COMPARISON STUDY ON TREATMENT OF CAMPUS WASTEWATER BY CONSTRUCTED WETLANDS USING CANNA INDICA & PHRAGMITES AUSTRAILS PLANTS

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Abstract - The constructed wetlands have gained significance for treatment of wastewater and is considered as successful optional for treatment system. The major components of the constructed wetland are vegetation type, hydraulic retention time (HRT) and bed media. The main aim of the present study was treatment of untreated wastewater from campus through horizontal subsurface flow constructed wetland and compare the efficiency of two different plants. The pilot scale model of horizontal subsurface flow constructed wetland consists of 0.6mx0.4mx0.3m dimensions and total wetland volume was 0.03363m^3 provided with suitable outlets. Sand and gravels were used as bed media and plants were used for experiment were Phragmites Austrails (CW1) and Canna Indica (CW2). In this paper we are evaluated performance of Pharagmites Austrails and Canna Indica in subsurface flow systems for removal percentage of pollutants such as Chemical oxygen demand(COD), Biochemical oxygen demand (BOD$_3$) ,Total solids (TS) , Total suspended solids (TSS) , Total dissolved solids (TDS) and Phosphate at different Hydraulic retention time.

Key Words: *Constructed wetlands, HRT (Hydraulic Retention Time), Horizontal subsurface flow and wetland plants.*

1. INTRODUCTION

Constructed wetlands innovation is a built technique for refining wastewater as it goes through a characteristic procedure, which includes soil, sand, miniaturized scale life forms and vegetation [1]. Constructed wetlands also known as root-zone system is or bio-filter reed bed system or treatment wetland system or phytotechnology or phytoremediation system [1]. The study on the capacity of marshy plants in the decrease of natural contaminations and supplements in sea-going frameworks began in the 1950's in Germany. After that different plans of built wetland have been urbanized [2].

The developed wetlands are uncommonly built for treating wastewater; it can be utilized for essential, auxiliary & tertiary medicines of mechanical wastewater, household wastewater, metropolitan wastewater and farming wastewater [2]. In the recent years most of water bodies are polluted by direct discharge of domestic wastewater and because of anthropogenic activity and it is having higher tendency to remove pollutants such as TSS, TN, TP, COD, BOD and heavy metals. [3] Many wetland plants have capability to go down the organic and inorganic matter from wastewater [14]. The plants used in wetlands are Phragmites austrails (common reed), Typha lotifolia (common cattail), canna sieamensis, junus effuses (soft rush), scirpus lacustris (common bulrush) [30].The aim of this process is to reduce the pollutant concentration in wastewater.

1.1 Types of constructed wetlands

i. Surface flow constructed wetlands
ii. Sub-surface flow constructed wetlands.

Surface flow 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 the water surface is above the substrate. Surface flow wetlands look much like natural marshes and can provide wildlife habitat and aesthetic benefits as well as water treatment. In surface flow wetlands, the near surface layer is aerobic while the deeper waters and substrate are usually anaerobic. Storm water wetlands and wetlands built to treat mine drainage and agricultural runoff are usually surface flow wetlands. surface flow wetlands are sometimes called free water surface wetlands or, if they are for mine drainage, aerobic wetlands.

Subsurface flow system (SSF) also known as root-zone system reed-filters/vegetated submerged bed system is a type of treatment wetland, where wastewater flows horizontally or vertically through a porous media [45]. The workings of the SSF-CW system are vegetation, bed media, inlet and outlet arrangement and an impervious liner to prevent contamination of groundwater [48].

1.2 Horizontal subsurface flow system

In this system, wastewater is fed in and moves through the bed media under the surface of the bed until it achieves the outlet zone [48]. The wastewater will come into contact with a system of high-impact, anoxic and anaerobic zones [21]. The high-impact zones will be around the roots and rhizomes of the wetland vegetation that break oxygen into the substrate and wastewater goes through the rhizosphere, the wastewater is spotless by microbiological squalor by physical and chemical processes[24] [Figure 1.2] shows the longitudinal segment of level subsurface wetland and it can effectively uproot the natural contaminations (TSS, BOD_5 and COD) from the wastewater[24],[29]

