Natural Treatment Systems in Urban Water Management: A Review

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Abstract

As the good quality water sources are becoming more scarce, water and wastewater treatment standards are getting more stringent and the cost of treatment is increasing; there is therefore a need for a sustainable, low cost and robust water/wastewater treatment technology. In this context, natural treatment systems are getting increasing attention in urban water management. Natural treatment systems represent any type of water or wastewater treatment system in which the process of contaminant removal is not aided by the input of significant amounts of energy and/or chemicals. Natural systems include a wide range of soil/aquifer-based and vegetation-based systems applied for the treatment of drinking water, wastewater, and urban storm water. Such treatment processes are low-cost, sustainable, robust, and multi-objective/-contaminant targeting the removals of turbidity and suspended solids, biodegradable bulk organic matter and trace organic compounds, microorganisms and, to varying degrees, nutrients (N and P) (Sharma and Amy, 2010; Rousseau and Lesage, 2006). Natural treatment systems are cost effective and environmentally friendly technologies that can reduce stresses on water resources. There is an enormous potential for their application for treatment of water and wastewater in both developed and developing countries and, as such, they should be considered as alternatives to conventional water and wastewater treatment technologies. However, most of the natural systems have been employed in the past based on local experiences and natural treatment systems need to be adapted to suit the local conditions and requirements.

Natural systems provide innovative ways to promote safe wastewater reclamation/reuse including indirect potable reuse through use of appropriate environmental buffers. It promotes an integrated urban water management approach involving a semi-closed urban water cycle that includes subsurface and surface buffers that provide both storage as well as a sustainable natural-systems treatment barrier. Natural systems could be employed to manage the municipal water cycle or individual components thereof.

Natural systems like bank filtration (BF) and artificial recharge (AR) can be used for drinking water (pre-) treatment and for groundwater augmentation. These methods have been used in

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Europe for water treatment for more than 100 years. BF applied to a river or lake, is a reliable, natural and multi-objective treatment process which removes particles, biodegradable organic compounds, trace organics, microorganisms as well as ammonia and nitrate to some extent. Furthermore, it also dampens temperature peaks and concentration peaks associated with spills. BF could replace or support other treatment process, thus providing a robust barrier within a multi-barrier system and also decreases the costs of water treatment. AR can be applied to the area when local geological conditions or water quality in not suitable for BF system (Sharma and Amy, 2009; Maeng et al., 2009; Sharma and Amy, 2010).

Constructed wetland (CW) and waste stabilization pond (WSP) systems could be employed for wastewater and storm water treatment and reuse and at the same time provide important ancillary benefits such as habitat provision and urban greening. In addition, reuse is not restricted to the water phase (effluent), but also includes nutrient recycling via the appropriate use of biomass (algae, plants) grown in the systems. One recurring drawback mentioned in literature is their large space demand, which is easily 10 times higher than of activated sludge systems. Recent technological developments are aiming to reduce CW footprints such as reciprocating flows (Sun et al., 2005), aeration (Green et al., 1998; Wallace et al., 2006) or combining CWs with other wastewater treatment technologies.

Soil Aquifer Treatment (SAT) is an attractive natural treatment technology for multiple contaminants removal which, in combination with other available wastewater treatment technologies, can produce effluent of acceptable quality for indirect potable reuse. The application of SAT technology in arid and semi arid regions of the world where groundwater resources has been over exploited augments water supply. It is equally attractive for developed as well as developing countries as it is low cost, robust, removes multiple contaminants, is environment friendly, and minimizes the use of chemicals and energy. Implementation of SAT could ensures sustainability of both surface water and groundwater sources within the context of integrated water resources management. However, some pre-treatment and post-treatment may be required to reduce clogging of the infiltration basins and to ensure removal of all organic micropollutants, specifically for indirect potable reuse.

Natural systems could also be incorporated in strategic planning of urban environment for the stimulation of the self purification capacity of urban water resources. Studies in Lodz (Poland) have shown that it is possible to improve the quality of water in urban rivers by applying eco-hydrological approaches (Wagner et al., 2008).

Depending upon the influent water quality and intended use of the "treated water" from these natural systems, some pre-treatment or post-treatment may be required. Another attractive option is to combine different natural systems leading to a synergetic "hybrid system" to achieve the water quality objectives and treatment goals. For example CW could serve as pre-treatment for SAT system by reducing the nutrient loads. Electroflocculation pre-treatment of secondary effluent followed by constructed wetlands (EF-CW) is another innovative technology under development for upgrading secondary effluent to a level that will permit its use for stream rehabilitation, park irrigation and other municipal uses that require high quality reclaimed wastewater (Adin et al., 2009). Studies have also shown that SAT followed by NF treatment of wastewater treatment plant effluents not only reduces the fouling of the membranes and reduces the costs of wastewater reclamation, but also increases bulk organic matter and organic micropollutants removal efficiency (Cikurel et al., 2010).

In general, it can be concluded that natural systems have high potential for application in integrated urban water management ranging from drinking water treatment, wastewater and storm water treatment, groundwater augmentation to stimulating self purification of urban rivers and water bodies. They are robust, cost effective and environment-friendly; however these systems need to be adapted to local conditions and water quality requirements for different applications.

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