PREFACE: Water footprint

HE Jacobs[1] and AA Ilemobade[2] (Guest editors)
[1]*Department of Civil Engineering, Stellenbosch University, Private Bag X1, Matieland, 7602, South Africa*
[2]*School of Civil and Environmental Engineering, University of the Witwatersrand, Private Bag 3, WITS, 2050, South Africa*

INTRODUCTION

This special edition of *Water SA* presents a selection of papers presented at the 12th Water Institute of Southern Africa (WISA) conference held in Cape Town, South Africa, from 6 to 10 May 2012. The WISA 2012 conference theme was 'Water footprint'. Table 1 was adapted from Jacobs (2009) and provides an overview of all the WISA biennial conferences held up until WISA 2012. It is obvious from Table 1 that successive WISA conferences have attracted more delegates and showcased more paper presentations. It is from the diverse papers presented at WISA 2012 that this Special Edition ensues.

TABLE 1
WISA Conference history

Number	Year	Location	Number of	
			Papers presented[A]	Delegates attended[B]
N/a[C]	1985	Durban	41	N/a
N/a[C]	1987	Port Elizabeth	51	N/a
1[D]	1989	Cape Town	31	N/a
2	1991	Kempton Park	50	N/a
3	1993	Durban	75	N/a
4	1996	Port Elizabeth	95	N/a
5	1998	Cape Town	191	N/a
6	2000	Sun City	180	N/a
7	2002	Durban	195	575
8	2004	Cape Town	218	917
9	2006	Durban	200	1 060
10	2008	Sun City	200	1 249
11	2010	Durban	275	1 271
12	2012	Cape Town	322	1 625

Notes:
A. Includes full papers required by WISA for poster presentations; for WISA 2010, this included workshops.
B. This number represents delegates who attended the conference (i.e. arrived on site); in reality, more delegates were registered.
C. These two events were included in the eWISA/WISA database, but are not reported as 'WISA Conferences' in the literature.
D. This was specifically identified as the 'First WISA Conference' in the literature.

Paper selection

The WISA 2012 organising committee required full paper submission for all accepted abstracts, for both oral and poster presentations. The procedure employed in selecting the papers for peer review and possible publication in this WISA 2012 Special Edition is briefly described as follows:

- Step 1 – Selection: Authors had the opportunity to check a tick box during abstract submission to indicate whether their papers should be included in the pool for potential peer review or not.
- Step 2 – Screening of papers: the WISA 2012 technical committee screened the papers (not the presentations) proposed by authors to identify those that were considered suitable for full peer review.
- Step 3 – Filtering of papers: The papers identified for peer review were revisited and filtered by the WISA 2012 technical committee to ensure that (i) the total number of selected papers did not exceed Water SA's requirements of 20 papers for the Special Edition and (ii) the work had not been submitted for possible publication elsewhere.
- Step 4 – Fair representation: the technical committee made a decision prior to selection to ensure fair representation of the different themes at the WISA 2012 conference in the selection process. In order to achieve this goal, it was necessary after Step 3 to reduce the number of papers selected in some themes. Each of the authors was contacted to confirm that the work presented in the papers was, in the opinion of the authors, suitable for peer-review and had not been submitted elsewhere. From the steps undertaken above, 25 papers were identified. From these, 8 had already been published elsewhere, or the authors were no longer interested in pursuing peer review.
- Step 5 – Final selection: A final list of 17 papers was identified for peer review, of which 13 were ultimately included in this Special Edition.

Layout of papers in this special edition

Articles in this edition were laid out based on the following themes:

- Water footprint: an indicator of freshwater use that incorporates direct and indirect water use (Hoekstra, 2003).
- Sustainability: Holistically addressing present and future water needs from multiple perspectives (namely, environmental, social and economic) to achieve maximum benefit to people and environment.
- Basic service provision: Communities demand (clean) water and sanitation services as a matter of first priority for consumption and ablution.
- Acid mine drainage: In addition to meeting basic needs, water is also required for larger industrial operations such as mining. Some of these operations produce polluted water effluents such as acid mine drainage.
- Water and wastewater quality, treatment and management: Inadequately treated water and wastewater can present dire consequences to community health if quality, treatment and management are not adequately addressed.
- Financial sustainability: Water needs to be managed properly to ensure that a sufficient quantity can be provided at

[1] ☎ +27 21 808 4059; e-mail: hejacobs@sun.ac.za
[2] ☎ +27 11 717 7153; e-mail: Adesola.Ilemobade@wits.ac.za

Available on website http://www.wrc.org.za
ISSN 0378-4738 (Print) = Water SA Vol. 39 No 3 WISA 2012 Special Edition 2013
ISSN 1816-7950 (On-line) = Water SA Vol. 39 No 3 WISA 2012 Special Edition 2013

an acceptable quality to communities who need it. Hence, financial sustainability is crucial to ensure delivery of water at the required levels of service.