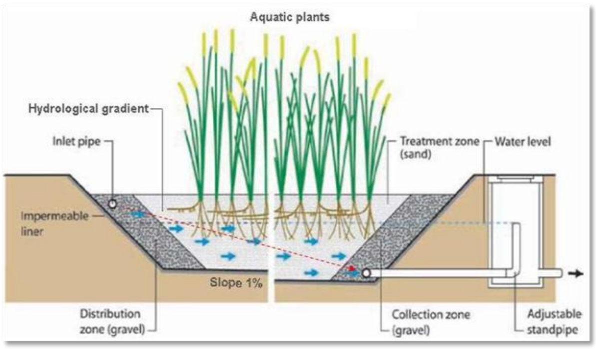

Fig -1: Horizontal subsurface flow system

1.3 Vertical subsurface flow system

In vertical subsurface flow systems wastewater is fed intermittently and it flows in the direction of vertical through the channel funnels and it is gathered by a seepage system at the base [29]. [Figure 1.3] shows the longitudinal area of vertical subsurface wetland. In 1990s, increased interest of nitrogen expulsion from wastewaters prompted more consistent utilization of vertical subsurface system built wetlands which give higher level of filtration bed oxygenation.[15]

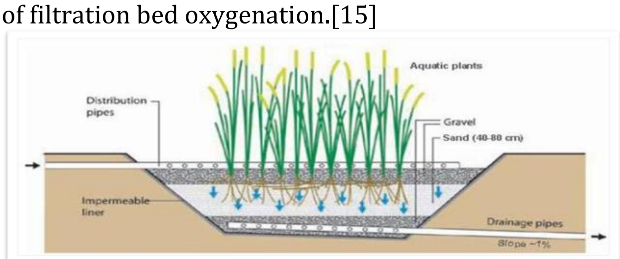

Fig -2: Vertical subsurface flow system

1.4 Hybrid System

Constructed wetlands could be consolidated subsurface system, keeping in mind the end goal to accomplish higher treatment productivity by utilizing points of interest of individual frameworks and most crossover developed wetlands join VF and HF system. "The VF-HF system was initially composed by Seidel as in the late 1950s and the mid 1960s and in the 1980s" [15]. "VF-HF hybrid built wetlands were France and United Kingdom"[24]. At present, wetlands are more acknowledged in numerous nations.

1.5 Advantages of wetland constructions [1]

i. Constructed wetlands are less expensive as compare to other treatment methods.
ii. Initial investment is low and operation and maintenance cost is low.
iii. Operation and maintenance require only intermittent, rather than continuous monitoring.
iv. More effective on low strength pollutants

1.6 Disadvantages of wetland constructions[1]

i. More area or land is require for establishment.
ii. Highly toxic materials can effect on wetlands activity.
iii. Pretreatment is necessary for a medium and high concentrated pollutants.
iv. Frequent cleaning is necessary.

2. REVIEW OF LITERATURE

M.G.Healy et.al. [2] Worked on *"Treatment of dairy wastewater using constructed wetlands and intermittent sand filters"* in Ireland. The work discussed the discharge of dairy parlor washing which was creating many problems to the public and natural sources, treating the dairy parlor washing by using constructed wetlands along with intermittent sand filters (ISF) was the traditional method in Ireland. The proposed work concluded that ISF treatment method reduced the pollutant concentration and gave higher efficiency achievement in recirculation system.

Keffala C, Gharabi A. [3] studied on *"Nitrogen and bacterial removal constructed wetlands treating domestic wastewater"* in Tunisie. The work carried out on removal rate of planted and unplanted system for nitrogen and nitrogen ammonia. The experiment was carried out for a performance of two combined system of vertical and horizontal subsurface flow. "In vertical flow bed was planted with Phragmites austrails and horizontal flow bed planted with Typha lotifolia and another wetland was unplanted. The experiment was carried out from February to August 2003 with a hydraulic loading rate of $0.024m^3/j$ and organic loading of 208kg/COD/ha.d at flow rate of

6litters/hours. The collection of influent and effluent water was taken from fixed location equivalent to the four tanks sample were analysis for a TKN,NH_4, NO_3-NO_2 and Total Coliform". The "removal rate for nitrogen was 27% for planted, 5% for unplanted and nitrogen ammonia 19% for planted and 6% for unplanted". Removal rate for nitrate nitrogen unplanted system is greater than planted system, 4% for planted and 13% for unplanted and bacterial removal in both systems was same. In the horizontal flow bed nitrate and nitrite removal are about 27% for planted and 24% unplanted. The denitrifications depending on the flow type were nutrients uptakes in horizontal flow system. The work concluded that removal of nitrogen in vertical flow bed system was support to the nitrification and horizontal flow system support to denitrification.

