Domestic Wastewater Treatment Trought Constructed Wetland System

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Abstract- *Water is most essential for sustenance of life on this earth. Due to increase in population and urbanization the demand for fresh water is increasing and fresh water resources are getting polluted. One such method is the estimation of domestic waste water potential through constructed wet land. A wetland is a land area that is saturated with water, either permanently or seasonally, such that it takes on the characteristics of a distinct ecosystem. Constructed wetlands can be used to treat municipal and industrial wastewater as well as storm water runoff. Constructed wetlands can be used to treat raw sewage, storm water, agricultural and industrial effluent. Other advantages of constructed wetlands are wetlands can be less expensive to build than other treatment options, utilization of natural processes, simple construction (can be constructed with local materials),simple operation and maintenance, cost effectiveness (low construction and operation costs), process stability etc. There are certain disadvantages like wetland treatment may be economical relative to other options only where land is available and affordable, design criteria have yet to be developed for different types of wastewater and climates etc.*

Keywords- Domestic Wastewater Treatment, wetlands, Canna, Water pollution

I. INTRODUCTION

The constructed wetland systems for wastewater treatment facility involve the use of engineered systems that are designed and constructed to utilize natural processes. These systems are designed to mimic natural wetland systems, utilizing wetland plants, soils and associated microorganisms to remove contaminants from wastewater effluents. CWS pretreats wastewater by filtration, settling and bacterial decomposition in a natural looking lined marsh. Constructed wetland systems have been used internationally with good results. A properly operating constructed wetland system should produce an effluent with less than 30 mg/L BOD, less than 25 mg/L total suspended solids and less than 10,000 cfu/100 mL. The first experiments aimed at the possibility of wastewater treatment by wetland vegetation were conducted by K. Siedel in Germany in early 1950s at the max Planck Institute in Plon (Vymazal, 2005) She carried out numerous experiments on the use of wetland vegetation for treatment of various types of wastewater, like, dairy wastewater and live stock waste water. In early 1960s the scientist carried out different trials to grow macrophytes in wastewater and sludge of different origin and tried to improve the performance of rural and decentralized wastewater treatment which was either septic tanks or ponds systems with inefficient treatment.
Siedel named this early system as hydrobotanical method (Vymazal 2005). In 1970s and 1980s, constructed wetlands were nearly exclusively built to treat domestic or municipal sewage. Since 1990s, the constructed wetlands have been used for all kinds of wastewater including landfill leachate, runoff (e.g. urban, highway, airport and agricultural), food processing (e.g. winery, cheese and milk production), industrial (e.g. chemicals, paper mill and oil refineries), agriculture farms, mine drainage or sludge dewatering.

II. TYPES OF CONSTRUCTED WETLANDS

Constructed Wetland Systems generally fall into two general categories: Subsurface Flow System and Free Water Surface Systems. Both types utilize emergent aquatic vegetation and are similar in appearance to a marsh. The subsurface flow (SF) wetland consists of a basin or channel with a barrier to prevent seepage, but the bed contains a suitable depth of porous media. Rock or gravel are the most commonly used media types in the U.S. The media also support the root structure of the emergent vegetation. The design of these systems assumes that the water level in the bed will remain below the top of the rock or gravel media. These systems are also referred to as “root zone systems”, “rockreed filters” and “vegetated submerged systems”.

III. OBJECTIVE OF INVESTIGATION

- To analyze waste water sample taken from primary sedimentation tank of conventional waste water.
- To analyze effluent parameters of conventional sewage treatment plant after complete treatment.

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IV. PROBLEM STATEMENT

A) The free water surface (FWS) wetland typically consists of a basin or channels with some type of barrier to prevent seepage, soil to support the roots of the emergent vegetation, and water at a relatively shallow depth flowing through the system. The water surface is exposed to theatmosphere, and the intended flow path through the system is horizontal.

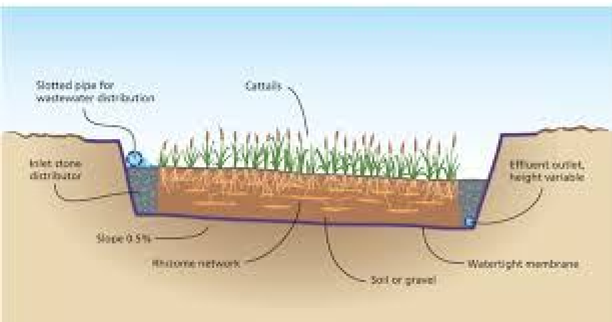

Figure 1. Subsurface Flow Constructed Wetland System

Free water systems are designed to simulate natural wetlands with water flow over the soil surface at shallow depth. Fig 2(a) and (b) shows the two types of FWS. The open water wetland has a small layer of sand to root the plants while sand layer is absent in the hydroponic wetland. FWS are better suited for large community systems an mild climates. The SF type of wetland is thought to have several advantages over the FWS type. If the water surface is maintained below the media surface there is little risk of odours, odours, exposure, or insect vectors. In addition, it is believed that the media provides greater available surface area for treatment than the FWS concept so the treatment responses may be faster for the SF type, which therefore can be smaller in area than a FWS system designed for the same wastewater conditions. The subsurface position of the water and the accumulated plant debris on the surface of the SF bed offer greater thermal protection in cold climates than the FWS type.

