Waste water as a source for secondary resources and linkage to other urban systems

Claudia Agudelo*, Adriaan Mels and Huub Rijnaarts

Wageningen University, The Netherlands

Nowadays, urban planners face the enormous challenge of meeting citizens' needs while protecting and assuring natural resources. Population growth and higher living standards will cause ever increasing demands for good quality municipal and industrial water, and ever increasing sewage flows within a limited area (Jiménez et al., 2008). Urban metabolism studies have shown that, in terms of sheer mass, water is the largest and the most vital component (Kennedy et al., 2007). Additionally, the problem with regard to the requirement for water by terrestrial ecosystems (including humans) is not only related to its availability, but more in particular to its quality, notably its chemical and bacteriological composition (Worp, 2002 in Bruggen et al., 2005). To alleviate these pressures it is needed to shift from linear to circular metabolism, in which recycling and reusing are key activities.

A general scheme of the existing situation is shown in the figure 1, in which different activities within the built environment required different water quality. Analyzing this figure, it is evident that there is a "quality surplus" supplied and that there are efficiency losses due to the unused quality of the flow that is discharged into the wastewater treatment plant (WWTP). Within this paper we will address the question whether there are better ways of meeting the various qualities and consequently reduce our water needs. The quantitative assessment of water quality and its relationships with management activities is a necessary step in efficient water resources management (Agudelo et al., 2009).

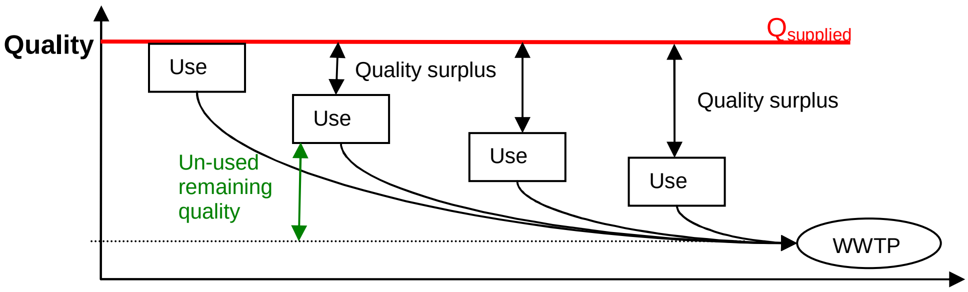

Figure 1 Schematic presentation of the quality loses in the urban system. (Agudelo et al., 2009)

The so called waste-water has been seen, over the last decades, as urban nuisance, which should be removed and treated as far as possible from the production site (Zeeman et al., 2009). Nevertheless, the same stream can be used as a source of fertilizer due to the presence of nitrogen, phosphorous and potassium, which can be used for urban agriculture. Looking back at history, there is evidence that past-civilizations and also some of our current cities in earlier stages benefited from the benefits of this secondary resources.

The world urban population will be likely to increase by 3.1 billion between 2007 and 2050, passing from 3.3 billion to 6.4 billion (UN, 2007), therefore, higher crop yield and larger food demand are needed in order to feed the increasing population in urban regions. Additionally, depletion of the phosphorus resources all over the world, increasing urbanization and larger food demand in cities, has becoming a hot issue that should be paid special attention. Consequently, recovery of nutrients from human excreta and organic kitchen waste as fertilizer to be applied in urban agriculture to provide locally produced food is a promising strategy. Because this practice can replace part of the mineral used, improve the soil quality, ensure food security, improve the environment state by decreasing the nutrients load to the receiving river, and close the loop between sanitation and urban agriculture (Gao, 2010).

Waste water is a source of secondary resources and also provides linkages with other urban system. The links between sanitation and agriculture are obvious. Currently new technologies of heat exchangers are able to harvest the residual heat from the wastewater, minimizing in this way the losses of the system. Table 1 summarizes the relationships between wastewater and other flows. To solve urban water problems, we have to solve the "metabolic" problems of cities. Treating the wastewater is treating the symptoms and not the disease. To reach sustainable urban planning, it is important to study a system from the perspective of resources and resource flows.

