Issues of water quality in stormwater harvesting: Comments on Fisher-Jeffes et al. (2017)

AUTHOR:
Jasper Knight[1]

AFFILIATION:
[1]School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, Johannesburg, South Africa

CORRESPONDENCE TO:
Jasper Knight

EMAIL:
jasper.knight@wits.ac.za

KEYWORDS:
stormwater run-off; climate change; water systems

HOW TO CITE:
Knight J. Issues of water quality in stormwater harvesting: Comments on Fisher-Jeffes et al. (2017). S Afr J Sci. 2017;113(5/6), Art. #a0207, 2 pages. http://dx.doi.org/10.17159/sajs.2017/a0207

Stormwater harvesting (SWH) has long been considered a potential solution to water insecurity in water-scarce areas, especially in urban settings with a high proportion of impermeable surfaces.[1-3] The recent paper in this journal by Fisher-Jeffes et al.[4] provides a summary of the potential benefits of SWH in South Africa, grouped under three themes: water security, flood prevention and additional benefits through enhancing natural assets. Some specific examples of SWH reuse and management were provided from the Western Cape region to illustrate their points. Whilst it is absolutely the case that, on a national scale, SWH is an under-exploited resource in South Africa, there are many problems with stormwater use that are not discussed in the article but which may significantly limit the extent to which this greywater is beneficial to the environment and communities. In this commentary I highlight additional factors not considered by Fisher-Jeffes et al.[4], but which are significant in a South African context, including (1) climate and precipitation variability, (2) water quality, (3) management of urban water systems, and (4) infrastructural and community adaptive capacity. I then identify some future research directions.

Firstly, ensemble climate models for southern Africa are consistent in their predictions of an overall future drying trend across the region, but all models suggest significant spatial variations in precipitation trends, changes in seasonality and a shift towards heavier single-event rainfall.[5,6] Fisher-Jeffes et al.[4] mention increased evapotranspiration as a climate change impact but this has minimal effect on individual storm events. A more significant effect of heavier rainfall is increased overland flow, flooding and impacts, including loss of life and property. SWH of such events is problematic because of high water volumes, which can overwhelm sewer transport and storage capacity[7], and the sudden onset and unpredictable timing of individual storm events[8]. Such climate variability has implications for the development and sustainability of infrastructure for managing stormwater, and how this management imperative is built into any future plans for wider water resource management systems (e.g. management of potable water, existing greywater, sewage/sanitation).[9]

Secondly, water quality is a very significant issue with respect to the reuse of stormwater or other greywater, but was not mentioned by Fisher-Jeffes et al.[4] who assumed that all stormwater is potentially available for use. In the urban environment, however, stormwater flow over roads washes sediment, trash and many chemicals into sewage systems. The latter components include oil, spilt fuel, heavy metals (e.g. lead, copper, zinc, chromium, manganese), polycyclic aromatic hydrocarbons and non-volatile organic compounds derived from fuel, tyre wear etc.[10,11] Airborne chemical pollutants and particulate matter can experience wet or dry deposition on to the land surface or vegetation, and can also get washed into the sewer system.[12] Collectively, these pollutants result in lowered water quality and significant potential human health effects, including from *E. coli* and novovirus.[13,14] Biofiltration through urban wetlands, discussed below, is a key method for cleaning contaminated water and improving water quality.

Thirdly, management of urban water systems, including stormwater, requires an understanding of future patterns of climate and urbanisation[15], and potentially conflicting water management issues of aquifer recharge, maintaining urban rivers and water quality, equity of service provision, and economic sustainability[16,17]. Studies are now looking at the functioning of urban water systems from the viewpoint of integrated systems management, and flux and water budget modelling.[8,18] These methodological approaches are better able to incorporate greywater as part of the active water management system rather than as an unquantified part of the precipitation input to the system.[18,19] Fisher-Jeffes et al.[4] take the position that SWH can reduce flood risk when water is stored in retention dams on rivers, or when pumped into aquifers. More integrated and sustainable 'systems' approaches to water management are not discussed.

