Chapter 8
Constructed Wetlands for Industrial Wastewater Treatment and Removal of Nutrients

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ABSTRACT

Constructed Wetlands (CWs) are low-cost and sustainable systems for wastewater treatment. Traditionally they have been used for urban and domestic wastewater treatment, but in the last two decades, the applications for industrial wastewater treatment increased due to the evolution of the technology and the extended research on the field. Nowadays, CWs have been applied to the treatment of different kind of wastewaters as such as refinery and petrochemical industry effluents, food industry effluents including abattoir, dairy, meat, fruit and vegetables processing industries, distillery and winery effluents, pulp and paper, textile, tannery, aquaculture, steel and mixed industrial effluents. In this chapter, the authors present the main types of CWs, explain how they work and the expected performances, and describe the principal applications of CWs for industrial wastewater treatment with particular attention to suspended solids, organic matter and nutrient removal. A review of these applications as well as some case studies will be discussed.

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INTRODUCTION

In this chapter, the authors refer to the use of constructed wetlands (CWs) for industrial wastewater treatment and their efficiency for nutrient removal. CWs are engineered systems that have been designed and constructed to utilize the natural processes involving wetland vegetation, soils, and their associated microbial assemblages to achieve wastewater treatment (Vymazal, 2014). "Modern treatment wetlands are man-made systems that have been designed to emphasize specific characteristics of wetland ecosystems for improved treatment capacity" (Kadlec & Wallace, 2009). "Besides treatment wetlands", constructed and engineered wetlands can cover a broad range of objectives such as improving biodiversity and environmental conditions related to, wildlife use, irrigation of agriculture lands, improving river water quality, or riverine restoration. Some misleading names have been given to the technology including green filters, biofilters and even sand filters or artificial wetlands. As CWs have evolved with time and applications, other terms like engineered wetlands have appeared that might include the use of devices that upgrade the performance using energy input.

CWs are low-cost and ecofriendly technologies, that take advantage of natural processes to remove pollutants from the water, generally avoiding the use of chemical products and the input of high amounts of external energy. On the other hand, CWs may require a large surface, which is its major drawback. As a result; they are included in the group of extensive technologies for wastewater treatment.

The first research into CWs for wastewater treatment took place in Germany, in the 1950s (e.g., Seidel, 1961), with special focus on phenols removal. From the beginning, the first applications of CWs dealt with urban wastewater, but in the last two or three decades, they have been applied for industrial and agricultural wastewater, as well as stormwater runoff and the treatment of landfill leachates (Vymazal 2011a).

CONSTRUCTED WETLANDS: HOW DO THEY WORK?

Pollutant removal in natural wetlands takes place due to the combination of physical, chemical and microbial processes. The processes involved in pollutant removal are sedimentation, sorption, precipitation, evapotranspiration, volatilization, photodegradation, diffusion, plant uptake, and microbial degradation (for instance, nitrification, denitrification, sulphate reduction, carbon metabolization, etc.) among others.

Types of Constructed Wetlands

There are several types of CWs, depending on the hydrology, the type of macrophytic growth and the direction of the flow inside the wetland. As a result, if the hydrology is considered, the principal types of CWs are surface flow (or free water systems) or subsurface flow systems (Figure 1). According to the macrophytic growth, there are emergent, submerged, free-floating and floating leaves. Finally, the direction of flow inside the CW can be vertical, horizontal or mixed flow.

The most widespread CWs are the surface flow systems (FWS), the horizontal subsurface flow systems (HSSF) and the vertical subsurface flow systems (VF). For improving the performance and the removal of pollutants and nutrients, a combination of these systems can be used, known as hybrid systems. The hybrid systems can combine several features in only one or in several sequential steps.