The Potential of Sewage Treatment through Constructed Wetlands in Northeast India: A Critical Review

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ABSTRACT

The benefits of economical treatment systems and global demand for introducing sustainable way of environmental management, the Constructed Wetlands (CWs) treatment of domestic sewage is rising rapidly all over the globe. The Total nitrogen in the sewage is the summation of Organic Nitrogen, Nitrate Nitrogen, Nitrite Nitrogen and Ammonium Nitrogen. Ammonification, Matrix Adsorption, Nitrification, Denitrification, Plant Uptake and Ammonia Volatilization are the principle involved for total nitrogen removal in the treatment of sewage using CWs. This paper provides a comprehensive review by comparative analysis of effects of type and nature of flow system, wetland structures, types of Macrophyte, removal mechanisms, Aeration, Step-feeding and other key operational parameters and conditions for the enhance removal of total nitrogen in CWs.

Keywords: Constructed Wetlands (CWs); Macrophyte; Total Nitrogen Removal; Domestic Sewage Treatment;

1 INTRODUCTION

The contemporary rising problems of water environment like water crises, water pollution and global water resources degradation. India is one of the fastest developing countries in the world. Moreover, the condition is fetching further serious because of combined effects of environmental-unfriendly activities and population explosion particularly in developing countries [Vymazal, 2011]. The assessed waste water generation in the country was 61754 MLD as compared to the developed waste water treatment volume of 22963 MLD. due to gap in sewage treatment volume, about 38791 MLD of untreated waste water (62% of the total waste water generation) is discharged straight into water bodies in the year 2015. No waste water treatment system found in seven states/UTs viz. Arunachal Pradesh, Chhattisgarh, Daman Diu, Nagaland, Assam & Tripura [CPCB, 2016]. Most of these states are located in Northeastern India.

The Northeast states of India are enriched with wetlands with enormous bio-diversity. Considering the importance of water bodies, the Ramsar Convention of Wetlands designated Rudrasagar situated in Tripura, Loktak lake situated in Manipur, Deepor beel situated in Assam as Ramsar sites (Wetland of International Importance). There are still many more wetlands of the northeast region which need such initiative keeping in views of their importance role in ecology and socio-economic of the people. These wetlands are under pressure due to overexploitation and other anthropogenic activities leading to deterioration of water qualities and degradation of bio-resources.

Conventional waste water treatment plant such as Activated Sludge Process, Trickling Filter, Upflow Anaerobic Sludge Blanket etc. have been employing effectively for treating sewage. Poor collection, high cost and

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sometime non eco-friendly are the main factor on which Conventional sewage treatment systems are unacceptable. Therefore, constructed wetland (CWs) is a realistic choice for treating sewage and is enticing great concern owing to lesser cost, a reduced amount of operation and maintenance necessities [Rai et al., 2013]. Constructed wetlands make use of natural processes in order to remove pollutants from sewage.

2 MATERIALS AND METHODS

2.1 Constructed Wetlands

CWs is defined as engineered systems that have been designed and constructed to utilize the natural processes involving wetland vegetation, soils, and the associated microbial assemblages to assist in treating wastewaters (Vymazal, 2010a). It is intended to yield benefit of many of the same processes that happen in natural wetlands, but do so within a more controlled environment.

2.2 Horizontal Subsurface flow Constructed Wetlands (HSSFCW)

It is called HSSFCW due to the sewage is feed as influent and move gradually through the permeable bed in a plane path until it reaches the effluent zone. All through this route the waste water will subjected to the condition of aerobic, anaerobic and anoxic. The aerobic zones will be around the roots and rhizomes of the wetland vegetation that leak oxygen into the substrate [Brix, 1987]. Throughout the route of sewage into the rhizosphere, the sewage is treated by biological degradation and by physical and chemical processes [Cooper et al., 1996]. The vital parameter in constructed wetland treatment of sewage are filling media, influent and effluent structures and vegetation.