Lastly, for SWH to become a reality in urban settings, significant changes in water management thinking are needed. These changes may involve devolution of water management decision-making to the community level, to build community resilience and water security.[20,21] The social and institutional barriers to widespread stormwater use identified by Fisher-Jeffes et al.[4], including regulatory frameworks for potable water supply, can be better tackled through bottom-up community initiatives, including use of domestic water butts, urban food gardens and urban greening of waste ground. These initiatives have been shown to have positive community benefits as well as reducing run-off and improving wastewater quality.[22] Such ideas of sustainable and integrated water systems represent an emerging research field in sub-Saharan Africa.[23]

In summary, the article by Fisher-Jeffes et al.[4] highlights many of the advantages of SWH but does not expand upon their limitations or the interconnections between stormwater, natural hydrological (river) systems in urban areas, and the built infrastructure of urban water management. Many studies show that stormwater can be naturally cleaned by biofiltration through urban wetlands[24], and this method has the advantage of providing green spaces within the urban environment, cooling local climate and increasing biodiversity and human well-being. An alternative option for urban areas is to develop soakways alongside roads and pavements, which has not yet been explored. Water from green roofs or from roof catchment systems may be of better quality than stormwater run-off from roads, and thus can be used for different purposes within integrated water systems. Thus, not all stormwater exhibits the same properties or has the same filtration needs. In South Africa, SWH has greatest potential in urbanised areas with impermeable surfaces, not in rural areas where land surface run-off following storms results in significant negative impacts such as soil erosion, and contamination by sewage or agricultural run-off. In South Africa, future changes in climate, urban planning and infrastructure must be considered in the design and management of water systems, which are needed for sustainable development and climate resilience.

