Wastewater for Urban Agriculture

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Wastewater for urban agriculture: a significant factor in dissemination of antibiotic resistance

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It is estimated that antibiotic-resistant bacteria cause 23,000 and 25,000 deaths in the United States and Europe respectively[1]; the situation is similar worldwide and even worse in low and middle income countries (LMICs) where a high infectious disease burden is coupled with rapid emergence and spread of microbial drug resistance[1]. Populations from LMICs are facing an increasing rise in numbers of antibiotic-resistant bacteria; members of the *Enterobacteriaceae* and *Pseudomonaceae* are the most frequently isolated bacteria from clinical samples[2]. Deaths from antibiotic-resistant bacteria are under-reported[1], but available data indicates that a large number of neonatal deaths due to drug-resistant sepsis occur every year in India, Pakistan, Nigeria, and in the Democratic Republic of Congo[2]. Taking this into account, it is no surprise that globally by 2030 infectious diseases are predicted to be one of the most frequent causes of death[1].

The important role of the environment in the dissemination of antibiotic resistance is acknowledged, and the aquatic environment has been shown to act both as a natural reservoir and a channel for the spread of clinically relevant antibiotic resistance traits[3]. Approximately 50-90 % of antibiotics are excreted in urine or faeces from people or animals, either in their original formulation, partly degraded or as metabolites. Consequently, due to the higher consumption of antibiotics without control in LMICs, huge quantities of antibiotics end up in water ecosystems[4]. To survive in the presence of antibiotics, bacteria have evolved a plethora of different antibiotic resistance genes (ARGs) many of which are easily transmitted between bacteria via horizontal transfer. The occurrence of antibiotics in wastewater increases the opportunity for survival of drug-resistant pathogens as drug susceptible strains are killed. Consequently, antibiotic-resistant commensal, opportunistic and pathogenic bacteria occur due to both evolution and the acquisition of ARGs[3].

Population growth associated with urbanization is increasing the pressure on regional water resources. With decreasing freshwater availability, using wastewater for irrigating agricultural lands is increasing globally. In 2014, the United Nations estimated that 3.9 billion of the world's population resided in urban areas, with 2.8 billion living in LMICs. The continuing population growth and urbanization are projected to add 3.1 billion people to the urban world population by 2050, with a 2.25 billion-population increase in Asian and African cities[4]. The rapid increase in the urban population in LMICs is a source of concern as it is associated with an increase in urban poverty, food insecurity and environmental pollution[5]. In LMICs, urban agriculture (the production of crops for sale or consumption within and around cities) has been developed by urban dwellers to supply food to the city inhabitants; it consequently provides a source of employment and income. Urban agriculture is fully integrated in the cities; it is usually practised along roadsides, rivers and river valleys, in wetlands, in the middle of roundabouts, in open spaces and parks, and within backyards of residential plots. Urban agriculture production systems can provide 41 % of a city's total food supply and up to 90 % of its demand for perishable vegetables[5]. Perishable vegetables are produced throughout the year in wetlands, along city drainage canals and surface runoff, and need a constant water supply. Due to water scarcity and cost, urban farmers generally use untreated wastewater irrigation, since more than 80% of the sewage generated in LMICs is discharged untreated into the environment[6]; this is both easily accessible and has fertilizing capacity.

Approximately 50% of the world's population depend on polluted water sources, including for irrigation of agricultural lands; of which 20 million hectares of arable land worldwide, giving rise to 10% of the world population's food production, with one billion consumers, is reported to be irrigated with wastewaters[6]. It has been shown that wastewater used for this form of agriculture expose humans and animals to various enteric diseases caused by pathogenic bacteria, protozoa, and helminths[7]. Furthermore, ingestion of faecally contaminated water and/or food by microorganisms is one of the major reasons for the higher number of gastro-intestinal and waterborne diseases in LMICs[8]. In 2015, globally 1.87 million children under 5 years old worldwide died from diarrhoea, representing 19% of total child deaths, with 78% (1.46 million) occurring in Africa and South-East Asia[8].

Wastewater not only contains bacteria but it can also contain high concentrations of antibiotics from abattoirs, domestic use and hospitals[1]. Therefore, wastewater use in urban agriculture is likely a strong vector of bacterial resistance in wastewater irrigation-based farming systems, and the risks associated with the use of raw wastewater in LMICs needs to be urgently assessed. Research should include measuring the potential of wastewater for urban agriculture to disseminate ARGs; the population dynamics of pathogenic antibiotic-resistant bacteria in polluted wastewater, and their transmissibility to humans and animals via direct water exposure and the food chain. The use of raw wastewater for irrigation by urban farmers should be avoided and water sanitation and good public health systems should be intensively promoted and introduced in LMICs.

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Notes

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References

(1) AMR review. The review on antimicrobial resistance, tackling drug-resistant infections globally: Final report and recommendations, May 2016. https://amr-review.org/sites/default/files/160525_Final%20paper_with%20cover.pdf (accessed April 24, 2017).

(2) Laxminarayan, R.; Matsoso, P.; Klugman, K.P.; et al. Access to effective antimicrobials: a worldwide challenge. *Lancet* **2016**, 387, 168–75.

(3) Michael, I.; Rizzo, L.; McArdell, C.S.; Manaia, C.M.; Merlin, C.; Schwartz, T.; et al., Urban waste water treatment plants as hotspots for the release of antibiotics in the environment: a review. *Water Res*. **2013**, 47, 957-993.

(4) World urbanization prospects; United Nations, Department of Economic and Social Affairs, Population Division. The 2014 Revision, Highlights (ST/ESA/SER.A/352), 2014. https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf (accessed April 24, 2017).

(5) Drechsel, P.; Dongus, S., Dynamics and sustainability of urban agriculture: examples from sub-Saharan Africa. Sustain. Science 2010, 5, (1), 69-78.

(6) Mateo-Sagasta, J.; Medlicott, K.; Qadir, M.; Rashid-Sally, L.; Drechsel, P.; Liebe, J. Proceedings of the UN-Water project on the Safe Use of Wastewater in Agriculture; UNW-DPC Proceedings Series, August 2013. http://collections.unu.edu/eserv/UNU:2661/proceedings-no-11_WEB.pdf (accessed April 24, 2017).

(7) Dickin SK, Schuster-Wallace CJ, Qadir M, Pizzacalla K. A Review of Health Risks and Pathways for Exposure to Wastewater Use in Agriculture. Environ. Health Persp. 2016, 124, 900-9.

(8) Liu L, Oza S, Hogan D, Chu Y, Perin J, Zhu J, et al. Global, regional, and national causes of under-5 mortality in 2000-15: an updated systematic analysis with implications for the Sustainable Development Goals. Lancet 2016; 388, 3027-35.