Project title: **Hydrological Extremes in Urban Environments: impacts on River Water Quality**	
Host institution: **University of Birmingham**	
Key words: **urban hydrology, flood, drought, water quality**	
Supervisory team: **Anne F. Van Loon (a.f.vanloon@bham.ac.uk), Jon Sadler, Chris Bradley, David M. Hannah**	

Opportunity summary

The School of Geography, Earth and Environmental Sciences at the University of Birmingham offers a 3-year funded PhD scholarship on the scientific and applied hot-topic of ***Urban Hydrology***. This exciting PhD project is funded by the UK Engineering and Physical Sciences Research Council (http://www.epsrc.ac.uk/).

The aim of the project is to ***investigate how cities alter runoff regimes and hydrological extreme events (floods and droughts) and how these changes impact on urban river stream water quality***. From a hydrology perspective, we are most interested in changes in baseflow and extreme events in urban environments due to increases in impermeable surfaces. In terms of water quality, the important variables to take into account are water temperature and organic matter.

Rationale

Urbanisation is taking place at a rapid pace all around the world. Urban environments significantly alter the landscape, which influences processes related to the hydrological cycle and water quality (Figure 1).

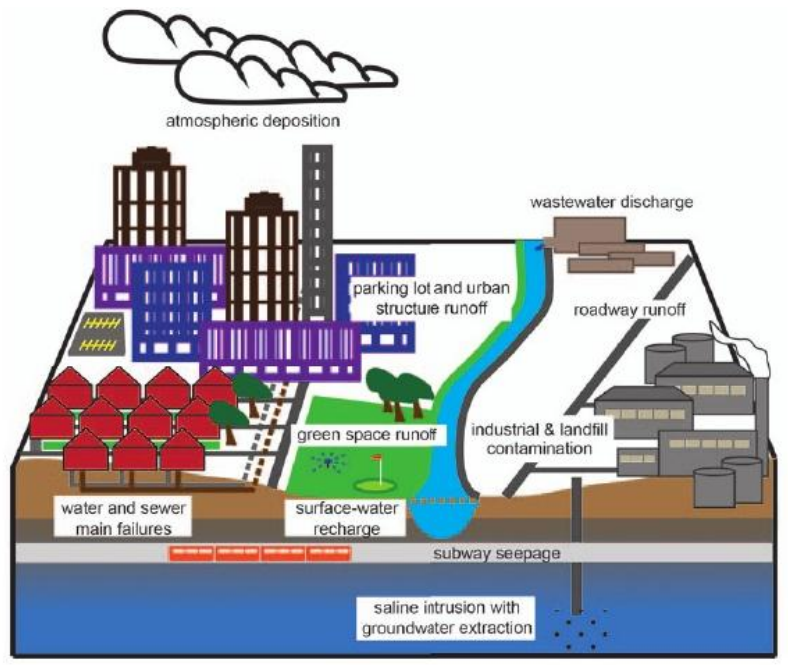

Figure 1: Conceptual diagram of the aspects of the urban hydrological cycle that affect water quality (Wong et al. 2012)

The high percentage of impermeable or low-permeable surfaces in cities influences evapotranspiration, infiltration, and surface runoff, which consequently changes the streamflow regime. Figure 2 shows that in most urban streams flow peaks increase and baseflow decreases.

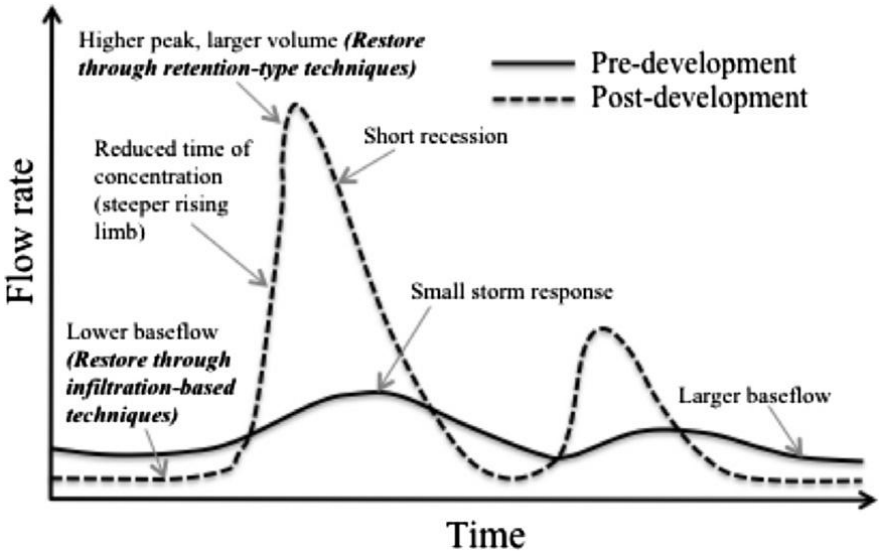

Figure 2: Schematic illustration of the pertinent impacts of urbanisation on hydrology at the catchment scale (Fletcher et al. 2013).

This increase in extreme hydrological events in the urban environment is hypothesised to impact significantly on water quality, with consequent influences on aquatic ecology. For example, during low flow events water temperatures and concentration of certain dissolved and suspended materials will increase and during peak flow events chemicals stored in the catchment may be flushed into urban water courses (Figure 3). A very important aspect are combined sewer overflows that can result in huge decreases in urban stream water quality during a high intensity rainfall event.

