Potential of CWTS as a Treatment option for Small Waste Producer

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Abstract:

The design and construction of green buildings needs careful consideration to three main elements like healthy indoor environment, maximum energy efficiency and conservative, thoughtful use of natural resources. Thus in the era of Green Buildings there is need of low cost user friendly technology in order to treat waste produced by small waste producer. In India septic tanks are conventionally accepted as total treatment option for small waste producer. However the septic tanks may not provide total treatment and effluent may cause contamination of ground water and surface water resources. The nutrients, nitrogen and phosphorus are common constituents of septic effluents and both have biological detrimental effects. High levels of nitrate in sources of potable water and pose a threat to human health where as phosphorus is an essential nutrients and causes eutrophication of water bodies. To avoid the detrimental effects it is essential to treat septic effluent before its safe disposal. Though numerous advances are made in traditional wastewater treatment methodologies, reactor based chemical or biological nutrient removal technologies are not practically feasible and not affordable for small wastewater producer. The option of Constructed Wetland Treatment Systems (CWTS) may prove to be a viable alternative being a natural system of the treatment. A brief account of this technology is presented in this paper.

Introduction:

According to official figures, 43 per cent of urban households are without latrines or connections to septic tanks or sewerage. Access to excreta disposal systems in urban areas varies from 48 per cent to 70 per cent. Out of 300 Class I cities about 70 have partial sewerage systems and treatment facilities. A study by the Central Pollution Control Board in 1994-95 had shown that 15,800 million liters of wastewater is generated in Class I cities every day but treatment facility is available for only 3,750 million liters. Of the total wastewater generated in the metros hardly 30 per cent is treated before disposal. Most of the cities have only primary treatment facilities. This is a cause for concern because the untreated and partially treated municipal waste water finds its way into water sources like rivers, lakes and ground water leading to pollution.

The septic tank as a sewage treatment unit has been in use for number of years. It is assumed to be total treatment where conventional sewerage system is not available and the septic tank effluent is disposed off through soakage pits, absorption trenches or some other suitable means. The septic tank effluent is both offensive and potentially dangerous. It is dark, malodorous, and septic. It also has suspended solids together with most of the colloidal and dissolved solids from the raw sewage. Bacteria, protozoa, viruses and worms are present in the effluent in large numbers. The performance of septic tank is very erratic. At times the effluent is clear and inoffensive, at times it carries out floating solids, scum, sludge, which increase BOD make it offensive. Principally it is expected to have complete conversion of organic matter to a stable form which is no more subjected to biochemical transformations, before safe disposal of the effluent. The factors like volume, rate of effluent flow, soil characteristics and topography, subsurface conditions, depth of GWT, proximity of water resources, future extension of habitation, existing wind patterns etc. need consideration while confirming the ultimate site for effluent disposal. Practically such considerations not seem to be given. The adoption of commercially available unit, lack of maintenance, unawareness of technical facts, apathy towards environmental hygiene, dense habitations may be the possible reasons.

A major concern of use of septic tank and subsequent disposal of septic effluent on land through soakage pits and absorption trenches is the potential of polluting the ground water. The problems are more worse when the communities that dispose of the septic effluent on land where open wells and tube wells are used as sources of drinking water. This is very common scenario especially in rural communities of India. To summarize the septic tank effluent is potentially harmful and no standards can be observed with it. The septic tank effluent must be provided with secondary treatment to prevent health hazards likely to arise because of its unsafe disposal. The secondary treatment can be provided in the form of constructed wetlands.

Application of CWTS –

Constructed Wetland Treatment System (CWTS) is a typical natural, engineered treatment system designed and developed to utilize the natural processes involving wetland vegetation, some filter bed consisting sand or gravel or such material and their associated microbial assemblage in order to treat wastewater. The CWTS is a common feature in Europe, America and Australia. However the spread of use of this technology in developing country like India is very slow.