The papers in this WISA 2012 Special Edition address various aspects of water, from extraction, treatment, storage, and reticulation via various routes to end in a polluted state, ready to be treated and reused again. The conference theme is therefore considered to be a convenient starting point for appreciating the articles presented in this Special Edition.

WATER FOOTPRINT

In view of the WISA 2012 theme, a brief review of 'water footprint' is presented herein, particularly since no papers on the particular topic were presented at the conference per se. The water footprint concept, introduced by Hoekstra (2003), is 'an indicator of freshwater use that incorporates direct and indirect water use'. The water footprint can also be regarded as 'a comprehensive indicator of freshwater resources appropriation' and 'is a multi-dimensional indicator, showing water consumption volumes by source and polluted volumes by type of pollution' (Hoekstra et al., 2009: 8). From the water footprint perspective, therefore, the understanding of 'freshwater use' differs from the classical measure of 'freshwater withdrawal' in the following ways (Hoekstra et al., 2009: 8):

- Freshwater use includes the use of blue water, green water and grey water.
- Freshwater use includes direct water use and indirect water use.
- Freshwater use does not include blue water use in so far as this water is returned to where it came from.

According to Hoekstra et al. (2009), a water footprint may be categorised into blue water, green water and grey water footprints. The blue water footprint refers to the consumption of blue water resources (surface and ground water) along the supply chain of a product. The green water footprint refers to consumption of green water resources (rainwater stored in the soil as soil moisture). The grey water footprint refers to pollution and is defined as the volume of freshwater that is required to assimilate the load of pollutants based on existing ambient water quality standards. From the brief discussion above, it is clear that the water footprint addresses the beneficial use of the different water qualities emanating from freshwater resources. It is however of note that blue water, green water and grey water mean different things in Southern Africa and this is discussed below.

The colour of water

Since the introduction of the so-called 'Blue Drop' and 'Green Drop' programmes in 2005, South Africans have grown accustomed to the concepts of 'blue' and 'green' water, meaning potable water and wastewater respectively (South African legislation views wastewater as a component of water use). Since 2005, the Regulatory Performance Management System (RPMS) of the South African Department of Water Affairs (DWA), has successfully employed the Blue Drop to ensure that the South African water sector has intensified its focus on the manner in which tap water quality is being managed (DWA, 2009). In a similar fashion, the Green Drop regulation programme has sought to identify and develop the core competencies required for the sector, which, if strengthened, will gradually and sustainably improve the level of wastewater management in South Africa (DWA, 2011). These forms of incentive- and risk-based regulation hold the intent to synergise with the current goodwill (exhibited by municipalities and existing South African government support programmes) to give the focus, commitment and planning needed to ensure effective and efficient delivery of sustainable water services (DWA, 2011). At WISA 2012, special workshops were held to address Blue Drop and Green Drop accreditation issues and a gala was held to acclaim service providers who achieved Blue and/or Green Drop certification.

Therefore, in relation to papers presented in this WISA 2012 Special Edition, the following are the definitions for the different colours of water:

- Blue water – potable (drinking) water.
- Green water – this refers to all wastewater streams proceeding from domestic and non-domestic water users and conveyed to a wastewater treatment works.
- Greywater – according to Ilemobade et al. (2013), greywater refers to wastewater from showers, baths, hand wash basins, laundry and kitchens but excludes toilet wastewater. Greywater is categorised into light and dark greywater, with light greywater of better quality because it excludes kitchen effluent.
- Black water – a combination of greywater and toilet wastewater.

