CAI 334 IRRIGATION WATER QUALITY AND WASTE WATER MANAGEMENT

UNIT III NOTES

Constructed Wetlands for Wastewater Treatment

Wetland ecosystems can act as sources, sinks, or transformers of nutrients and carbon (C) (Mitsch and Gossenlink, 1993). This ability of wetlands has led to a widespread use of natural and constructed wetlands (CWs) for water quality improvement. Constructed wetlands systems are fully human-made wetlands for wastewater treatment, which apply various technological designs, using natural wetland processes, associated with wetland hydrology, soils, microbes and plants. Thus, 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 assist in treating wastewater. Synonymous terms to "constructed" include "man-made", "engineered" or "artificial". "Semi-natural treatment wetlands" (SNTWs) for wastewater treatment are natural wetland systems that have been modified for this purpose. Modifications made within these systems are usually based on increasing the volume of water reserved (i.e. dams) and constructing channels for targeting the influent and effluent. These systems can be found in both freshwater and coastal wetlands. The functioning of SNTWs is similar to those of surface flow CWs.. CW is a wastewater treatment pathway not specifically described in 2006 IPCC Guidelines. Constructed wetlands and SNTWs can be used to improve the quality of collected wastewater including domestic wastewater, industrial wastewater such as wastewater from processing factories of agricultural products and dairy farms, collected runoff from agricultural lands and leachate from landfills. For some wastewaters, CWs are the sole treatment; for others, they are one component in a sequence of treatment processes (US EPA, 1995). There are various types of CWs used for treatment of wastewater, the following paragraphs highlight the main classification of CWs.

TYPE OF CONSTRUCTED WETLANDS FOR WASTEWATER TREATMENT

Constructed wetlands may be categorized according to various design parameters, but the three most important criteria are hydrology (water surface flow and subsurface flow), macrophyte growth form (emergent, submerged, free-floating, and floating leaved plants) and flow path (horizontal and vertical. Different types of CWs may be combined (which are called hybrid or combined systems) to utilize the specific advantages of the different systems.

Constructed Wetlands with Surface Flow Constructed wetlands with surface flow (SF), known as free water surface CWs, contain areas of open water and floating, submerged, and emergent plants .The shallow water depth, low flow velocity, and presence of plant stalks and litter regulate water flow and, particularly in long, narrow channels (Crites et al. 2005),

ensure better water purification. The most common applications for SF CWs are for tertiary treatment of municipal wastewater and also for stormwater runoff and mine drainage waters (Kadlec and Knight 1996; Kadlec and Wallace 2008). SF CWs are suitable in all climates, including the far north .Constructed Wetlands with Subsurface Flow In horizontal subsurface flow constructed wetlands (HSSF CWs), the wastewater flows from the inlet and flows slowly through the porous medium under the surface of a bed planted with emergent vegetation to the outlet where it is collected before leaving via a water level control structure .During passage the wastewater comes into contact with a network of aerobic, anoxic, and anaerobic zones. Most of the bed is anoxic/anaerobic because of permanent saturation of the beds. The aerobic zones occur around roots and rhizomes that leak oxygen into the substrate (Brix 1987). HSSF CWs are commonly sealed with a liner to prevent seepage and to ensure the controllable outflow. HSSF CWs are commonly used for secondary treatment of municipal wastewater although many other applications have been reported in the literature (Vymazal and Kröpfelova 2008). The oxygen transport capacity in these systems is insufficient to ensure aerobic decomposition, thus, anaerobic processes play an important role in HSSF CWs (Vymazal and Kröpfelova 2008). Some HSSF CWs, having the ability to insulate the surface of the bed, are capable of operation under colder conditions than SF systems.

A constructed wetland is an engineered ecosystem designed to replicate the functions of natural wetlands for the purpose of wastewater treatment, stormwater management, or habitat restoration. These wetlands are typically built using a variety of vegetation, soils, and other materials to mimic the natural processes that occur in wetlands, such as filtration, sedimentation, and biological degradation.

Constructed wetlands can be used to treat various types of wastewater, including municipal sewage, agricultural runoff, and industrial wastewater. They can effectively remove pollutants such as organic matter, nutrients (like nitrogen and phosphorus), heavy metals, and pathogens through physical, chemical, and biological processes.

There are two main types of constructed wetlands:

1. **Surface Flow Wetlands**: In surface flow wetlands, water flows horizontally through shallow, planted basins or channels. These wetlands rely on the interaction between plants, microbes, and soil to remove contaminants.

2. **Subsurface Flow Wetlands**: Subsurface flow wetlands, also known as vertical flow or gravel-bed wetlands, have water flowing vertically through a bed of porous media, such as gravel or sand. Microorganisms living in the media and plant roots help break down pollutants as the water passes through.

Constructed wetlands offer several advantages over conventional wastewater treatment systems, including lower energy consumption, reduced chemical usage, and providing additional benefits such as wildlife habitat and aesthetic value. However, their effectiveness can vary depending on factors such as design, hydraulic loading rates, climate, and the specific contaminants being treated

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