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***Short communication***

# General Aspects of Phytoremediation

## [Aspectos Generales de la Fitorremediación]

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## Abstract

Phytoremediation is a set of viable technologies that uses selected plants and their microorganisms to degrade, extract, contain, or immobilize contaminants from soil and water. It is based on natural processes that can be effective at a variety of sites and on numerous contaminants. Processes are carried out by selected plant species that possess the genetic potential to remove, degrade, metabolize, or immobilize a wide range of contaminants.

## Resumen

La fitorremediación es un conjunto de tecnologías viables que utilizan plantas seleccionadas y sus microorganismos para degradar, extraer, contener o inmovilizar contaminantes del suelo y el agua. Se basa en procesos naturales que pueden ser eficaces en una variedad de sitios y en numerosos contaminantes. Los procesos son llevados a cabo por especies vegetales seleccionadas que poseen el potencial genético para eliminar, degradar, metabolizar o inmovilizar una amplia gama de contaminantes.

## Constructed Wetlands

Among other phytoremediation processes, constructed wetlands (CWs) are a consolidated eco-friendly, nature-based technology that has gained popularity for decentralized wastewater treatment in small communities and rural areas of both industrialized and less developed countries (Álvarez *et al.*, 2017, Machado *et al.*, 2017).

They are low-cost treatment systems, in terms of maintenance and operation, and have proven to efficiently remove organic matter, nitrogen (N) and pathogenic microorganisms from wastewater (Wu *et al.*, 2016, Castillo-Valenzuela *et al.*, 2017, Ilyas and Masih, 2017). During the last decades, this technology has greatly been developed, using, and evaluating different CW designs and operational modes. CWs have been successfully used for the treatment of various types of wastewaters such as textile waste, dairy waste, industrial waste, piggery waste, tannery waste, petrochemical waste, municipal waste (Parde *et al.*, 2021).

Constructed wetlands can be classified into free water surface flow constructed wetland (FW) CW and sub-surface flow constructed wetland (SSF) CW. Subsurface flow is divided, according to the flow direction, into vertical flow (VF) CW, horizontal flow (HF) CW, hybrid systems combining VF and HF CW are also used (Vymazal and Kröpfelová, 2008).

In constructed wetlands, several pollutants removal mechanisms act together, including physical, chemical, and biological processes. The physical process involves sedimentation of the suspended particles present in the wastewater, which leads to the removal of pollutants.

Sedimentation process not only reduce the organic matter but also eliminates the coliform bacteria (Dotro *et al.*, 2015). On the one hand, constructed wetland media is helpful for the accumulation of organic matter, phosphorus, sulphate, arsenate and removal of pathogens (Stanković, 2017). On the other hand, macrophytes used in the wetland provide huge surface area for the microbial growth, which helps in stabilizing the organic matter (Brix, 1994). It is important to take into account that constructed wetland performance depends upon the various factors like temperature, applied hydraulic load, vegetation, media, etc (Tilak *et al.,* 2016).

Sludge treatment wetlands, also known as sludge drying reed beds, are rather new sludge treatment (ST) systems based on constructed wetlands. Sludge treatment wetlands have been used in Europe for sludge dewatering and stabilisation since the late 1980s. The largest experience comes from Denmark, where there are over 140 full-scale systems currently in operation (Nielsen, 2008).

Other systems implemented in northern Europe are located in Poland, Belgium, and the United Kingdom. In the Mediterranean region, full-scale systems are operating in Italy, France, and Spain (Uggetti *et al.*, 2010). Sludges from different sources have been treated in wetlands, including anaerobic digesters, aerobic digesters, conventional activated sludge systems, extended aeration systems, septic tanks, and Imhoff tanks.

Sludge is directly spread into the basins from the aerations tanks or is previously homogenised in a buffer tank before its discharge into the wetlands. From this tank, the sludge is diverted into one of the beds, following a semi-continuous regime. The number of beds may vary, according to the treatment capacity of the facility, between 3 and 18, which correspond to 400 and 123,000 population equivalent (PE), respectively. The result of sludge dewatering and stabilisation processes is a final product that is suitable for land application, either directly or after additional composting.