Table 1. Different flows that can be harvested from urban water flows. (Agudelo et al., 2009)

Urban flows	Water	Heat	Nutrients	Organic matter
Rain water	●			
Urban Wastewater (mixed)	●	●	●	●
Urban Wastewater (separated)				
Grey water	●	●		
Black water			●	●
Urine			●	

Most of the current improvements in the field of integrated water resources management are aimed at end-of-pipe technologies for wastewater treatment to fulfill discharge requirements. There are many unexplored potentials within urban areas to (re)cover water resources demand, and a single criterion - effluent quality – is not enough to evaluate the sustainability of a wastewater treatment system. Future developments must also consider all other resources, including capital, energy and nutrients (Wilsenach et al., 2003). "However, the task of optimal water resource management requires predefined standards of water quality as integral components of the optimization criteria" (Parparov et al., 2006). The way of how to value other resources within the system will indicate the feasibility of the options. For instance upgrading of resources need energy and material inputs, if those resources are available or scarce are determine by the local setting characteristics. Moreover, water reuse or recycled within the urban area minimize costs regarding water extraction and transportation. Also, when qualities are better match, savings in water treatment will be achieved.

Cities are complex entities, and multiple flows are present to maintain all their functions, when optimizing water flow, it is necessary to study the interrelation with other flows. There are several options for win-win arrangements see figure 2. Since the environment for each city will be different, each city must choose a development path that is applicable to and appropriate for its local situation: a 'one-size-fits-all' concept will not work. A paradigm shift from a system which sees wastes as hazard to a system where the same waste is seen as a resource qualifies to be treated as a technological transition. Such a change will not only require a change in infrastructure but also changes in relations, human behavior, legislation and policies among others (Tettey, 2009).

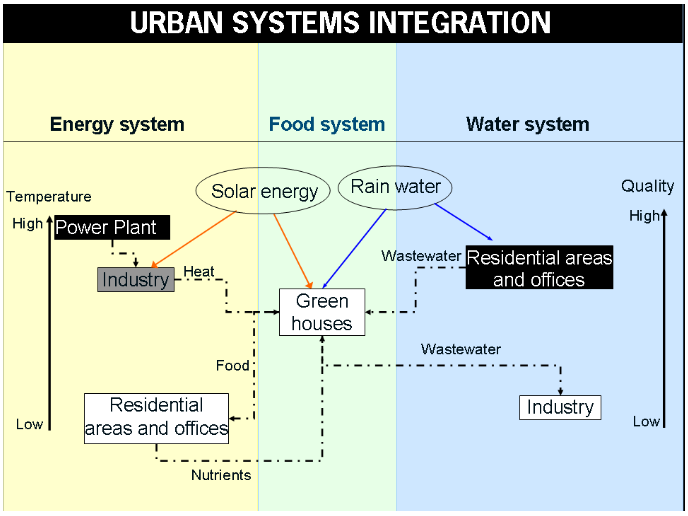

Figure 2 Schematic presentation of integration of urban systems towards sustainable cities

REFERENCES

Agudelo C, Mels A, Rovers R. Urban Water Tissue: Analysing the Urban Water Harvest Potential. In: Dobbelsteen, A., Dorst, M. and Timmeren, A, editors. Smart building in a Changing Climate. Amsterdam: Techne Press; 2009. p. 63- 78.

Bruggen, B. Van der., Boussu, K., Vreese, I.D. De., Baelen, G. van., Willemse, F., Goedeme, D., and Colen, W. 2005, Industrial Process Water Recycling: Principles and Examples. *Environmental Progress.* 24**,** 417-425.

Gao, X. 2010 Development of a methodology to measure the potential of harvesting urban nutrients for urban agriculture. MSc Thesis. Wageningen University.

Jimenez, B. and Asano, T. 2008, Water reclamation and reuse around the world. In Jimenez, B. and Asano, T. (ed.), *Water reuse : an international survey of current practice, issues and needs,*IWA, pp. 3-26.

Kennedy, C., Cuddihy, J. and Engel-Yan, J. 2007, The changing metabolism of cities. *Journal of Industrial Ecology*, 11, pp. 43-59.

Parparov, A., Hambright, K.D., Hakanson, L. and Ostapenia A. 2006, Water quality quantification: Basics and implementation. *Hydrobiologia*, 560**,** 227-237.

Wilsenach, J. A., Maurer, M., Larsen, T.A. and Loosdrecht, M.C.M. van,. 2003, From waste treatment to integrated resource management. *Water science and technology*. 48, pp. 1-9.

Tettey F 2008. Closing the loop between sanitation and agriculture in accra, ghana. MSc Thesis. Wageningen University.

Zeeman, G. and Lettinga, G. The role of anaerobic digestion of domestic sewage in closing the water and nutrient cycle at community level. Water science and technology. 39, pp. 187-194.