SUSTAINABILITY

In terms of the sustainability of a water footprint, Hoekstra et al. (2009) note three perspectives that the footprint addresses, namely, environmental, social and economic. Papers in this edition address these three perspectives. In particular, Carden and Armitage (2013) and Ilemobade et al. (2013), address more than one perspective in their papers:

Carden and Armitage (2013) describe a systems approach to create an understanding of, and measure the potential for, sustainability in a South African urban water context. This was achieved through the development and evaluation of a novel composite index – the Sustainability Index for Integrated Urban Water Management (SIUWM). Key performance indicator results from the RPMS, Green Drop System (GDS) and Blue Drop System (BDS) were used as partial input into the SIUWM.

Interest in water reuse, and in particular greywater reuse, is increasing all over the world and particularly in South Africa, because of its potential to supplement scarce freshwater resources in the face of increased demand and aridity. Ilemobade et al. (2013) noted the importance of implementing reuse sustainably after researching the perceptions of beneficiaries before and after greywater reuse and calculating the economics of the greywater reuse implemented during the study. As part of the study, the attributes of greywater that were important to beneficiaries when reusing greywater were determined and the willingness to pay for these attributes was assessed.

BASIC SERVICE PROVISION

Water and sanitation services are required to address basic human needs and are a means to upgrading informal settlements. The provision of communal water and sanitation facilities is a mandate of the South African Government to communities and typically the first infrastructure implemented within communities. Crous et al. (2013) investigated the water demand characteristics of community ablution blocks, provided a detailed methodology for collecting the data and obtained the 15-minute peak and average water demand for a case study site. The peak and average water demands are a requirement for the hydraulic design and modelling of water networks serving users, e.g., communal ablution facilities.

ACID MINE DRAINAGE

In addition to providing basic water services to communities, products (e.g. processed natural resources) are needed (or desired) to sustain society and promote economic development. To this end, industries and mines contribute notably to the water footprint of most countries, and particularly, South Africa. One of the key issues from large-scale industrial operations is the pollution of water. Acid mine drainage (AMD) is liquid drainage from existing or historic mining operations which is typically characterised by low pH, very high sulphate content and high concentrations of heavy metals. Subsurface-flow constructed wetlands (CW) with charcoal- or slag-based bed matrices were investigated by Sheridan et al. (2013) for their potential use in remediating AMD. Their results showed that the systems removed almost all soluble iron, and most of the sulphate, and were able to increase the pH of the AMD.

WATER AND WASTEWATER QUALITY, TREATMENT AND MANAGEMENT

Water and wastewater treatment

Chlorine on its own is adequate for many potable water pre-oxidation and disinfection systems at water treatment plants where the application is straightforward. Similarly, most wastewater can be disinfected by chlorine in one of its commercially available forms. However, when more intense pre-oxidation is required or significant iron or manganese is present in a potable supply, the use of alternative disinfectants is often preferable. Similarly, when secondary problems are present in wastewater effluent, such as high ammonia, a stronger oxidant may be preferable (Bekink and Nozaic, 2013). Bekink and Nozaic (2013) assessed a commercial product which is dissolved in water in tablet or granular form and generates chlorine dioxide on solution in water. The solution can be used for disinfection or pre-oxidation purposes. The chemical was assessed in a series of tests and the performance of the chlorine dioxide product was compared to sodium hypochlorite for different water types.

Natural organic matter (NOM) is present in water resources. NOM can be removed by different methods, including activated carbon adsorption. Due to the variability of NOM in natural waters, both in terms of its nature and its concentration, a study was undertaken by Lobanga et al. (2013) to investigate NOM removal for a wide range of South African surface waters, sampled at different periods, by the use of granular activated carbon (GAC). Comparison between the UV absorbance and dissolved organic carbon (DOC) data suggested that, for some waters, UV_{254} absorbance can be used as a rapid substitute for DOC. Also, the high GAC dosage rates required for the target criterion in this research revealed that the process is inadequate to use in the initial stage of treatment of raw water. It was concluded that GAC adsorption should be used in the later stages of drinking water treatment.

Surface water and potable water microbiology

Jordaan and Bezuidenhout (2013) and Leat and Grundlingh (2013) investigated surface water and potable water microbiology, respectively:

Jordaan and Bezuidenhout (2013) identified bacterial community structures in the Vaal River using polymerase chain reaction denaturing gradient gel electrophoresis (PCR-DGGE) and high-throughput sequencing, and then investigated the impact of physico-chemical characteristics on the identified bacterial structures through multivariate analysis. Their study therefore provides an overview of the dominant bacterial groups in the Upper Vaal River and the impact of environmental changes on bacterial diversity.

