Geophysical Research Abstracts
Vol. 15, EGU2013-10822, 2013
EGU General Assembly 2013

The use of geoinformatic data and spatial analysis to predict faecal pollution during extreme precipitation events

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The Water Framework Directive (WFD) regulates surface water quality standards in the European Union (EU). The Directive call for the identification and management of point and diffuse sources of pollution and requires the establishment of a 'programme of measures' for identified river basin districts, in order to achieve a "good status" by 2015. The hygienic quality of water is normally monitored using faecal indicator organisms (FIO), such as Escherichia coli, which indicate a potential risk to public health from human waterborne pathogens. Environmental factors influence the transmission of these pathogens and indicator organisms, and statistically significant relationships have been found between rainfall and outbreaks of waterborne disease. Climate change has been predicted to lead to an increase in severe weather events in many parts of Europe, including an increase in the frequency of extreme rainfall events. This in turn is likely to lead to an increase in incidents of human waterborne disease in Europe, unless measures are taken to predict and mitigate for such events.

This study investigates a variety of environmental factors that influence the concentration of FIO in surface waters receiving faecal contamination from a variety of sources. Levels of FIO, including Escherichia coli, intestinal enterococci, somatic coliphage and GB124 (a human-specific microbial source tracking marker), were monitored in the Sussex Ouse catchment in Southeast England over a period of 26 months. These data were combined with geoinformatic environmental data within a GIS to map faecal contamination within the river. Previously, precipitation and soil erosion have been identified as major factors that can influence the concentration of these faecal markers, and studies have shown that slope, soil type and vegetation influence both the mechanisms and the rate by which erosion occurs in river catchments.

Of the environmental variables studied, extreme precipitation was found to be a major factor contributing to increased levels of FIO. This study identifies areas within the catchment that are likely to demonstrate elevated erosion rates during extreme precipitation events, which are likely to result in raised levels of FIO. The results also demonstrate that increases in the human faecal marker were associated with the discharge points of wastewater treatment works, and that levels of the marker increased whenever the works discharged untreated wastewaters during extreme precipitation. Spatial analysis also highlighted locations where human faecal pollution was present in areas away from wastewater treatment plants, highlighting the potential significance of inputs from septic tanks and other un-sewered domestic wastewater systems.

Increases in the frequency of extreme precipitation events in many parts of Europe are likely to result in increased levels of water pollution from both point- and diffuse-sources, increasing the input of pathogens into surface waters, and elevating the health risks to downstream consumers of abstracted drinking water. This study suggests an approach that integrates water microbiology and geoinformatic data to support a 'prediction and prevention' approach, in place of the traditional focus on water quality monitoring. This work may therefore make a significant contribution to future European water resource management and health protection.