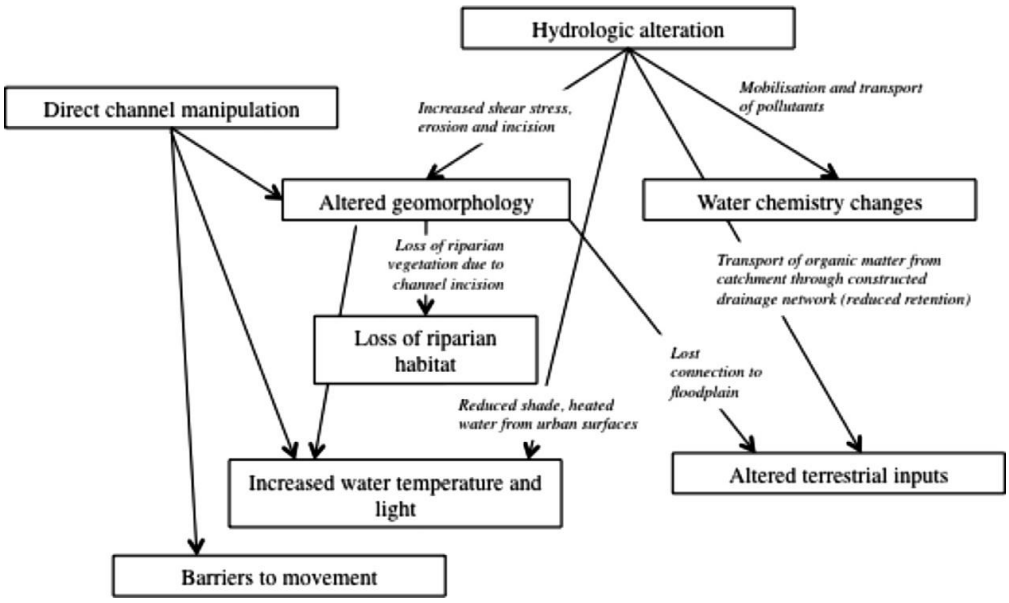

Figure 3: Illustration of some of the principal mechanisms by which urbanisation degrades aquatic ecosystems (the principal 'symptoms' of urbanisation). The role of hydrology as a 'master variable' is illustrated with examples (in italics) given to show the relationship between symptoms (e.g. total runoff volume, peak flows, baseflows, lag time) (Fletcher et al. 2013).

Currently, the relationship between hydrological extremes and water quality in urban environments is only studied for single events, although for water quality it makes a big difference whether a discharge peak occurs after a long dry period or after an earlier high flow event. The sequence of hydrometeorological events influences accumulation and release of material and also shapes the path ways for the water and dissolved and suspended material.

These hypothesised relations still need to be tested in real-world cases. To quantify the effects of the sequence of extreme hydrological events on water quality, an interdisciplinary approach is needed that explores the link between climate, hydrology, urban landscape and river water quality, both at a high temporal resolution and spatially distributed. This PhD project will answer the following research question: "what are the processes connecting hydrological extremes and water quality in urban environments?"

Methodology

In this project, we focus on UK rivers, in particular those in Birmingham. Birmingham is chosen because the city is forms the headwater of a number of streams, which offers a unique opportunity to study the hydrology and water quality of a purely urban catchment. At a later stage the results for Birmingham will be compared with other UK cities that are located more downstream in a catchment and therefore are expected to show difference water quality responses to hydrological extremes.

The work consists of data collection (partly secondary data from existing databases and partly primary data from field work), data analysis, and modelling. The following research steps are expected:

- perform a literature review on hydrological extremes in cities and their effects on water quality;
- collect data for streams in the city of Birmingham on climate variables (i.e. precipitation, temperature, evapotranspiration), hydrology (i.e. stream discharge, groundwater levels), water quality (especially water temperature and organic matter), and thematic information (e.g. GIS maps of land cover) from different sources, most of this data is already available at the University of Birmingham;
- supplement existing archived data with additional field work, especially on expanding the spatial coverage of the monitoring sites;
- undertake data analysis and modelling to quantify links and study process interactions;
- compare the results for Birmingham with other UK cities located more downstream in a catchment to discover relative importance of different process sets in different geographical contexts.

Training and skills:

The University of Birmingham offers extensive training to PhD students, which ranges from in-depth understanding of the topic(s) to technical skills in field work, data analysis and modelling.

In this project, the student will especially develop skills in interdisciplinary research. (S)he will be expected to become proficient in urban hydrology, which is a very timely and growing research field. The project will provide an excellent opportunity to work with different types of data, and learn

about the relation between climate, hydrology, and water quality, key skills which will be beneficial in a future career. In this project, the student will interact and collaborate within a network of scientists and will have the opportunity to present his/her research at conferences.

The supervisory team of this project is: Anne Van Loon, David Hannah, Chris Bradley, and Jon Sadler of the University of Birmingham. This team has wide experience in the topics of this project, i.e. hydrological extremes (Anne Van Loon), hydroclimatology and water temperature (David Hannah), urban hydrology (Chris Bradley), and urban landscapes and water quality (Jon Sadler).

Student requirements:

For this project we are looking for a student with a BSc or MSc in Physical Geography, Environmental Science, Hydrology, Engineering, or a similar field. (S)he should have excellent technical skills to be able to do data-analysis (preferably in R or another programming language), hydrological modelling, and GIS analysis. For the EPSRC scholarship for this project only UK students can apply.

Start date:

28 September 2015

Application deadline:

15 June 2015

For more information, please contact dr. Anne F. Van Loon (a.f.vanloon@bham.ac.uk).

Further reading:

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