A LAB SCALE MODEL ON SUBSURFACE CONSTRUCTED WETLAND

[1]Azharuddin Burhanuddin, [2]J. S. Main

[1]M-tech student, Environmental Engineering, VJTI, Mumbai (India)

[2]Associate professor, Civil and Environment Engineering Department, VJTI, Matunga, Mumbai (India)

ABSTRACT

To foster the practical development of constructed wetlands, two parallel sets of constructed wetland lab scale models with identical design configuration, one planted and another one without planted system were built at VJTI, Matunga. Wetland system was planted with common cattails (Typha Latifolia). Objective of this research was to quantify the effect of planted and without planted systems on the removal performance of subsurface flow constructed wetlands. Thus, both the subsurface constructed wetlands were operated identically with pre-settled domestic sewage as well as synthetic wastewater. It was observed that synthetic wastewater gave 89% efficiency of COD on organic loading 18.52 gm COD/m^2-day for planted system and for without planted system it was 76% which was optimum and for domestic sewage efficiency of COD was 70% for planted and 50% for without planted system as well as BOD removal efficiency for planted system was 75% and for without planted system it was 50%.

Keywords- Synthetic Wastewater, Domestic Wastewater Treatment, Subsurface Flow Constructed Wetland, Typha Latifolia (Native Cattail), Planted And Without Planted Constructed Wetlands

I. INTRODUCTION

Almost all of the world's major cities have gone in to the 21st Century facing an environmental crisis. The world's cities not only face the challenge of supplying adequate sanitation facilities to its residents, but must also ensure that the available water resources are not contaminated. The discharge of untreated wastewater is a major contributor to deteriorating health conditions and pollution of nearby water bodies.[1]

People of developing countries are still facing the environmental and related health problems including water borne diseases even in the 21st century. Since most of the conventional wastewater treatment systems are very energy intensive and expensive for developing countries; effective but simple, cheap and reliable, wastewater treatment alternatives are needed.

Being a natural, low-cost, eco-technological biological wastewater treatment technology like "constructed wetlands" (CWs) are now standing as the potential alternative or supplementary systems for the treatment of municipal, industrial, agricultural wastewater, as well as storm water [2]. Since the 1960s, constructed wetlands have been used effectively to treat different wastewaters with different configurations, scales and designs throughout the world.

Constructed wetlands were first developed in 1960. These systems have been modified until the current advanced technology was obtained & have been effectively used for the treatment of domestic waste; compared to high-cost conventional mechanical treatment systems, constructed wetland technology is cheaper, more easily operated, more efficient to maintain. Moreover, minimal or no fossil fuel is required, no chemicals are necessary as well as it is a green technology. Implementing low cost technology systems like constructed wetlands can also be a proper solution for treatment of different types of wastewater in India. However, there have been hardly few constructed wetland applications in India until 2013; also research has been initiated for a few laboratory scale experimental studies on constructed wetlands [3].

This work is carried out in two phase to study the performance of constructed wetland treating phase-I on synthetic wastewater and phase-II on domestic sewage for different physico-chemical parameter. Moreover, this dissertation aimed to quantify the effect of planted and unplanted substrates (gravel media) on the treatment performance of the constructed wetlands operated identically in the prevailing climate of Mumbai city

II. MATERIALS AND METHODS

2.1 Characteristics of Models

Two lab scale subsurface constructed wetland were made up of acrylic tank having size (0.5 m x 0.5 m x 0.6 m) and square shape in plan. The inner dimensions were (0.45 m x 0.45 m x 0.45 m).The inlet pipe was provided at the top of the filter and outlet for effluent collection or sampling port was located at the bottom of the tank. Whole arrangement is shown in figure 1. Model was packed with gravels of different sizes 15mm, 25mm, and 40mm in layers having depth of 0.15m, 0.2m, and 0.1m respectively from the base.