Gauang Sun et.al. [7] Studied on *"Purification efficiency of sewage in constructed wetland with different plants"* in china , with three different plants and HRT's to treat the wastewater. The plants were used for experiment cattails, common reed and acorus calamus with a HRT's of 3days, 4days and 5days. The analyses were carried out for COD,NH_4-N and TN. Overall removal rate of COD was 54.9% , NH_4-N was 54.8% and TN was 90%. The proposed work concluded that removal efficiency was higher in the 3days of HRT as compare to other two HRT's and cattails was better than common reed and acorus calamus plants.

C.A Prochaska et.al. [8] Conducted study on *"Treatment performance variation at different depths within vertical subsurface-flow experimental wetlands fed with simulated domestic sewage"* in Thessaloniki. The work was four experimental trials with different depths of 40cm and 60cm along with different HRT's of 3days and 1.5days. The experimental setup of vertical constructed wetland was planted with pharagmites austrails and each experimental trial had cylindrical polyethylene container and perforated PVC drainage pipe with three different size of gravels were used. Analysis was carried for the pollutants COD, PO_4 - P & TN. The result of removal rate along with higher HRT of 3days for COD was 96%, PO_4 – P was 52% & TN was 60%.

3. MATERIAL AND METHODOLOGY

3.1 Materials Used For Constructed Wetlands Setup

Materials

Various materials used for the constructed wetlands were as follows

1) Plastic container
2) Plastic buckets with lid
3) PVC pipe of 1.25 cm diameter
4) Fiber sheets
5) Nuts, closets
6) Taps

3.2 Experimental Setup

The experimental setup consists of a two units of constructed wetland systems. The pilot scale model of horizontal subsurface flow constructed wetland has been built in open air at a site of "Dr.M.S.Sheshgiri College of Engineering and Technology, Belagavi, India". The size of each tub was 0.6mx0.4mx0.3m and vertical bucket were used to hold the wastewater. The capacity of each vertical bucket was 25 litters. The total volume of root zone bed was 0.0336m^3 with suitable outlets. To enable the flow of wastewater gravitationally from inlet to outlet, a longitudinal slope of 7% was provided during filter media filling [38]. The vertical pipe was placed above the tub in the inverted 'T' shape for equal flow of wastewater, which was connected with flexible pipe to the inlet of holding tank for each set. The length of PVC pipe was 0.4m and the holes were provided on the plastic pipe at equal intervals of 5cm for equal flow and taps were adjusted by manually [23]. Fiber sheets were used as partition and beakers were used for collection of treated water from outlet.

The two pilot units were "filled (from bottom to top) first layer of 0.1m consisted of coarse aggregate gravel, second layer of 0.1 m consisted of fine aggregate sand and 0.1m freeboard". First constructed wetland unit was planted with Phragmites Austrails, plant and second unit was planted with Canna Indica plant, both units were planted the plants in 3x3 row. The experimental setup is shown in Fig 3.1

Fig 3 The experimental setup

3.3 Experimental Procedure

The experiment was carried out from December 2014 to May 2015 and two pilot scale units were fed with fresh water for a period of one month [38]. The untreated wastewater from campus were collected and analyzed for various parameters [31]. Initially both the wetland were feed with wastewater of COD concentration 250mg/L and optimum HRT was found by varying the HRT of 1,2,3,4,5 and 6 days. Once the optimum HRT was set , the feed COD concentration of wastewater was varied and operated at 250mg/L,500mg/L and 750mg/L. At optimum HRT and feed concentration of 250mg/L of COD, the results of COD reduced from both constructed wetlands and it was compared with unplanted constructed wetland system.

3.6 Plants Growth

The growth of the plants were observed throughout the experiment period from the beginning of project to 6months and plant growth was monitored and found to be 0.2-1.5m height and 0.15- 1.2m height for phragmites Austrails and Canna indica respectively.