Wetlands are commonly known as biological filters, providing protection for water resources such as lakes, estuaries and ground water. Although wetlands have always served this purpose, research and development of wetland treatment technology is a relatively recent phenomenon. Studies of the feasibility of using wetlands for wastewater treatment were initiated during the early 1950s in Germany. In the United States, wastewater-to-wetlands research began in the late 1960s, and increased dramatically in scope during the 1970s. As a result, the use of wetlands for water and wastewater treatment has gained considerable popularity worldwide. Currently, an estimated one thousand wetland treatment systems, both natural and constructed, are in use in North America. (Brix 1998)

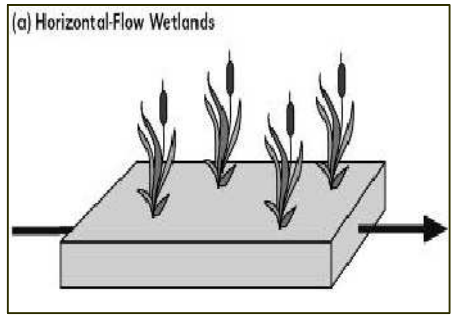
Classification of CWTS:

There are three major types of constructed wetlands; free water surface (surface flow, or open water), horizontal subsurface flow (vegetated submerged bed, root-zone or rock-reed filters), and vertical flow systems. All three have been employed in pollutants removal systems and are discussed below.

Free Water Surface

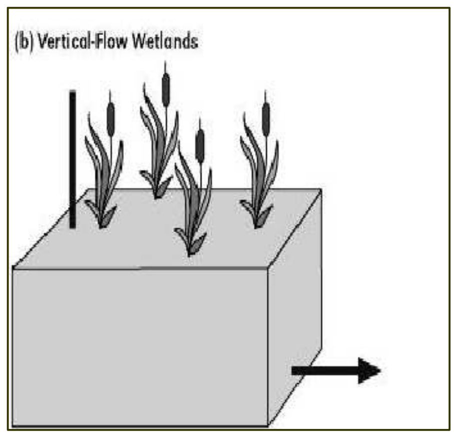
Free water surface (FWS) wetlands consist of a shallow basin, typically 60 to 90 cm deep, which supports the growth of emergent wetland plants. These systems closely resemble natural marshes (EPA 2000). Because they contain open water, these wetlands are typically employed as polishing systems. These wetlands are often thought to support relatively high oxygen transfer rates due to their exposed water surface and atmospheric diffusion. However, it has been demonstrated that vegetated zones within the wetland exert an internal oxygen demand due to decaying vegetation and that as a result, vegetated zones function as reducing environments.

Horizontal Subsurface Flow (HSSF) Wetlands



Horizontal subsurface flow (HSSF) wetlands are commonly employed as an onsite treatment technology. These systems use a gravel bed planted with wetland vegetation (Seidel, 1973). The water surface is kept below the top of the gravel so that wastewater is not exposed during the treatment process, making HSSF wetlands suitable for onsite applications. A design criterion established by the Tennessee Valley Authority (Steiner & Watson, 1993) has resulted in large numbers of small HSSF wetlands being constructed.

Vertical Flow (VF) Wetlands



Vertical flow wetlands use a gravel bed planted with emergent wetland plants. These systems can be operated in either a downward or upward flow mode (IWA 2000). Work with a vertical flow wetland system indicated that operating the system in an upflow mode created a reducing environment appropriate for denitrification, while operating the system in a downflow mode created an aerobic environment appropriate for nitrification.

Mechanisms of Pollutants Removal in Constructed Wetlands

Wetlands enhance water quality using a combination of physical, biological, and chemical mechanisms (EPA, 1993).

Physical Removal Processes

Wetlands are capable of providing highly efficient physical removal of contaminants associated with particulate matter in the water or waste stream. Surface water typically moves very slowly through wetlands due to the characteristic broad sheet flow and the resistance provided by rooted and floating plants. Sedimentation of suspended solids is promoted by the low flow velocity and by the fact that the flow is often laminar (not turbulent) in wetlands. Mats of floating plants in wetlands may serve, to a limited extent, as sediment traps, but their primary role in suspended solids removal is to limit resuspension of settled particulate matter.