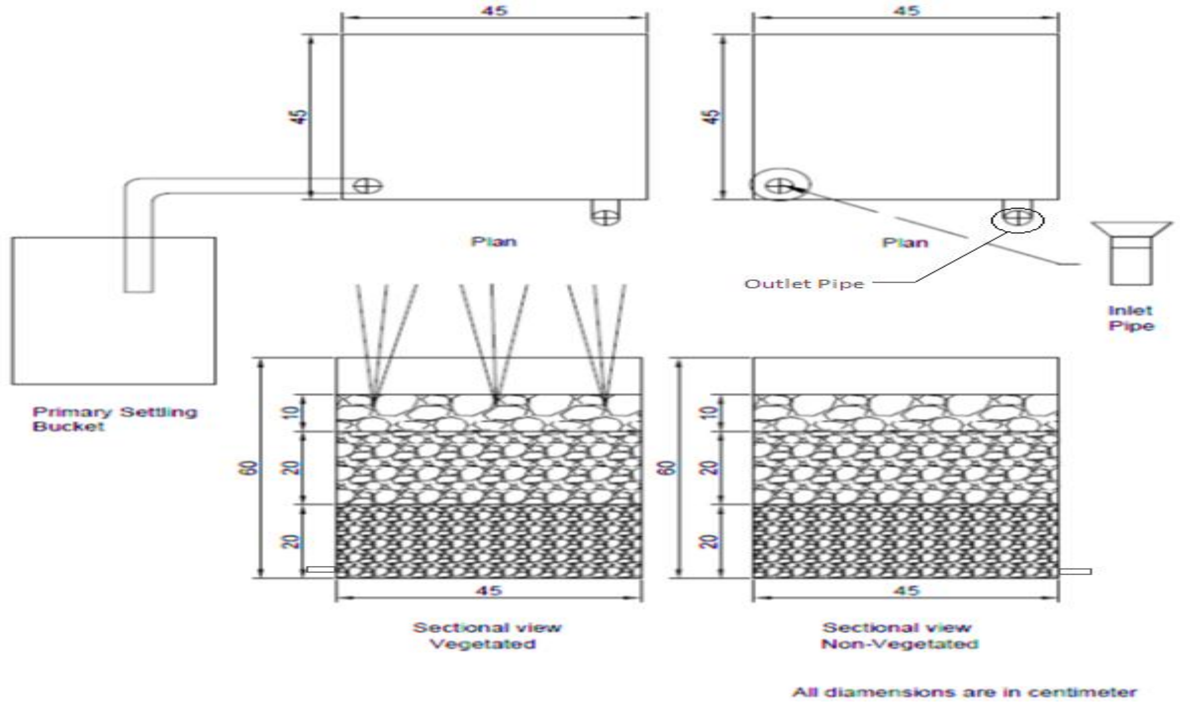

Figure 1 Schematic diagram of lab scale model on subsurface constructed wetland

The site for the Experimental Lab scale model of CW's model was chosen to be the open space besides the Examination Centre in the college, in the Civil and Environmental Department. The site is located behind the staff offices of Civil & Environmental Department and has been used as a location for models before. The influent pipe is kept at the top level, and the effluent collection pipe is kept at the bottom of the tank. Bottom of the tank kept 15 cm above the floor level for convenience while sampling

One PVC pipe diameter of 1 cm at bottom was inserted to collect the sample. Batch flow was given 25 litres of wastewater applied to each tank and effluent was drawn after 3 days to check its efficiency for different parameters. The model was assembled, and was filled with tap water and checked it for leakages on 02 Jan 2014. The experimentation was carried out in two phase over a period of 135 days, from 15/01/14 to 31 /05/14

2.2 Experimental Procedure

Phase I

The plant Typha latifolia a native cattail was taken from its original locations (Vasai) on 15/01/2014, same day before transplanting them to the system. The roots of the extracted plant were washed off and cleaned. The spacing between the plants was set to 20-30 cm. 16/01/2014 onwards domestic sewage brought from Matunga sewage pump house, was applied to the system till 21/02/2014 with low organic loading (by mixing tap water in domestic sewage) for acclimatization purpose. Initial 36 days period was given for seeding purpose to develop growth & initial built up to plant. On 24/02/2014 Trial test was carried out on synthetic wastewater with low organic loading (18.52 gm COD/m^2-day). Therefore synthetic wastewater sample was prepared of 150 mg/lit by adding glucose into water along with other essential nutrients like Calcium chloride, Magnesium sulphate etc. through different compounds. Before feeding the synthetic wastewater to model, it was analyzed in the laboratory for COD.