2.3 Pollutants Removal Mechanisms

The primary pollutants removal mechanisms in constructed wetlands are listed in Table 1.

Table 1: Pollutants removal mechanisms in CWs (Cooper et al., 1996).

Sewage constituents	Removal Mechanisms
Suspended solids	Sedimentation, Filtration
Soluble organics	Aerobic microbial, degradation, Anaerobic microbial degradation
Phosphorus	Matrix sorption, Plant uptake
Nitrogen	Ammonification followed by microbial nitrification, Denitrification, Plant uptake, Matrix adsorption
Metals	Adsorption and cation exchange, Precipitation, Plant uptake, Microbial oxidation/ reduction
Pathogens	Sedimentation, Filtration, Natural die off

2.4 Design considerations

The important factors to be considered while designing a HSFCW for domestic sewage treatment are; Pre or primary treatment, media selection, Aspect ratio, water depth, surface area, substrate selection, feeding mode, seasonal variation and Hydraulic Loading Rate (HLR) and Detention period. The different types of media and their roles used in constructed wetlands are discussed. The criteria's which dominates the selection of media are its hydraulic permeability and sorption capacity along with its availability at reasonable cost. The finer particles have little hydraulic conductivity which produce surface flow. The coarser particles have more conductivity, but have tiny wetted surface area per unit volume of microbial habitat. Particles which are large and angular medium is hostile to root spread. sanitary sewage treatment using are found to be more efficient

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when an aspect ratio (length: width) of 4:1 for sub-surface flow wetlands. Generally, the depth of substrate is restricted to roughly the rooting depth of plants in case of SSF wetland because the macrophyte are interaction with the flowing sewage and have an consequence on treatment system. However, Detention period is to be taken care of while choosing of the bed height of the wetland system.

As per review, it is found that most wetlands in Europe provide a bed depth of around 60 cm. On the other hand, the United States has wetlands have usually been designed with around beds depth of 30 cm to 45 cm deep (Steiner & Watson, 1993). An experimental study carried out in Spain exposed that shallow wetlands with an average depth of 27 cm were more effective than deep horizontal flow wetlands with an average water depth of 50 cm (Garcia et al., 2004). It is recommended to use an average depth of 40 cm taking into considerations of the rainfall which create surface flow.

The hydraulic loading rate or hydraulic retention time directly affects the organics, nutrients and pathogens removal efficiencies of CW systems. Operation and maintenance of CWs can be categorized in relations of start-up, routine and long-term. There are significant differences between these; start-up necessities will display more site-to-site variability, routine operations may be more affected by design particulars and long-term operations replicate loading. As the constructed wetlands are "natural" systems, routine operation is generally passive and entails slight operator involvement. The greatest serious matters in which operator involvement is required are: Alteration of water levels, Maintenance of flow homogeneousness (inlet and outlet structures), Managing the vegetation, odour control etc.

3 Critical Conclusions

This review study demonstrate that the significant parameter affecting design and operation of HSSFCW are media selection, Aspect ratio, water depth, surface area, substrate selection, feeding mode, seasonal variation, HLR & HRT which are crucial to achieve best performance HSSFCW. Most of the researchers have reported that the Vertical Subsurface Flow CW (VSSFCW) are effective for the elimination of organics and nitrification (in case of intermittent feeding only), also the organics aerial loading rates for VSSFCW are also high (less area requirement) as compared with HSSFCW. However, HSSFCW requires simple influent distribution and effluent collection systems, less energy necessity, better denitrification rate than VSSFCW, and there is greater possibility for growing the aerial loading rate for HSSFCW along with facilitating greater nitrification rate by employing higher length to width ratios. By providing baffles or chambers across the length of wetland, employing step feeding and in some cases intermittent aeration for effective nitrification was realize. Review further implies that the future studies should focus on comprehensive evaluation comprising different stages CWs system in the field trial under real life condition with various combinations for effective treatment of sewage in northeast India as a particular and developing country like India as a whole.

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