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## Wastewater and Rainwater Management in Urban Areas: A Role for Constructed Wetlands

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### Abstract

Lower space requirement, simple operation and economical aspects as well as landscape integration make decentralized natural sanitation systems necessary in eco-city construction. This paper focuses on water management through natural and alternative solutions in urban and peri-urban areas. Results and efficiency of raw wastewater by decentralized natural systems, intelligent storm water management and reuse of treated water in urban irrigation are discussed. Several full scale examples are presented regarding to their removal efficiency and environmental benefits. Their contribution in climate change mitigation is presented as a necessity in today's eco-city conception.

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### 1. Introduction

Urban water and wastewater management generally use centralized systems inheriting from concepts created in

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the early twentieth century<sup>1</sup>. With the expansion of cities, sewer systems have been developed up to thousands of kilometres using the “end of pipe” concept. The large quantity of collected wastewater is then conveyed and treated in centralized industrial plants. In the 21st century, limited space, high human population density, noise and pollution become common issues in the modern urban areas. Urbanization is the trend of economic development but it also brings us serious environmental issues such as waste and water pollution, decreased biodiversity and urban heat islands effect (UHI), which are definitely not what we are looking forward to. With the expansion of urbanization, the “Eco-city” paradigm was introduced as an environmental-friendly city in which water and energy are valorised, wastes are managed and recycled. In most cities, wastewater is collected and conveyed far to a central treatment plant. This kind of approach requires long sewer systems and underground pipe layout construction which are expensive to build and maintain, and not necessarily environmental-friendly.

Constructed wetlands for domestic raw wastewater treatment are extensive systems that have demonstrated their high pollutants removal efficiency for over 20 years<sup>2</sup>. Recent developments make them more intensive while enhancing their treatment efficiency. The potential of these systems for decentralized sanitation in urban areas is described in this paper.

Constructed wetlands are also adapted to rainwater management and will be presented in this paper. The modified two-stage vertical flow constructed wetland system is able to deal with combined sewer effluent, while a properly engineered single-stage constructed wetland can handle with combined sewer overflows.

Treated wastewater and harvested rainwater can be reused into agricultural irrigation, gardening and public utilizations. Constructed wetlands can be designed to produce water reaching standards for reuse purposes.

This publication will concentrate on these three main roles of constructed wetlands for decentralized wastewater treatment in urban areas, with respect to eco-city construction.

## 2. Constructed wetlands for wastewater treatment

Constructed wetlands (CW) for domestic wastewater treatment, developed by Epur Nature (Syntea Group) over 15 years as Phragmifilter<sup>®</sup> (more than 900 CW plants), can achieve high pollutant removal efficiency<sup>2</sup>. They have been widely adopted by small communities in France over the last 20 years (>3 000 plants). They ensure good landscape integration and low operational costs compared to conventional treatment plants. They are usually considered as extensive systems which are not suitable for urban areas. However, a recently developed technology by the Syntea group in collaboration with Scott Wallace<sup>3</sup> and Dion van Oirshot, “Rhizosph’air<sup>®</sup>” led to an intensification of these systems in which a better treatment efficiency is achieved, infiltration surface is decreased from 2 m<sup>2</sup> p.e<sup>-1</sup> (square meters per person equivalent) to 0.8 m<sup>2</sup> p.e<sup>-1</sup>. The birth of CW with forced aeration technology marked the turning point of natural sanitation systems and made decentralized wastewater treatment by constructed wetlands possible in urban areas. Experiences showed classic constructed wetland systems generally refer to large space requirement while conventional wastewater treatment plants, which are largely adopted in cities, generally require a high level of exploitation and maintenance, as well as a high energy demand.

### 2.1. Technology description

“Rhizosph’Air<sup>®</sup>” is a combination of classic CWs with forced aeration system at the bottom of the basin (as shown in figure 1). This technology allows an increase in oxygen transfer by a factor of 3, meaning plant surface can be divided by 2 to 3. Nitrification (bacterial reaction that transforms ammonium to nitrate) is complete as well as denitrification (bacterial reaction that transforms nitrate to gaseous N<sub>2</sub>), which is difficult to be managed in natural sanitation systems. This innovation can also deal with inflow coming from industry and agro-food industry.

“Rhizosph’Air<sup>®</sup>” technology solves the space requirement problem of traditional constructed wetlands, making urban wastewater treatment plant decentralized and improving treatment efficiency at the same time.

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