Environmental Science and Pollution Research

Special Issue: Developments in water management technologies and systems

Susanne Charlesworth s.charlesworth@coventry.ac.uk Centre for Agroecology, Water and Resilience, Coventry University, Ryton Gardens, Wolston Lane, Coventry, CV8 3LG, UK. (See Lavers and Charlesworth this volume)

Kemi Adeyeye k.adeyeye@bath.ac.uk Centre for Advanced Studies in Architecture, University of Bath, Claverton Down, Bath BA2 7AY, UK. (See Miereles et al. and Ip et al. this volume)

This Special Issue of Environmental Science and Pollution Research highlights selected papers presented at the Fourth Annual Water Efficiency Conference (7-9 September 2016, Coventry University, UK) which focused on developments in water management technologies and systems applied to water efficiency. This included approaches at all scales, from individual buildings to efficiency in water use and management through the whole water cycle, and involves research from across disciplines from the social to the physical sciences, representing a truly multi-, trans- and cross disciplinary area of study.

Originally set up in 2011, then funded by Defra, the Water Efficiency Network provides a forum to collaboratively explore the supply, treatment, distribution, risk monitoring, improved efficiency, management and conservation of water. It also investigates challenges in improving the adaptive capacity of building users, providers and professionals and consequently facilitate long-term, adaptable water efficiency through behaviour change and the use of technology. Its' brief includes the harvesting of rainwater, reuse of greywater and the sustainable, efficient management of stormwater. Papers in this Special Issue therefore reflect the efficient management of water at all scales, applied to many contemporary issues of concern and involve the inclusion of users and communities in participatory research.

As is clearly stated by Miereles et al., in order to improve the sustainability of water consumption, the concept of water efficiency has become increasingly important. When introducing new technologies and new ways of doing things, they need to be flexible in use and multiple benefit; in this way they can provide added resilience to the system, improving sustainability and effectiveness. However, if the end-user does not engage with them or understand how they should be used, or is simply not interested, then it is unlikely that they will be taken up to eventually become the normal way of doing things. Miereles et al., examined a specific approach in the University of Aveiro, Portugal in which they trialled four different types of aerators in toilet washbasin taps which provided various discharge reductions. They found that user factors controlled how much water could be saved based on a comparison of water saved versus reduction in discharge of water from the tap, dependent on user comfort and water efficiency, resulting in less water savings in comparison with discharge reductions.

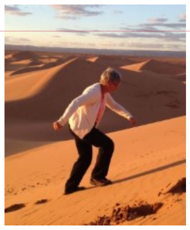
Reducing the amount of potable water use can also be achieved by utilising alternative water sources, and whilst approaches such as rainwater harvesting (RWH) and greywater reuse (GWR) have become increasingly used in the commercial sector, they have yet to achieve such a level of popularity at the individual household level. Sousa et al. investigated pay back periods and non-potable water savings in shopping centres in both Portugal and Brazil. Whilst technically the design and installation of RWH in such commercial situations is relatively straightforward, with calculations available to determine tank volumes, it was found that the main factors driving the payback period were investment costs and water fees which were country specific. Oviedo-Ocana et la., on the other hand, surveyed 35 high water using households in Columbia assessing the potential for RWH and GWR designed by the occupants themselves. The selected design afforded savings in drinking water use of 44% and a return on investment of 6.5% with the payback estimated at 23 years. This is in comparison with the findings of Sousa et al., whose savings varied between 60% in Portugal, paying back in 19 years, whereas in Brazil the savings were between 20 and 50% but with a pay back of only 2 years as investment costs were lower, and water fees higher. The challenges around large scale implementation of RWH schemes which are efficient and multiple purpose were examined by Behzadian et al., by modelling the installation of a "smart" system which was proactive in controlling water level in the storage tank such that sufficient capacity was always available in order to contain rainfall from subsequent storms. The outcome of this modelling exercise found that the harvested rainfall could not only be used for non-potable uses at the household level, but by providing volume to store stormwater, local flooding could be reduced as excess would be released slowly to the storm water sewer system. RWH and GWR therefore have the potential to reduce potable water use, but a third type of water is generally wasted and that is stormwater which is currently directed into the storm sewer system (SSS) and thence to the Waste Water Treatment Plant (WWTP). If it could be harvested, it would reduce the volume of water in the SSS and reduce flooding, and also reduce the expense of treating it at the WWTP. It could be used for non-potable activities, but there may be risks associated with this. Lundy et al. assessed these risks using a source-pathway-receptor model for the common bacterial pollutant in stormwater, *E. coli*. Their findings indicated low to medium risk for most uses apart from car washing and the irrigation of raw edible food crops indicating the potential for stormwater collection, but also the need for some form of treatment under certain scenarios.