Leat and Grundlingh (2013) report on the optimisation and validation of the first polymerase chain reaction (PCR) assay to be implemented at a Rand Water facility. The polymerase chain reaction (PCR) assay rapidly (within 24 hours of samples receipt) identifies the ctxA gene of toxigenic *Vibrio cholerae* strains, a waterborne pathogen.

Wastewater characterisation

Wastewater is conveyed via a sewer system to a wastewater treatment plant (WWTP), before it is released into the environment. Wastewater characteristics depend on the sources within the catchment served by a particular WWTP, and the presence of industrial effluents can cause the wastewater to be significantly different from purely domestic wastewater. eThekwini Municipality's wastewater treatment system is one of the most affected by industrial effluents in South Africa. Where industrial pollutants cause particular problems, additional measurements, beyond the standards applied in sewage treatment, are required. Mhlanga et al. (2013) present and compare results obtained from the characterisation of wastewater from three municipal WWTPs operated by eThekwini Water Services, which receive a combination of domestic and industrial wastewater. Although wastewater characterisation involves determining the volumes and concentrations of carbonaceous, nitrogenous and phosphorus fractions, and other constituents, the study focused on the carbonaceous fraction in the wastewater.

Water quality management

In South Africa, the management and monitoring of drinking water quality is governed by policies and regulations based on international standards. The DWA uses information systems such as the Blue Drop and Green Drop for monitoring purposes. Water service providers are required to submit information regarding water quality and the management thereof at regular intervals. A concern has been that rural municipalities in South Africa are failing to report the required information and are not complying with some of the regulator's requirements that speak to the overall management of water quality monitoring. Rivett et al. (2013) conducted research in four South African rural municipalities, where a cellphone-based information system was implemented to collect water quality information relevant to each municipality. The decentralisation of national water quality monitoring to municipal level was assessed in this research, concluding that it had limited usefulness in the rural municipalities partaking in the research.

FINANCIAL SUSTAINABILITY

The third of the Hoekstra et al. (2009) sustainability perspectives (i.e. economic), is important in order to physically deliver (construct) and sustain (operate and maintain) water services. Money is a key issue in Southern African water service delivery – in terms of providing and discharging the required water quantity at an acceptable quality. The papers authored by Wegelin and Jacobs (2013), Hoffman and Du Plessis (2013) and Fisher-Jeffes and Armitage (2013) address different aspects of economic sustainability.

Obtaining sufficient funds for infrastructure projects is one of the limitations to effective service delivery. In this light, water conservation (WC) and water demand management (WDM) have gained increasing focus in Southern Africa. Unfortunately, many financial institutions struggle to fund WC/WDM projects partly due to poorly structured funding applications and business plans. Wegelin and Jacobs (2013) present a pragmatic approach to the development of a WC/WDM strategy and business plan, thus empowering municipalities to plan effectively and subsequently obtain funding for viable WC/WDM projects.

Cost recovery of water services is fundamental to financial sustainability. Correctly designed water tariff structures are required for this purpose. Increasing block tariffs are known to be very suitable cost recovery instruments, but these tariffs are often poorly understood. Hoffman and Du Plessis (2013) describe a model that is able to calculate the predicted change in water use and the associated income resulting from a tariff change. The model takes into account variation in price elasticity per water tariff block and is aimed at application in relatively small municipalities, where limited resources do not allow room for advanced commercial products.

In the past, cost recovery and charging for water services used to refer exclusively to potable water consumption, or direct potable water sales. As at the time of publishing of this Special Edition, charging consumers for sewer services, often a percentage of potable water consumption, is the norm in Southern Africa. Stormwater management, however, is generally funded through municipal rates and consumers are not billed directly for stormwater services. Competition with other pressing needs frequently results in the stormwater departments being significantly under-funded. An increasing number of cities worldwide are introducing a direct charge for stormwater management in order to secure the funding required to manage stormwater and its pollution of downstream waters. Such a charge also serves as a disincentive to polluting practices on the part of landowners. Fisher-Jeffes and Armitage (2013) recommend that municipalities may have to consider charging for stormwater in order to ensure adequate future funding for stormwater management. Such a stormwater charge may be based on an Equivalent Residential Unit (ERU) or Residential Equivalent Factor (REF), combined with an appropriate discount scheme for on-site stormwater management. Preliminary indicative rates were calculated for municipalities across South Africa using the Damage Avoidance Cost (DAC) approach.

