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Microbial Health Risks Associated with Exposure to Stormwater in a Water Plaza

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Climate change scenarios predict an increase of intense rainfall events in summer in Western Europe. Current urban drainage systems cannot cope with such intense precipitation events. Cities are constructing local stormwater storage facilities to prevent pluvial flooding. Combining storage with other functions, such as recreation, may lead to exposure to contaminants. This study assessed the microbial quality of rainwater collected in a water plaza in Rotterdam (The Netherlands) and the health risks associated with recreational exposure. The water plaza collects street run-off, diverges first flush to the sewer system and stores the rest of the run-off in the plaza as open water.

A rain simulation experiment was conducted using drinking water from fire hydrants. The water flowed over the street pavement into the street gutters and into the square. Samples were collected from the first flush diverted water and from two different levels of the water plaza at different points in time. Campylobacter spp., Cryptosporidium, and Legionella pneumophila were the pathogens investigated, using quantitative PCR. Escherichia coli was quantified with culture methods to obtain information on faecal contamination. Microbial source tracking tools (human Bacteroides, avian Helicobacter and canine mitochondrial DNA, all analysed with quantitative PCR) were used to determine the origin (human, animal) of the intestinal pathogens.

To estimate the health risks for children playing in the water plaza after a rain event, a quantitative microbial risk assessment model was built. The volume of water ingested was obtained from literature on similar locations (flooded streets). Published dose-response models were used to calculate the risk per event. Exposure frequency was estimated using weather data (precipitation events).

E. coli concentrations were below the level for excellent bathing water in the EU Bathing Water Directive. Cryptosporidium was not found in any sample. Campylobacter spp. was found in all samples, with higher concentrations in samples that contained human Bacteroides than in samples with contamination from birds and dogs (15 vs 3.7 gc (genomic copies)/100mL). In both cases, the estimated disease risk associated with Campylobacter and recreational exposure to the water plaza were higher than the Dutch national incidence. This indicates that the health risk associated with recreational exposure to the water plaza is significant. L. pneumophila was found only in two out of ten pond samples. Legionnaire's disease risks were lower than the Dutch national incidence. However,higher health risks are expected in the future because of increased frequency of rain events.

Presence of human Bacteroides indicates possible cross-connections with the combined sewer system that should be identified and removed to reduce the gastrointestinal disease risks. Other measures include cleaning/disinfection of the water plaza after extreme precipitation; increasing the capacity of the first flush pump; regular cleaning of the catchment area and gutters; informing the neighbours of the importance of keeping the streets clean of pets depositions; and informing the public about the health risks derived from recreational uses of the water plaza after rain events. Finally, monitoring the water quality during real rain events is recommended to better characterize the health risks.