Constructed wetland for waste water treatment and its types An Over view

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Abstract
Wetlands, either constructed or natural, offer a cheaper and low-cost alternative technology for wastewater treatment. A constructed wetland system that is specifically engineered for water quality improvement as a primary purpose is termed as a 'Constructed Wetland Treatment System' (CWTS). Many such systems were constructed to treat low volumes of wastewater loaded with easily degradable organic matter for isolated populations in urban areas. However, widespread demand for improved receiving water quality, and water reclamation and reuse, is currently the driving force for the implementation of CWTS all over the world. Constructed wetland system are engineered systems that have been designed and constructed to utilize the natural process involving wetland vegetations, soils and their associated microbial assemblages to assist in treating waste water. They are designed to take advantages of many of the process that occur in natural wetlands, but do so within a more controlled environment. The other terms are used in constructed wetland are manmade, engineered or artificial wetlands.

Key words: Constructed wetland, types, advantages, disadvantages

Why use a constructed wetland

Constructed wetlands can treat wastewater from a variety of sources. One of the more common uses is to provide additional or advanced treatment of wastewater from homes, businesses and even communities. Wetlands treat wastewater that has already had most of the solid materials removed from it through some type of primary or secondary treatment.

Homes, businesses, farms, schools and other individual wastewater sources in rural areas sometimes can add a constructed wetland to a septic system or other onsite system to replace or assist a soil absorption field. Some onsite systems can be specifically designed from the start to use a constructed wetland in addition to a soil absorption field on properties with site constraints, such as tight or saturated soils.

Wetlands are good at handling intermittent periods of both light and heavy wastewater flows. Therefore, they often work well with wastewater treatment systems that serve hotels, campsites, resorts and recreational areas (Wang et al., 2017).

In environmentally sensitive areas, constructed wetlands can be used with onsite systems to improve the quality of the effluent before it is returned to the environment. They are also used on farms as an inexpensive way to provide extra treatment to animal wastes and by certain industries such as pulp and paper mills. Constructed wetlands are common in mining regions and are used to treat mine drainage. Wetlands are not practical for treating industrial wastewater that includes pesticides, herbicides or large amounts of ammonia. Additionally, wetland plants may accumulate high concentrations metals from some wastewater sources. This may affect the habitat value of the wetland (Haiming et al., 2015).

Natural wetlands vs. constructed wetlands

Constructed wetlands, in contrast to natural wetlands, are man-made systems or engineered wetlands that are designed, built and operated to emulate functions of natural wetlands for human desires and needs. It is created from a non-wetland ecosystem or a former terrestrial environment, mainly for the purpose of contaminant or pollutant removal from wastewater (Malyan et al., 2020).

These constructed wastewater treatments may include swamps and marshes. Most of the constructed wetland systems are marshes. Marshes are shallow water regions dominated by emergent herbaceous vegetation including cattails, bulrushes, rushes and reeds. Constructed wetlands could be classified according to the various parameters but two most important criteria are water flow regime (Surface and subsurface) and the type of macropytic growth. Different types of constructed wetlands may be combined with each other (Hybrid system) in order to exploit the specific advantages of the different systems. The quality of the final effluent from the systems improves with the complexity.

Horizontal flow system (HFS) is, wastewater is fed at the inlet and flows horizontally through the bed to the outlet. Vertical flow systems (VFS) are fed intermittently and drain vertically through the bed via a network of drainage pipes.

Surface Flow (SF) - The use of SF systems is extensive in North America. These systems are used mainly for municipal wastewater treatment with large wastewater flows for nutrient polishing. The SF system tends to be rather large in size with only a few smaller systems in use. The majority of constructed wetland treatment systems are Surface-Flow or Free-Water surface (SF) systems. These types utilize influent waters that flow across a basin or a channel that supports a variety of vegetation, and water is visible at a relatively shallow depth above the surface of the substrate materials. Substrates are generally native soils and clay or impervious geotechnical materials that prevent seepage (Rahman et al., 2020). Inlet devices are installed to maximize sheet flow of wastewater through the wetland, to the outflow channel. Typically, bed depth is about 0.4 m.

Sub-surface Flow (SSF) system - The SSF system includes soil-based technology which is predominantly used in Northern Europe and the vegetated gravel beds are found in Europe, Australia, South Africa and almost all over the world.

In a vegetated Sub-surface Flow (SSF) system, water flows from one end to the other end through permeable substrates which is made of mixture of soil and gravel or crusher rock. The substrate will support the growth of rooted emergent vegetation (Cangioli et al., 2022). It is also called "Root-Zone Method" or "Rock-Reed-Filter" or "Emergent Vegetation Bed System". The media depth is about 0.6 m deep and the bottom is a clay layer to prevent seepage. Media size for most gravel substrate ranged from 5 to 230 mm with 13 to 76 mm being typical. The bottom of the bed is sloped to minimize water that flows overland. Wastewater flows by gravity horizontally through the root zone of the vegetation about 100-150 mm below the gravel surface. Many macro and micro-organisms inhabit the substrates. Free water is not visible. The inlet zone has a buried perforated pipe to distribute maximum flow horizontally through the treatment zone. Treated water is collected at outlets at the base of the media, typically 0.3 to 0.6 m below bed surface (Zhang et al., 2014).

Examples of wetland plants

There is a variety of marsh vegetation that is suitable for planting in a CWTS (Table 1). These marsh species could be divided into deep and shallow marshes.

Table 1: List of emergent wetland plants used in constructed wetland treatment systems.

Planting zones	Common name	Scientific name
Marsh and deep marsh (0.3-1.0 m)		
	Common Reed	*Phragmites karka*
	Spike Rush	*Eleocharis dulcis*
	Greater Club Rush	*Scirpus grossus*
	Bog Bulrush	*Scirpus mucronatus*
	Tube Sedge	*Lepironia articulata*
	Fan Grass	*Phyllidrium lanuginosum*
	Cattail	*Typha angustifolia*
Shallow marsh (0-0.3 m)		
	Golden Beak Sedge	*Rhynchospora corymbosa*
	Spike Rush	*Eleocharis variegata*
	Sumatran Scleria	*Scleria sumatrana*
	Globular Fimbristylis	*Fimbristylis globulosa*
	Knot Grass	*Polygonum barbatum*
	Asiatic Pipewort	*Eriocaulon longifolium*

Advantages

- Constructed wetlands are typically inexpensive to build and maintain.
- They require little or no energy to operate.
- They can provide effective tertiary treatment
- They can provide additional wildlife habitat.
- They can be aesthetically pleasing additions to homes and neighborhoods.
- They are viewed as an environmentally friendly technology and are generally well received by the public.

Disadvantages

- Constructed wetlands require more land area than many other treatment options.
- Surface flow wetlands can attract mosquitoes and other pests.
- Wetlands are not appropriate for treating some wastewater with high concentrations of certain pollutants.
- The performance of wetlands may vary based on usage and climatic conditions.
- There is a prolonged initial start-up period before vegetation is adequately established.

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