 50 exposures was higher than 1/100 for enterohemorrhagic *E. coli*, *Giardia*, and *Norovirus*. The dose-response models needed to estimate risk for *Enterococcus* or *Clostridium* species are not available.

For toilet flushing, an assumption of three flushes per day was used. For the stormwater supplied toilet, risk of infection was acceptable for indoor exposures (less than 1/10,000 per year) for most *Escherichia* species. However, if the same median concentration and daily exposure is assumed for one full year (365 days), the risk of infection is estimated to be more than 1/10,000 infections per year for enterohemorrhagic *E. coli*, *Giardia*, and *Norovirus*. *Adenovirus* was not detected in stormwater-supplied toilet during the sampling.

The science of microbial risk assessment is relatively new and there many uncertainties in these risk estimates. For example, viability of the microbe and its ability to cause infection, the variability in concentration of microbes over time, and the number of genetic copies that are equivalent to an infectious dose are still topics of research. Likewise, variables associated with sample collection and laboratory analyses, such as potential for contamination, cause further uncertainty. As the science matures in coming years, some of these uncertainties will be likely be reduced.

While more research is needed to better understand the factors contributing to these estimated risks, the level of these risk predictions could be considered unacceptably high by some individuals. More research is needed to further refine these risk estimates, and to explore the risks associated with other water reuse scenarios.

References

Hunter, P. R., & Fewtrell, L. (2001). Acceptable risk (www.who.int/water_sanitation_health/dwq/iwachap10.pdf). Water Quality: Guidelines, Standards and Health. Risk assessment and management for water-related infectious disease. London: IWA Publishing, 207-227. Accessed September 26, 2016.

Water Environment & Research Foundation (WE&RF). (2017). Risk-Based Framework for the Development of Public Health Guidance for Decentralized Non-Potable Water Systems. Retrieved December 1, 2017 from <https://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=SIWM10C15>

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