Development of a Protocol for Risk Assessment of Microorganisms in Separate Stormwater Systems

The purpose of this project was to develop risk assessment guidance to enable more accurate evaluations of stormwater microorganism data and the associated risks to human health from exposure to pathogenic microorganisms (i.e., pathogens) in stormwater.

This research provides insight on the potential human health risk associated with exposure to pathogens in stormwater. Risk associated with these organisms can be quantitatively characterized if data are available to model risk.

The literature review revealed that an insufficient number of epidemiology studies relate human illness to stormwater exposure, and that the data available to parameterize human health risk models are not robust. Specifically, there is a lack of information regarding the two most important inputs to the static risk model: pathogen concentrations and exposed populations. Therefore, the report presents a prioritized, phased approach for acquiring the data necessary to characterize the range of potential human health risks associated with exposure to microorganisms in stormwater.

Managing Exposure

Stormwater regulations require monitoring of indicator microorganisms to identify potentially unsafe conditions and minimize human exposures. National Pollutant Discharge Elimination System (NPDES) permits issued to local public agencies commonly include monitoring of bacterial indicator organisms in receiving waters and stormwater discharges. Public agencies conduct such monitoring to identify impacts on beneficial uses and evaluate effectiveness of best management practices (BMPs) designed to reduce stormwater microorganisms in recreational surface waters.

The presence of indicators in stormwater, usually very high, has been shown to have little relationship with the occurrence of pathogens in recent research. Also, the mix of pathogens present in stormwater (such as *Pseudomonas aeroginosa*, *Shigella*, etc.) are quite different than those historically used to develop and justify indicator guidance. All of these factors have made it difficult to interpret indicator data collected by local public agencies in the context of potential risk to human health. In addition, actual health effects associated with water contact in urban streams have been largely overlooked.

This research provides insight into the potential human health risk associated with exposure to pathogens in stormwater.

Performing Risk Assessment

The proposed plan emphasizes development of methods and sampling schemes to overcome key inconsistencies in collection of microorganisms in stormwater, given that the few available studies of concentrations of microorganisms in stormwater are insufficient for performing a defensible risk assessment.

Phase 1a: Interim Guidance and Management Prioritization

An appropriate first step in the assessment of risk associated with exposure to microorganisms in stormwater is the development of an interim guidance plan that could prioritize management considerations, especially in risk management and resource allocation.

BENEFITS

- Identifies waterborne pathogens that pose the greatest risk to human health and measures their concentrations in stormwater.
- Provides defensible relations between indicator organisms and pathogens of public health concern in stormwater.
- Clarifies environmental fate of pathogens and indicator organisms in stormwater.
- Assesses the effectiveness and costs of stormwater microorganism control technologies.
- Provides a data collection program to assess the associated risk to human health from exposure to pathogenic microorganisms in stormwater.

RELATED PRODUCTS

Evaluation of Microbial Risk Assessment Techniques and Applications (00PUM3)

Microbial Risk Assessment for Reclaimed Water-Development of a User-Friendly Interface (04HHE3)

RELATED ONGOING RESEARCH

Stormwater BMPs Linking BMP Systems Performance to Receiving Water Protection to Improve BMP Selection and Design (SW1R06)

Making Needed Advancements in Wastewater Microbes and Public Health (PATH1R06)

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Such interim guidance could be based on qualitative information and expected levels of exposure. For example, a qualitative approach may facilitate risk management related to recreational water beneficial use impairment. In that case, data from a sanitary survey, relevant water quality data, and specific knowledge about microbiological sources are used along with water quality monitoring and exposure data to derive a relative level of public health concern associated with recreational activities. Thus, management actions could be based on the prioritized level of public health concern.

Phase 1b: Methods Development

The concentration of pathogens in stormwater is a key input to a risk-based model. There are a handful of methods currently used for determining concentrations of pathogens in stormwater, including nucleic-acid based, culture-based, microscopy-based, and hybrid detection techniques. However, few pathogens of public health concern that are likely to be present in stormwater are usually not measurable at levels necessary to make critical management decisions. A static risk model was used to "back calculate" epidemiological significant concentrations of pathogens to determine if methods development/refinement is needed.

It is recommended that research to improve techniques for enumerating pathogens in stormwater is a logical first step, in parallel with the development of the interim risk management guidance discussed above. This research should include new approaches to removing inhibitors that are also present in stormwater and that may interfere with an enumeration assay.

Phase 2: Pilot Monitoring Program and Risk Assessment in a Single Watershed

Once methods are available to characterize concentrations of pathogens of public health concern at critical levels, a screening-level risk assessment could be conducted. It is recommended that a pilot monitoring program be conducted in a single watershed, followed by a risk assessment investigation. This pilot-scale investigation will encompass many of the aspects of a national monitoring program, but will represent a modest investment. The lessons learned will increase the likelihood of gathering useful data in a subsequent full-scale investigation.

Instruments should be deployed to measure both rainfall and volumetric flow rate as functions of time in the stormwater conveyance. Grab samples used to assay microorganisms should also be used to assay chemical and physical indicators of water quality including temperature, salinity, nitrate, ammonium, soluble reactive phosphate, turbidity and total suspended solids. Sediment samples should be analyzed for clay, silt, and sand content, and organic carbon components.

From the onset of the storm until sampling is complete, two days after the end of the rain event, the number of individuals recreating in the receiving water and their activities should be recorded. The activity types and exposure frequencies can be used to: 1) estimate the volume ingested, and 2) determine the population-based risk of illness using the dynamic risk assessment models.

Using the measured concentrations of pathogen during the storm and the recorded exposure frequency, along with an assumed dilution and die-off factor, one can estimate the risk of illness from exposure to a particular pathogen during a storm event for individuals in a receiving water. These data should be used in conjunction with the risk equations.

Phase 3: National Stormwater Monitoring Program and Risk Assessment

The overall goals of a national stormwater monitoring program will be to quantify: 1) the concentration of target infectious/ viable pathogens in stormwater at the "end of the pipe," and 2) the number of individuals exposed to storm water in receiving waters for various types or classes of stormwater.

Once the national stormwater monitoring program is completed, the next goal will be to develop a generalizable risk model. It should relate risk to easily quantifiable watershed characteristics so that specific watershed types may receive high priority for future study and monitoring. Use of data collected during previous phases could help direct management actions, inform the utility of future epidemiology studies, and inform regulatory limits for microorganisms in stormwater.

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