Fig 4 Photograph of growth of plants

4. RESULTS AND DISCUSSIONS

4.1 Optimum HRT for Constructed Wetland Systems

To find out the optimum HRT for constructed wetland systems, wastewater was fed with 250mg/L concentration of COD. The HRT was varied for 6day, 5day, 4day, 3day, 2day and 1day keeping COD concentration constant at 250mg/L. The samples were collected from outlet of both wetlands systems and analyzed for the COD removal efficiency.

Table 4.1 Percentage COD reduction at different HRT for constructed wetland systems.

COD reduction in constructed wetlands					
Conc mg/L	HRT in days	PA in mg/L	CI in mg/L	Removal efficiency in %	
250	1	57	65	77%	74%
250	2	52	60	79%	76%
250	3	48	68	81%	73%
250	4	40	60	84%	76%
250	5	35	55	86%	78%
250	6	30	44	88%	82%

4.2.1 COD Removal

Keeping the 4days of HRT as constant, the feed concentration was changed. The feed concentration was changed with an increment of 250 mg/L COD. The COD removal in Phragmites Austrail bed and Canna indica bed was observed for every COD loading rates of 250mg/L, 500mg/L and 750mg/L. The COD removal in both wetlands given in the Table 1

Table -2: Variation in COD

Variation in COD at different feed concentrations					
COD in mg/L	COD Inffluent in mg/L	COD Effluent in mg/L		Removal efficiency of COD in %	
		PA in mg/L	CI in mg/L	PA	CI
250	250	40	60	84%	76%
500	500	140	160	72%	68%
750	750	240	290	68%	61%

4.2.2 BOD_3 Removal

The analysis of BOD_3 was carried out for the samples from outlet. Table 4.4 shows the values of BOD_3 at different loading.

Table -3: Variation in BOD

Variation in BOD_3 at different feed concentrations					
COD in mg/L	BOD_3 Inffluent in mg/L	BOD_3 Effluent in mg/L		Removal efficiency of BOD_3 in %	
		PA in mg/L	CI in mg/L	PA	CI
250	86	25	28	71%	67%
500	155	58	61	63%	61%
750	265	120	130	55%	51%

The BOD_3 reduction was maximum of 71% for Phragmites Austrail plant and 67% for Canna Indica plant at a feed concentration of 250 mg/L. It is also seen that at feed concentrations of 500mg/L of COD, the BOD concentration after reducation is 58 mg/ L and 61 mg/ L for Phragmites Austrail plant and Canna Indica plant respectively and which is well within permissible limit as per CPCB.

4.2.3 pH and Temperature.

The pH and temperature of inlet and outlet was recorded day by day. It was observed that the pH range between 6.1 to 8.3 and the temperature between 28^{o}-36^{o}C.

5. CONCLUSIONS

1) The analysis result shows that most of the parameters of wastewater are above permissible limits for discharge. Hence treatment is necessary before discharge of wastewater.
2) The optimum Hydraulic Retention Time (HRT) for both the constructed wetlands units was found to be 4 days.
3) The pH range of effluent from Phragmites Austrails bed and Canna Indica bed were 6.4-7.6 and 6.7-8.1 respectively.
4) The maximum COD removal for Phragmites Austrail bed and Canna Indica bed was 84% and 76% respectively at 250mg/L COD loading for 4days of HRT and further increase in loading rate decrease the efficiency.
5) The maximum BOD_3 removal was found in Phragmites Austrails bed and Canna Indica bed were 71% and 67% respectively at feed concentration of 250mg/L COD.
6) The maximum solids removal efficiency for Phragmites Austrail bed was 80%, 81% and79% for Total, Dissolved and Suspended respectively at 250mg/L COD loading for 4days of HRT.
7) The maximum solids removal efficiency for Canna Indica bed were 75%, 76% and 74% for Total, Dissolved and Suspended respectively at 250mg/L COD loading for 4days of HRT.
8) The maximum Phosphate removal was found in Phragmites Austrails bed and Canna Indica bed were 62% and 51% respectively.
9) Both the wetlands performed more efficiently at COD feed concentration of 250mg/L. However, the resultants obtained after treatment of COD feed concentration at 500mg/L are also well within the permissible limit for discharge as per CPCB.
10) The wetland with Phragmites Austrails plant is more efficient in treating campus wastewater compared to the wetland with Canna Indica plant.

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