Biological Removal Processes

Biological removal is perhaps the most important pathway for contaminant removal in wetlands. Probably the most widely recognized biological process for contaminant removal in wetlands is plant uptake. Contaminants that are also forms of essential plant nutrients, such as nitrate, ammonium and phosphate, are readily taken up by wetland plants. However, many wetland plant species are also capable of uptake and even significant accumulation of, certain toxic metals such as cadmium and lead. The rate of contaminant removal by plants varies widely, depending on plant growth rate and concentration of the contaminant in plant tissue. Woody plants, i.e., trees and shrubs, provide relatively long-term storage of contaminants, compared with herbaceous plants. However, contaminant uptake rate per unit area of land is often much higher for herbaceous plants, or macrophytes, such as cattail. Algae may also provide a significant amount of nutrient uptake, but are more susceptible to the toxic effects of heavy metals. Storage of nutrients in algae is relatively short-term, due to the rapid turnover (short life cycle) of algae. Bacteria and other microorganisms in the soil also provide uptake and short-term storage of nutrients, and some other contaminants.

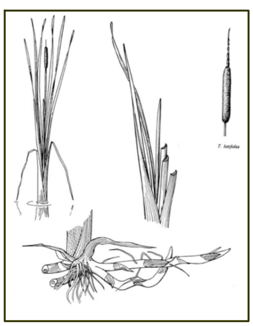
Chemical Removal Processes

In addition to physical and biological processes, a wide range of chemical processes are involved in the removal of contaminants in wetlands. The most important chemical removal process in wetland soils is sorption, which results in short-term retention or long-term immobilization of several classes of contaminants. Sorption is a broadly defined term for the transfer of ions (molecules with positive or negative charges) from the solution phase (water) to the solid phase (soil). Sorption actually describes a group of processes, which includes adsorption and precipitation reactions.

Role of Aquatic Macrophytes in CWTS

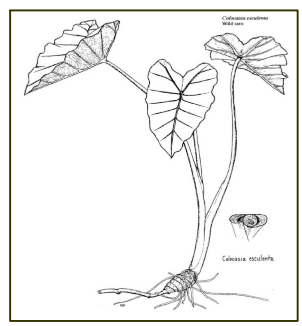
Blue Flag

Macrophytes have several intrinsic properties that make them an indispensable component of constructed wetlands. The most important functions of the macrophytes in relation to the treatment of wastewater are the physical effects brought about by the presence of the plants. The macrophytes stabilise the surface of the beds, provide good conditions for physical filtration, prevent vertical flow systems from clogging, insulate against frost during winter, and provide a huge surface area for attached microbial growth. Contrary to earlier belief, the growth of macrophytes does not increase the hydraulic conductivity of the substrate in soil-based subsurface flow constructed wetlands. The metabolism of the macrophytes affects the treatment processes to different extents depending on the design of the constructed wetland. Plant uptake of nutrients is only of quantitative importance in low-loaded systems (surface flow systems). Macrophyte-mediated transfer of oxygen to the rhizosphere by leakage from roots increases aerobic degradation of organic matter and nitrification. The macrophytes have additional site-specific values by providing habitat for wildlife and making treatment systems aesthetically pleasing.(Brix 1994). A few of the aquatic plants are shown in figures.



Cat Tail

Pickerel Weed



Colcacia

Operation and Maintenance of CTWS

CTWS are designed to be low maintenance systems and do not need continuous attention. However they involve so many parameters to bring about changes in its treatment potential. Major operation and maintenance program needs to maintain the water level in reactor beds, the proper growth of wetland plants and neat working of inlet and outlet structures. The main objectives of this program (CPCB 2001), therefore, are:

- To ensure the wetland to operate as per design objectives under all circumstances
- To maximize treatment efficiency and capacity

- To save costs by providing early warning mechanisms through detection of problems at early stages
- To extend the active life span of the system thereby delaying the need for major retrofitting and hence long term viability of the system

Conclusion:

Septic tanks are accepted as total treatment unit where conventional sewerage system is not available. However treatment is not total and septic effluent must be treated before its safe disposal. Though secondary treatment options are available, they may not be affordable for the small waste water producer. Even it may not be practical to go for such treatment options due to some other constraints. The treatment of CWTS has inherent advantages and is not a new criterion as far as European scenario is concerned. The technology has entered in India but still is in its infancy stage. The technology may prove to be a viable alternative being a natural system of the treatment in the developing country like India. The system is energy efficient and saves operation and maintenance cost. It does not use chemicals and also does not give rise to waste materials hence reduce chemical and disposal costs. The wetland plants may be subjected to some other usage after harvesting hence it encourages reuse and recycling of the materials. On this ground treatment of CWTS seems to be beneficial component of Green Buildings.

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