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EMERGING ECO-FRIENDLY GREEN TECHNOLOGY FOR WASTE WATER TREATMENT IN INDIA

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ABSTRACT

Wastewater treatment is a problem that has plagued man ever since he discovered that discharging his wastes into surface waters can lead to many additional environmental problems. The Water (Prevention and control of Pollution) Act led to the construction of many new wastewater treatment facilities across the country to help control water pollution. Today, a wide range of treatment technologies are available for use in our efforts to restore and maintain the chemical, physical, and biological integrity of the nation's waters. One such emerging treatment technology for waste water is constructed wetlands. Constructed wetlands have great potential as a green technology for a variety of waste waters due to its in expensive nature, which makes it potentially cost effective. In this article an overview of Constructed wetlands as green emerging technology for waste water treatment in India.

INTRODUCTION

Water waste treatment refers for the process of removing contaminants and undesirable components from domestic, industrial and polluted water to safely return it to the environment industrial and other uses.

Today the increase in ecological awareness and enhance government regulations has made some conventional waste water treatment system questionable. To fill the gap left by less than adequate conventional technologies advanced green technologies are tested wetted and implemented as clean alternatives for waste water treatment purposes. Mankind has been exploiting the natural resources since the beginning of civilization to ensure his comfort and well being under an illusion that the demand for our natural resources could never exceed supply. This attitude has led man to consume his natural resources with little regard for conservation or economy. On the basis of natural average consumption our water resources are adequate for the present in some areas but marginal in other areas such as arid and semi arid regions. In order to meet the water needs, the wastewater from various sources are treated and reused. One such method of wastewater treatment is constructed wetlands. Constructed wetlands are now used to improve the quality of point and nonpoint sources of water pollution, including storm water runoff, domestic wastewater, municipal, industrial water waste, agricultural wastewater, and coal mine drainage. Constructed wetlands are also being used to treat petroleum refinery wastes, compost and landfill leachates, fish pond discharges, and pretreated industrial wastewaters, such as those from pulp and paper mills, textile mills, and seafood processing. For some wastewaters, constructed wetlands are the sole treatment; for others, they are one component in a sequence of treatment processes.

Constructed Wetlands as Ecosystems

Constructed wetlands are artificial wastewater treatment systems consisting of shallow (usually less than 1 m deep) ponds or channels which have been planted with aquatic plants, and which rely upon natural microbial, biological, physical and chemical processes to treat wastewater. They typically have impervious clay or synthetic liners, and engineered structures to control the flow direction, liquid detention time and water level. Depending on the type of system, they may or may not contain an inert porous media such as rock, gravel or sand. In general, constructed wetlands require little operation and maintenance when compared with technical treatment systems.

Wetland vegetation provides a substrate (roots, stems, and leaves) upon which microorganisms can grow as they break down organic materials. The microorganisms and natural chemical processes are responsible for approximately 90 percent of pollutant removal and waste breakdown. There is variety of wetland vegetation in the ecosystem buckbeans (Menyanthes trifoliata) and pendant grass *(Arctophila fulva)* like common reeds *(Phragmites australis),* bulrushes *(Schoenoplectus),* Water Hyacinth (Eichhornia crassipes), cattails *(Typha)* White Water lily *(Nymphaea⁻ alba),* and Pickerelweed *(Pontedaria cordata)* etc. whose choice depends on the existing climate conditions.

Types of Constructed Wetlands

Constructed wetlands for wastewater treatment can be categorized as either Free Water Surface (FWS) or Subsurface Flow (SSF) systems. Constructed wetland systems can also be combined with conventional treatment technologies.