Much of the research presented so far focused directly on water use and consumption, reducing potable water use. Other researchers took a wider approach, for example, Ip et al examined the efficient use of waste heat generated by several showers installed in a Sports Centre at the University of Brighton, UK. They found that heat recovery from these 8 showers had a seasonal thermal effectiveness of more than 50% by recycling the heat to preheat incoming cold water. In terms of carbon pay back, accounting for the extra green house gas emissions from the waste water heat exchangers, this was estimated to be achievable in less than 2 years. For life cycle costs, it was recommended by Ip et al. that this approach would benefit from heat recovery from fewer units to improve financial viability.

In order that the maximum benefits are gained from the use of water efficient technologies, they should have multiple roles in whatever system they are designed into. Two of the papers sought to improve the efficiency of drainage devices at the microbial level, and also provide benefits beyond just drainage. Firstly, using small-scale models, Coupe et al. modified a sustainable drainage system (SuDS) device, an infiltration or pervious paving system (PPS) and applied it to a landfill site where it would not only provide enhanced drainage capability and a vent for ground gases, but would also include an active microbial layer where methane would be oxidised and essentially removed. Methane is a greenhouse gas, and can pollute groundwaters, thus this approach would make use of a water efficient drainage device to reduce contamination in the environment. The second project by Theophilus et al., focused on a different type of drainage device, this time in the roadside environment, the filter drain, which runs alongside motorways and main roads in the UK. These are essentially aggregate-filled ditches which collect road runoff, slowly conveying it to the receiving watercourse. Their purpose is to protect the asset by conducting water away from the road structure and prevent the road flooding, thus protecting the road user. However, as explained by Theophilus et al., this water is contaminated by traffic-associated pollutants such as hydrocarbons and large amounts of total dissolved solids. Whilst percolating through the aggregate in the filter drain, a certain amount of treatment is afforded by the process of biodegradation due to the development of a biofilm on the aggregate particles, in a similar way to the development of a microbial layer in Coupe et al.'s study. Biodegradation is a slow process, dependent on the type of contamination, but also the availability of nutrients. The authors suggest that the addition of a slow-release fertiliser (in this case struvite) could enhance the biodegradation process in the filter drains. In laboratory-based experiments, oil and street dust contaminants were added to filter drain models which were then monitored for a variety of properties in the effluent water including bacterial and fungal growth, heavy metals, pH etc. It was found that biodegradation rates were improved by the addition of the fertiliser which was recommended for use in other drainage devices.

Coupe et al. and Theophilus et al. utilised small-scale models to replicate the environment in which they were able to test efficiencies at the microbial scale. At the other end of the scale, Lavers and Charlesworth's study of Natural Flood Management (NFM) was applied at the catchment scale, or Catchment Based Approach, in this case the rural Warwickshire Avon. By Working with Natural Processes (WwNP), engaging with local communities, farmers and landowners and careful design, the installation of NFM measures to slow the flow have the potential to provide flood resilience to downstream communities, as well as reduce pollution due to excess nutrients reaching local streams. Lavers and Charlesworth explain the methodology used to identify locations for these structures high up in the catchment including debris dams, off-line ponds and wet forests. They discuss the benefits of this approach as well as its limitations, the key lessons learnt during the study, and the potential application of this approach across different landscapes and land uses.

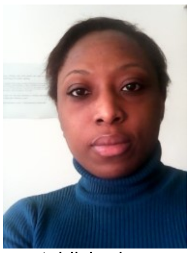
Professor Susanne Charlesworth: Professor of Urban Physical Geography at Coventry University in the Centre for Agroecology, Water and Resilience.



Commented [KA1]: Nice pic!

Sue's research revolves around Urban Physical Processes, beginning with urban hydrology and sedimentology, the contamination of urban lake and river sediments and the risk to children's health of contaminants in playground material. This led to an interest in Sustainable Drainage Systems (SuDS), more particularly the efficiency of porous paving in degrading oil and dealing with metal pollutants. The role of Green Infrastructure and Ecosystem Services provision led to Natural Flood Resilience Measures. Latterly, Sue has become particularly interested in the design and installation of SuDS and NFRM alongside WASH in informal settlements, favelas and refugee camps. She is the author of more than 80 peer reviewed journal articles on urban pollution and SuDS, many book chapters, and has co-edited books on aquatic sedimentology, water resources, urban pollution and SuDS. She collaborates with groups internationally and has given papers at international conferences worldwide.

Dr Kemi Adeyeye: Associate Professor in Integrated Design, University of Bath



Kemi is Associate Professor/ Senior Lecturer in Integrated Design in the Department of Architecture and Civil Engineering. She also co-leads the Water Awareness and Human Behaviour theme at the university's Water Innovation Research Centre. She was a recipient of the prestigious EPSRC Policy Fellowships in Defra in 2010, when she was funded to establish the Water Efficiency Network: www.watefnetwork.co.uk. Her research focuses on integrated design solutions for resource efficiency and resilience i.e.: People, Process, Product and Policy paying particular attention to the socio-cultural factors that influence adoptive and adaptive capacity before during and after spatial, physical, environmental and technical interventions. For this work, she has established research collaborative links with a network of policy makers and regulators, local community and user groups, construction companies, product manufacturers and other research-led organisations and academic institutions around the world.