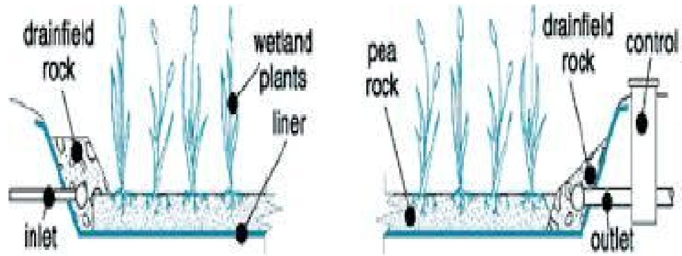

Figure 2(a). Open water wetland FWS

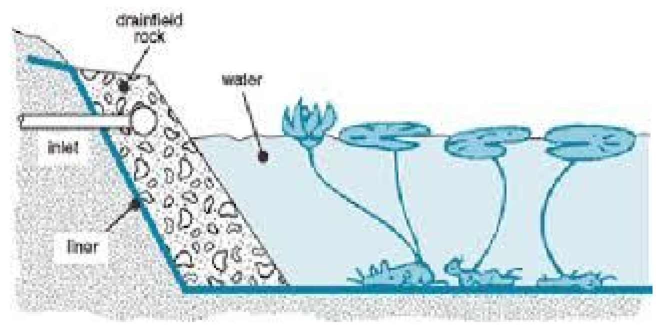

Figure 2(b). Hydroponic FWS Systems

B) Parts of Constructed wetland systems

Constructed wetland systems have generally four parts

(i) Liner
(ii) Distribution Media
(iii) Vegetation
(iv) Underdrain System

The liner helps in preventing the percolation of wastewater into the ground water. Although the liner can be made from a number of materials, Polyvinylchloride (PVC) is the most common and reliable material for liner (figure 3). Clay liners are not recommended as they are liable to crack that may allow wastewater to seep through it thereby contaminating the ground water. The distribution medium at the inlet in usually coarse drainfeild rock that ¾ to 21/2 inches in diameter. The first part of the distribution can be used to spread the wastewater evenly across the width of the wetland. Both gravity as well as pressure distribution can be used to spread the wastewater evenly over the system.

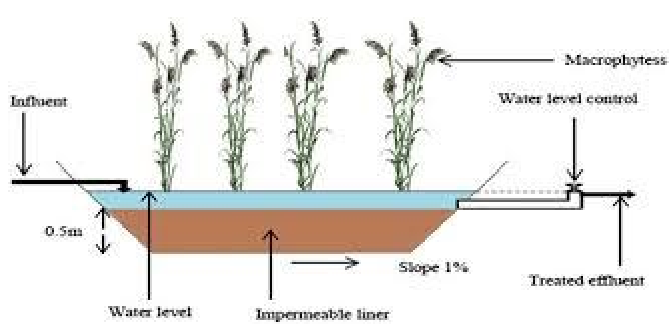

Figure 3. Wetland Controls and Liner

CWs with free floating macrophytes may contain large plants with well developed submerged roots such as water hyacinths cattails, bulrushes (Fig. 4) or a small surface floating plants with little or no roots such as duckweeds. The capacity of water hyacinths to purify wastewater is well documented. The extensive root system of the weed provides large surface area for microorganisms thus increasing the potential for decomposition of organic matter. Plant uptake is the predominant process for nutrient removal from wastewater treatment systems containing water hyacinth plants.

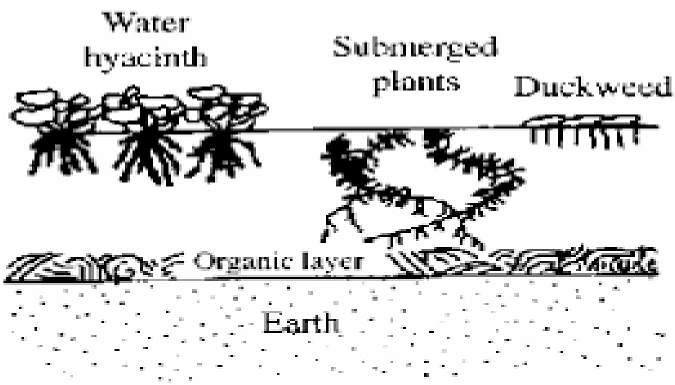

Figure 4. Floating Aquatic Plant System

The underdrain system at the end of the wetland is a slotted pipe covered with drain field rock. The underdrain moves the treated effluent out of the wetland and keeps the effluent level below the surface of the gravel. This prevents the effluent from coming into contact with people and also keeps the water level high enough to sustain growth.There are several design models based on first order plug flow kinetic models. One of the method is Reed method to calculate the area of free water surface constructed wetland considering the BOD removal, as described by the “Guide lines for using free water surface constructed wetland to treat municipal sewage” (Knight Mertz, 2000). In his model Reed incorporated flowrate, wetland depth, wetland porosity, a temperature-based rate constant, and inflow and outflow concentrations.