(a) Free Water Surface Wetlands: A surface flow (SF) wetland consists of a shallow basin, soil or other medium to support the roots of vegetation, and a water control structure that maintains a shallow depth of water a shown in figure I. The water surface is above the substrate. Water depths less than 0.4 m and typical hydraulic loading rates are between 0.7 and 5.0 cm d^{-1}.SF wetlands look much like natural marshes and can provide wildlife habitat and aesthetic benefits as well as water treatment. In SF wetlands, the near surface layer is aerobic while the deeper waters and substrate are usually anaerobic.[1]

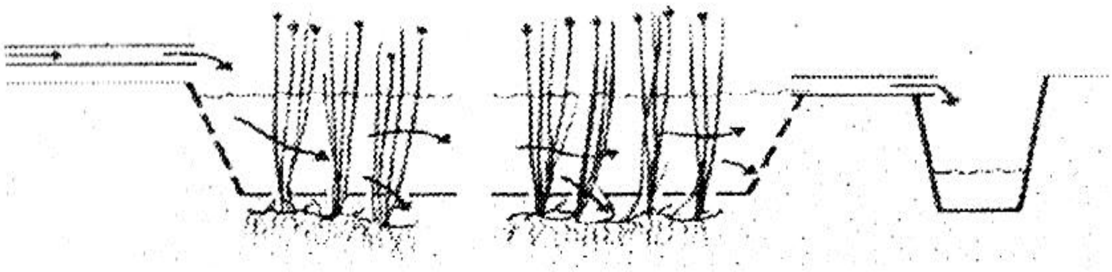

Fig. 1: Surface Flow Wetland.

(b) Sub Surface Flow Wetlands: subsurface flow (SSF) wetland consists of a sealed basin with a porous substrate of rock or gravel as shown in figure 2. The water level is designed to remain below the top of the substrate. The bed depth in SSF wetlands is typically between 0.6 and 1.0 m. and typical hydraulic loading rates in SSF wetlands range from 2 to 20 cm d-.[2] The environment within the SSF bed is mostly either anoxic or anaerobic. Oxygen is supplied by the roots of the emergent plants and is used up in the Biofilm growing directly on the roots and rhizomes, being unlikely to penetrate very far into the water column itself.

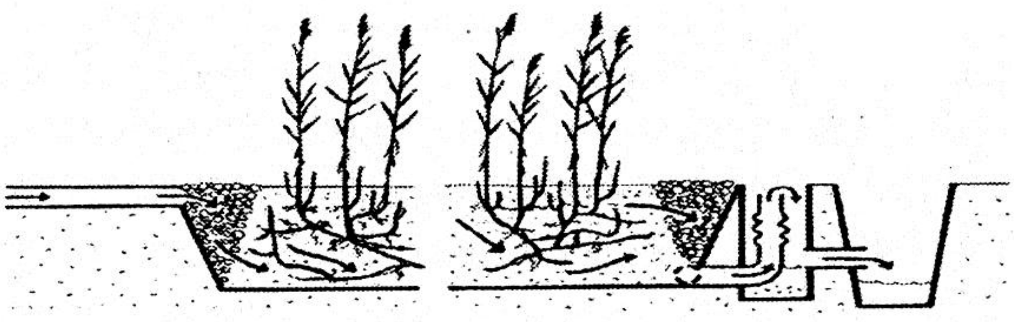

Fig. 2: Sub Surface flow Wetland.

There are two types of sub surface flow wetlands horizontal SSF wetlands and vertical SSF wetlands. The effluent may move either horizontally, parallel to the surface, or vertically, from the planted layer down through the substrate and out. Subsurface horizontal-flow wetlands are less hospitable to mosquitoes, whose populations can be a problem in constructed wetlands. The most common problem with horizontal SSF is blockage, particularly around the inlet zone, leading either to short circuiting, surface flow or both.

Treatment Processes in Constructed Wetlands

Wetland can effectively remove or convert large quantities of pollutants from point sources (municipal, industrial and agricultural wastewater) and non-point sources (mines, agriculture and urban runoff), including organic matter, suspended solids, metals and nutrients. The focus on wastewater treatment by constructed wetlands is to optimize the contact of microbial species with substrate, the final objective being the bioconversion to carbon dioxide, biomass and water. Wetlands are characterized by a range of properties that make them attractive for managing pollutants in water. These properties include high plant productivity, large adsorptive capacity of the sediments, high rates of oxidation by micro flora associated with plant biomass, and a large buffering capacity for nutrients and pollutants.[3] The processes are discussed below.