References

1. Mitchell VG, Deletic A, Fletcher TD, Hatt BE, McCarthy DT. Achieving multiple benefits from stormwater harvesting. Water Sci Technol. 2007;55(4):135–144. http://dx.doi.org/10.2166/wst.2007.103
2. Fletcher TD, Deletic A, Mitchell VG, Hatt BE. Reuse of urban runoff in Australia: A review of recent advances and remaining challenges. J Environ Qual. 2008;37(5):S116–S127. http://dx.doi.org/10.2134/jeq2007.0411
3. Hamdan SM. A literature based study of stormwater harvesting as a new water resource. Water Sci Technol. 2009;60(5):1327–1339. http://dx.doi.org/10.2166/wst.2009.396
4. Fisher-Jeffes L, Carden K, Armitage NP, Winter K. Stormwater harvesting: Improving water security in South Africa's urban areas. S Afr J Sci. 2017;113(1/2), Art. #2016-0153, 4 pages. http://dx.doi.org/10.17159/sajs.2017/20160153
5. Bellprat O, Lott FC, Gulizia C, Parker HR, Pampuch LA, Pinto I, et al. Unusual past dry and wet rainy seasons over southern Africa and South America from a climate perspective. Weather Clim Extremes. 2015;9:36–46. http://dx.doi.org/10.1016/j.wace.2015.07.001
6. Li L, Diallo I, Xu C-Y, Stordal F. Hydrological projections under climate change in the near future by RegCM4 in southern Africa using a large-scale hydrological model. J Hydrol. 2015;528:1–16. http://dx.doi.org/10.1016/j.jhydrol.2015.05.028
7. Haque MdM, Rahman A, Samali B. Evaluation of climate change impacts on rainwater harvesting. J Cleaner Prod. 2016;137:60–69. http://dx.doi.org/10.1016/j.jclepro.2016.07.038
8. Huang C-L, Hsu N-S, Wei C-C, Luo W-J. Optimal spatial design of capacity and quantity of rainwater harvesting systems for urban flood mitigation. Water. 2015;7(9):5173–5202. http://dx.doi.org/10.3390/w7095173
9. Tavakol-Davani H, Goharian E, Hansen CH, Tavokol-Davani H, Apul D, Burian SJ. How does climate change affect combined sewer overflow in a system benefiting from rainwater harvesting systems? Sustain Cities Society. 2016;27:430–438. http://dx.doi.org/10.1016/j.scs.2016.07.003
10. Brown JN, Peake BM. Sources of heavy metals and polycyclic aromatic hydrocarbons in urban stormwater runoff. Sci Total Environ. 2006;359(1–3):145–155. http://dx.doi.org/10.1016/j.scitotenv.2005.05.016
11. Hwang H-M, Fiala MJ, Park D, Wade TL. Review of pollutants in urban road dust and stormwater runoff: Part 1. Heavy metals released from vehicles. Int J Urban Sci. 2016;20(3):334–360. http://dx.doi.org/10.1080/12265934.2016.1193041
12. Murphy LU, O'Sullivan A, Cochrane TA. Quantifying the spatial variability of airborne pollutants to stormwater runoff in different land-use catchments. Water Air Soil Poll. 2014;225(7):2016. http://dx.doi.org/10.1007/s11270-014-2016-8
13. Jiang SC, Lim K-Y, Huang X. Human and environmental health risks and benefits associated with use of urban stormwater. WIREs Water. 2015;2(6):683–699. http://dx.doi.org/10.1002/wat2.1107
14. Ma Y, Egodawatta P, McGree J, Goonetilleke A. Human health risk assessment of heavy metals in urban stormwater. Sci Total Environ. 2016;557:764–772. http://dx.doi.org/10.1016/j.scitotenv.2016.03.067
15. Saraswat C, Kumar P, Mishra BK. Assessment of stormwater runoff management practices and governance under climate change and urbanization: An analysis of Bangkok, Hanoi and Tokyo. Environ Sci Pol. 2016;64:101–117. http://dx.doi.org/10.1016/j.envsci.2016.06.018
16. Burns MJ, Fletcher TD, Walsh CJ, Ladson AR, Hatt BE. Hydrologic shortcomings of conventional urban stormwater management and opportunities for reform. Landsc Urb Plann. 2012;105(3):230–240. http://dx.doi.org/10.1016/j.landurbplan.2011.12.012
17. Upadhyaya JK, Biswas N, Tam E. A review of infrastructure challenges: Assessing stormwater system sustainability. Can J Civil Eng. 2014;41(6):483–492. http://dx.doi.org/10.1139/cjce-2013-0430
18. Malinowski PA, Stillwell AS, Wu JS, Schwarz PM. Energy-water nexus: Potential energy savings and implications for sustainable integrated water management in urban areas from rainwater harvesting and gray-water reuse. J Water Res Planning Manag. 2015;141(12):A4015003. http://dx.doi.org/10.1061/(ASCE)WR.1943-5452.0000528
19. Walsh CJ, Fletcher TD, Burns MJ. Urban stormwater runoff: A new class of environmental flow problem. PLoS One. 2012;7(9), e45814, 10 pages. http://dx.doi.org/10.1371/journal.pone.0045814
20. Adegun OB. Coping with stormwater in a Johannesburg, South Africa informal settlement. Proc Inst Civil Eng. 2014;167(ME2):89–98. http://dx.doi.org/10.1680/muen.13.00030
21. Adegun OB. State-led versus community-initiated: Stormwater drainage and informal settlement intervention in Johannesburg, South Africa. Environ Urbanization. 2015;27(2):407–420. http://dx.doi.org/10.1177/0956247815569700
22. Ward EW, Winter K. Missing the link: Urban stormwater quality and resident behaviour. Water SA. 2016;42(4):571–576. http://dx.doi.org/10.4314/wsa.v42i4.07
23. Mguni P, Herslund L, Jensen MB. Sustainable urban drainage systems: Examining the potential for green infrastructure-based stormwater management for sub-Saharan cities. Nat Hazards. 2016;82:S241–S257. http://dx.doi.org/10.1007/s11069-016-2309-x
24. Rousseau DPL, Lesage E, Story A, Vanrolleghem PA, De Pauw N. Constructed wetlands for water reclamation. Desalination. 2008;218(1–3):181–189. http://dx.doi.org/10.1016/j.desal.2006.09.034