C) Mechanism of treatment

The two main mechanisms operative in most of the CWs are liquid/solid separations and constituent transformations. Separations typically include gravity separation, filtration, absorption, adsorption, ion exchange, stripping, and leaching. Transformations may be chemical,including oxidation/reduction reactions, flocculation, acid/ base reactions, precipitation and biochemical reactions occurring under aerobic or anaerobic conditions facilitated by root zone environment. Both separations and transformations may lead to contaminant removal in wetlands. The overall processes taking place in CWs for the removal of contaminants are divided into three categories i.e. physical, chemical and biological.

Suspended solids removal

Suspended solids removal is very effective in SF constructed wetlands. The predominant physical mechanisms for suspended solids removal are flocculation/ sedimentation and filtration. Suspended matter in wastewater may contain different types of contaminants, such as nutrients, heavy metals and organic compounds. The surface forces are also responsible for the reduction of suspended solids include Vander Waal’s force of attractions and electric forces, which may be attractive or repulsive depending on the surface charges (Metcalf and Eddy, 1991).

BOD and COD removal

The removal of BOD and COD is believed to occur rapidly through settling and entrapment of particulate matter in the void spaces in the gravel or rock media. Removal of BOD in CWs is mainly due to aerobic microbial degradation and sedimentation/filtration processes. Soluble organic compounds are removed by the microbial growth on the media surfaces and attached to the roots and rhizomes of plants. Organic matter contains approximately 45 to 50% carbon (C), which is utilized by a wide array of microorganisms as a source of energy. For this purpose oxygen is supplied by the helophytes in the root zone to convert organic carbon to carbon dioxide. Soluble organic matter may also be removed by a number of separation processes including adsorption/absorption (the movement of contaminants from one phase to another). The degree of sorption and its rate are dependent on the characteristics of both the organic matter and the solid surface (helophytes, substrate and litter). Biochemical conversions are important mechanisms to degradable organic matter in wetlands. They may account for removal of some organic constituents by virtue of mineralization or gasification and the production of organic matter through synthesis of new biomass. The decomposers (bacteria and fungi) in CWs play the main role of the removal of organic matter by way of mineralization and gasification. They are also responsible for the synthesis of biomass and the production of organic metabolic end products. In addition to this, phytovolatilization is also an important phenomenon for the removal of contaminants. Some wetland plants also take up contaminants through the root system and transfer them to the atmosphere via their transpiration stream (Hong et al., 2001; Ma and Burken, 2003). Hydrophilic compounds such as acetone (Grove and Stein, 2005) and phenol are directly removed by the process of volatilization/phytovolatilization.

V. EXPERIMENTAL IMPLEMENTATION AND RESULTS

1. CONTAMINANT REMOVAL MECHANISMS INCONSTRUCTED WETLANDS

TABLE I. Contaminant removal mechanisms in constructed wetlands

Parameters	Physical	Chemical	Biological
Suspended solids	Sedimentation Filtration		Biodegradation
Biochemical oxygen demand	Sedimentation	Oxidation Reduction	Biodegradation
Chemical oxygen demand	Sedimentation	Oxidation Reduction	Biodegradation PhytodegradationPhytovolatilization Plant uptake
Nitrogenous Compounds	Sedimentation Volatilization	Adsorption	Bio-denitrification- nitrification Plant uptake
Phosphoric Compounds	Sedimentation	Adsorption Precipitation	Microbial uptake Plant uptake
Metals	Sedimentation Filtration	Adsorption Precipitation	Plant uptake
Pathogens	Filtration UV ray action	Adsorption Oxidation	Natural death Exposure to natural toxins Bacteriophage attack

VI. CONCLUSIONS

Constructed wetlands have a great potential to treat contaminated wastewater from different origins. With careful designing and planning, a CW can efficiently remove variety of inorganic, organic and biological contaminants from domestic and industrial wastewaters.

Helophytes and microorganisms are the active agents in the treatment process. The cost for design and construction can be considerably lower than other conventional wastewater treatment options. These systems also enhance the aesthetic value of the local environment. Although this paper deals with the study of mechanism of several contaminants removal in CWs but still a long-term investigation is required.

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