1. Biological Processes: There are six major biological reactions involved in the performance of constructed, wetlands, including photosynthesis, respiration, fermentation, nitrification, denitrification and removal Photosynthesis is performed by wetland plants and algae, with the process adding carbon and oxygen to the wetland. Both carbon and oxygen drive the nitrification process. Plants transfer oxygen to their roots, where it passes to the root zones (rhizosphere). Respiration is the oxidation of organic carbon, and is performed by all living organisms, leading to the formation of carbon dioxide and water. The common microorganisms in the CW are bacteria, fungi, algae and protozoa. Fermentation is the decomposition of organic carbon in the absence of oxygen, producing energy-rich compounds (e.g., methane, alcohol, volatile fatty acids). This process is often undertaken by microbial activity. Nitrogen removal by nitrification/denitrification is the process mediated by microorganisms. The physical process of volatilization also is important in nitrogen removal. Plants take up the dissolved nutrients and other pollutants from the water, using them to produce additional plant biomass.[2] The nutrients and pollutants then move through the plant body to underground storage organs when the plants senesce, being deposited in the bottom sediments through litter and peat accretion when the plant die.

2. Chemical processes: Metals can precipitate from the water column as insoluble compounds. Exposure to light and atmospheric gases can break down organic pesticides, or kill disease-producing organisms. The pH of water and soils in wetlands exerts a strong influence on the direction of many reactions and processes, including biological transformation, partitioning of ionized and unionised forms of acids and bases, cation exchange, solid and gases solubility.

3. Physical processes: Sedimentation and filtration are the main physical processes leading to the removal of wastewater pollutants. The effectiveness of all processes (biological, chemical, physical) varies with the water residence time (i.e., the length of time the water stays in the wetland). Longer retention times accelerate the remove of more contaminants; although too-long retention times can have detrimental effects.[2] The overall removal of the pollutants in the waste water by various mechanisms is given in table 1.

Advantages and Disadvantages in Constructed Wetlands

Constructed wetlands are a cost-effective and technically feasible approach to treating wastewater and runoff .wetlands can be less expensive to build than other treatment options as the operation and maintenance expenses (energy and supplies) are low and require only periodic, rather than continuous, on-site labor. They are able to tolerate fluctuations in flow and also facilitate water reuse and recycling. Also they provide habitat for many wetland organisms and it can be built to fit harmoniously into the landscape.[4] They provide numerous benefits in addition to water quality improvement, such as wildlife habitat and the aesthetic enhancement of open spaces.

Table 1: Overview of Pollutant Removal Mechanisms.

Pollutant	Removal Processes
Organic material (measured as BOD)	Biological degradation, sedimentation, microbial uptake
Organic contaminants (e.g., pesticides)	Adsorption, volatilization, photolysis, and biotic/abiotic degradation
Suspended solids	Sedimentation, filtration
Nitrogen	Sedimentation, nitrification/denitrification, microbial uptake, volatilization
Phosphorous	Sedimentation, filtration, adsorption, plant and microbial uptake
Pathogens	Natural die-off, sedimentation, filtration, predation, UV degradation, adsorption
Heavy metals	Sedimentation, adsorption, plant uptake

There are limitations associated with the use of constructed wetlands as they generally require larger land areas than do conventional wastewater treatment systems. Wetland treatment may be economical relative to other options only where land is available and affordable Also they require a continuous supply of water i.e. supplemental water will have to be added if the wastewater supply is not sufficient to sustain plant populations during dry periods. The efficiency may vary `seasonally in response to changing environmental conditions, including rainfall and drought. While the average performance over the year may be acceptable, wetland treatment cannot be relied upon if effluent quality must meet stringent discharge standards at all times. The biological components are sensitive to toxic chemicals, such as ammonia and pesticides will destroy the plant life in the wetland.[4]

CONCLUSION

Constructed wetlands have a great potential for contaminated wastewater treatment. A variety of potential consumptive, non consumptive and economic benefits exist for constructed wetlands, including enhanced landscape diversity, wildlife and fisheries habitat, agricultural values, recreational activities, sediment retention, water pollution control, public water supplies, and industrial uses. With careful design and planning, a constructed wetland can efficiently remove a variety of contaminants. The cost for design, construction and implementation can be considerably lower than other wastewater treatment options. However, long-term management plans developed from research-based knowledge of ecosystem processes are required before multiple use values of these constructed wetlands can be realized.

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