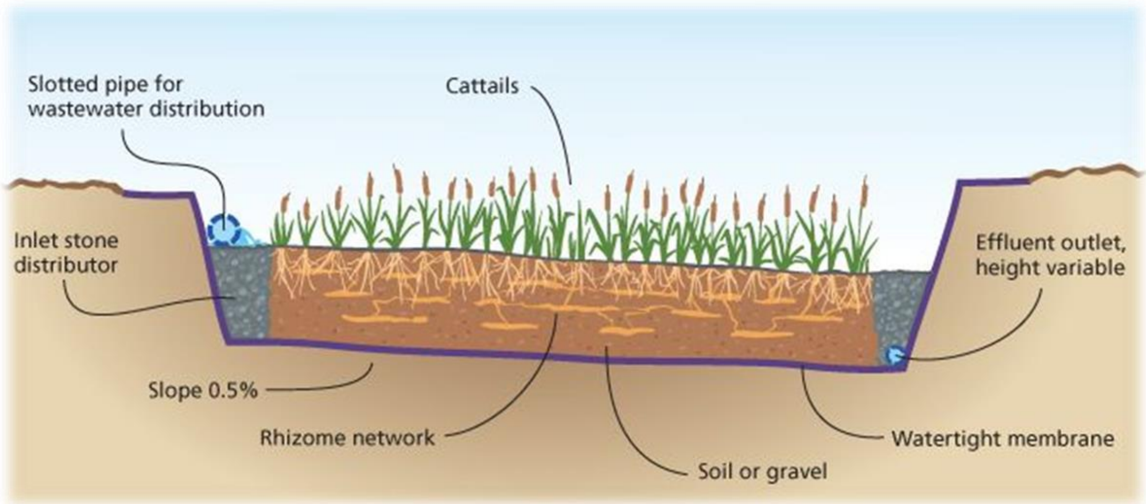


**Figure 1.** Scheme of a Constructed Wetland.

**Figure 2.** Aspect of a Vertical Flow Constructed Wetland located in Toulouse (France).

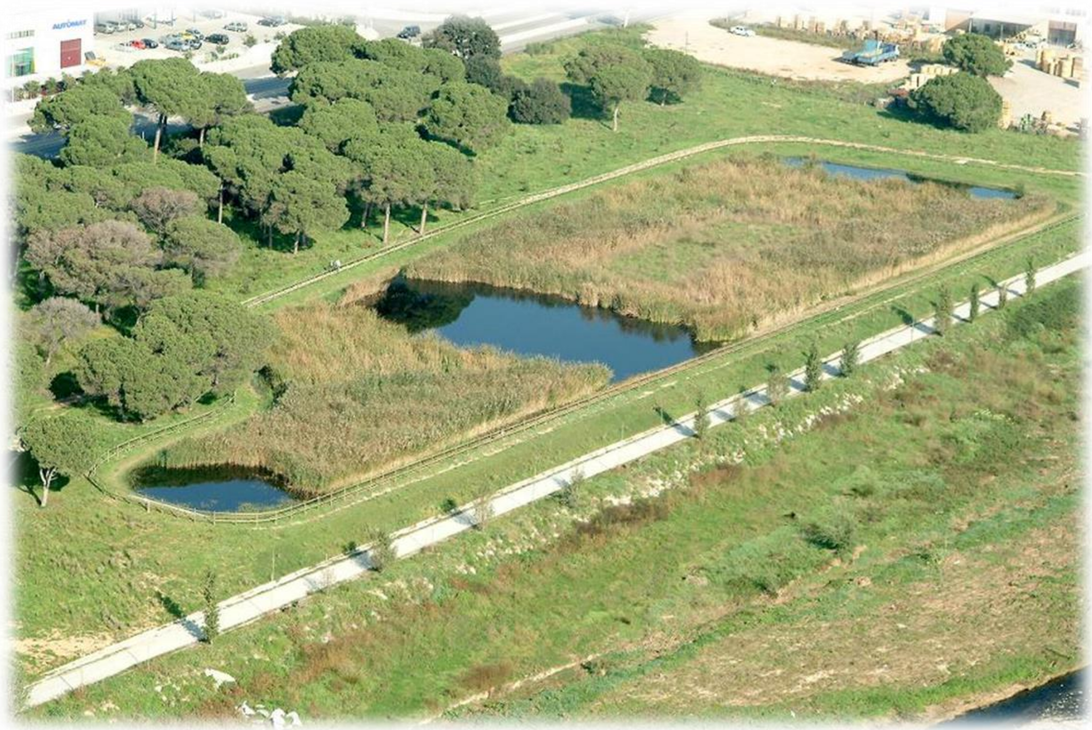

**Figure 3.** Constructed Wetland for ecosystem restoration located in Granoller, Barcelona (Spain).

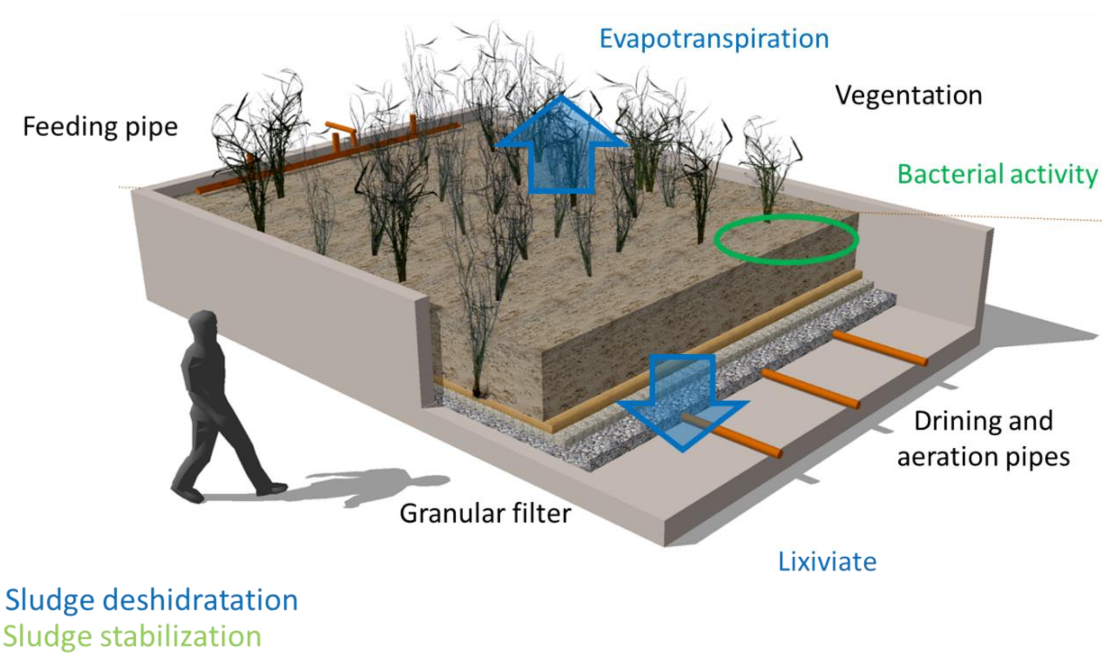


**Figure 4.** Scheme of Constructed Wetlands for sludge treatment.

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