ACKNOWLEDGEMENTS

We acknowledge and thank all authors and reviewers who contributed towards this WISA 2012 *Water SA* Special Edition, the WISA 2012 Technical Committee, the WISA 2012 Local Organising Committee, and Natalie Kensley, Sarah McChlery, Tanya Price and the team at The Conference Company responsible for WISA 2012.

REFERENCES

BEKINK MJ and NOZAIC DJ (2013) Assessment of a chlorine dioxide proprietary product for water and wastewater disinfection. *Water SA* **39** (3) 375-378.

CARDEN K and ARMITAGE NP (2013) Assessing urban water sustainability in South Africa – not just performance measurement. *Water SA* **39** (3) 345-350.

CROUS P, HAARHOFF J and BUCKLEY CA (2013) Water demand characteristics of shared water and sanitation facilities: Experiences from community ablution blocks in eThekwini Municipality. *Water SA* **39** (3) 361-368.

DWA (DEPARTMENT OF WATER AFFAIRS, SOUTH AFRICA) (2009) Blue Drop Report 2009. http://www.ewisa.co.za/misc/BLUE_GREENDROPREPORT/Blue%20drop%20report.pdf (Accessed 12 March 2013).

DWA (DEPARTMENT OF WATER AFFAIRS, SOUTH AFRICA) (2011) Green Drop Report 2011. URL: http://www.ewisa.co.za/misc/BLUE_GREENDROPREPORT/GREENDROP2011/GREEN_DROP_REPORT_CARD_FOR_2010.pdf (Accessed 27 May 2013).

FISHER-JEFFES L and ARMITAGE NP (2013) Charging for stormwater in South Africa. *Water SA* **39** (3) 429-436.

HOEKSTRA AY (2003) *Virtual Water Trade: Proceedings of the International Expert Meeting on Virtual Water Trade, Delft, The Netherlands, 12–13 December 2002.* Value of Water Research Report Series No. 12. UNESCO-IHE, Delft, The Netherlands. URL: www.waterfootprint.org/Reports/Report12.pdf.

HOEKSTRA AY, CHAPAGAIN AK, ALDAYA MM and MEKONNEN MM (2009) Water Footprint Manual – State of the Art 2009. Water Footprint Network, Enschede, The Netherlands. URL: http://doc.utwente.nl/77211/1/Hoekstra09WaterFootprintManual.pdf.

HOFFMAN JJ and DU PLESSIS JA (2013) A model to assess water tariff as part of water demand management. *Water SA* **39** (3) 423-428.

ILEMOBADE AA, OLANREWAJU OO and GRIFFIOEN ML (2013) Greywater reuse for toilet flushing at a university academic and residential building. *Water SA* **39** (3) 351-360.

JORDAAN K and BEZUIDENHOUT CC (2013) The impact of physico-chemical water quality parameters on bacterial diversity in the Vaal River, South Africa. *Water SA* **39** (3) 385-396.

LEAT N and GRUNDLINGH M (2013) Development and implementation of a rapid real-time polymerase chain reaction assay for the detection of toxigenic *Vibrio Cholerae* in water. *Water SA* **39** (3) 397-402.

LOBANGA KP, HAARHOFF J and VAN STADEN SJ (2013) Treatability of South African surface waters by activated carbon. *Water SA* **39** (3) 379-384.

MHLANGA FT and BROUCKAERT CJ (2013) Characterisation of wastewater for modelling of wastewater treatment plants receiving industrial effluent. *Water SA* **39** (3) 403-408.

RIVETT U, CHAMPANIS M and WILSON-JONES T (2013) Monitoring drinking water quality in South Africa: Designing information systems for local needs. *Water SA* **39** (3) 409-414.

SHERIDAN C, HARDING K, KOLLER E and DE PRETTO A (2013) A comparison of charcoal- and slag-based constructed wetlands for acid mine drainage remediation. *Water SA* **39** (3) 369-374.

WEGELIN WA and JACOBS HE (2013) The development of a municipal water conservation and demand management strategy and business plan as required under the Water Services Act. *Water SA* **39** (3) 415-422.