After getting satisfactory startup results, organic loading rate (OLR) was initiated from 18.52gm COD/m^2-d for first week & influent & effluent was analyzed after 3 days respectively. Likewise, OLRs were increased gradually to 24.69, 30.86, 37.04, 43.21, etc. upto 61.73 gm COD/m^2-day at each OLR's COD influent and effluent was analyzed

Phase II

Domestic Sewage was brought on 12/05/2014 from Matunga pumping station and on the same day was administered into the system. The results were evaluated after 3 days for the following parameters such as COD, TS, TSS, and BOD.

SYNTHETIC WASTEWATER COMPOSITION

1gm of glucose in one litre of water gives 1 gm/lit of COD [4]. The synthetic sewage was a modification of OECD standard sewage [5] and it was prepared prior to each (batch) feeding by mixing (in tap water) the following different components (For OLR's 18.52 gm COD/m^2-day): 150 g /m^3 glucose, 15 g /m^3 NaH_2PO_4, 1.5 g /m^3 KH_2PO_4, 4 g /m^3 $CaCl_2$, 2 g /m^3 $MgSO_4$ [6]. Likewise for different OLR's glucose concentration increased and other nutrients kept constant.

TESTING OF SAMPLE

All the wastewater analyses conducted during this research were performed in the Chemistry Laboratory of the Department of Environmental Engineering of VJTI. The analytical methods [7] and the instruments used within this dissertation were as follows, for Chemical Oxygen Demand, COD Open Reflux Method was used for Biochemical Oxygen Demand, BOD5 Oxygen Demand (Biochemical), Titration was used and for TS and TSS Evaporation and 0.45µm Cellulose filter paper were used. All the glassware used in these experiments was always cleaned as described in Standard Methods

III. RESULT AND DISCUSSION

On 24/02/2014 trial synthetic wastewater fed and efficiency were found out for both the system (planted and without planted). The effluents from the system were analyzed. After four days 84% COD removal efficiency were achieved. Hence actual study on model with initial loading of 18.52 gm COD/m^2-day started. It was seen that the evapotranspiration losses were high and water level had dropped down by end of 4 days so experimentation was done for 3 day

Model was fed with synthetic wastewater of OLR 18.52 gm COD/m^2-day on Monday 03/02/14 and batch study was made effluent were drawn from the system after 3rd days. So every week OLR's were increased and efficiency of COD was found out Table no 1 shows the removal efficiency for different OLR's. It was observed that the planted and without planted system the optimum efficiency of removal occurs during the OLR of 18.53 gm COD/m^2-day, and keep on decreasing down ever since the OLR's were increased.

Hence it was decided to stop conducting tests on synthetic wastewater and began conducting tests of actual sewage.

Table no 1. COD removal efficiency for different organic loading rates

OLR's	Influent Concentration	Effluent Concentration		COD Removal Efficiency	
		Planted	Without Planted	Planted	Without Planted
18.52	166.5	17.52	39.22	89.48	76.44
24.69	186.5	26.88	52.32	85.59	71.95
30.86	250.56	52.53	83.35	79.03	66.73
37.03	292	72.96	138.43	75.01	52.59
43.2	360.84	104.04	155.23	71.17	56.98
49.37	414.53	122.31	199.1	70.49	51.97
55.54	459.43	148.65	270.65	67.64	41.09
61.71	497.29	195.44	270.09	60.70	45.69

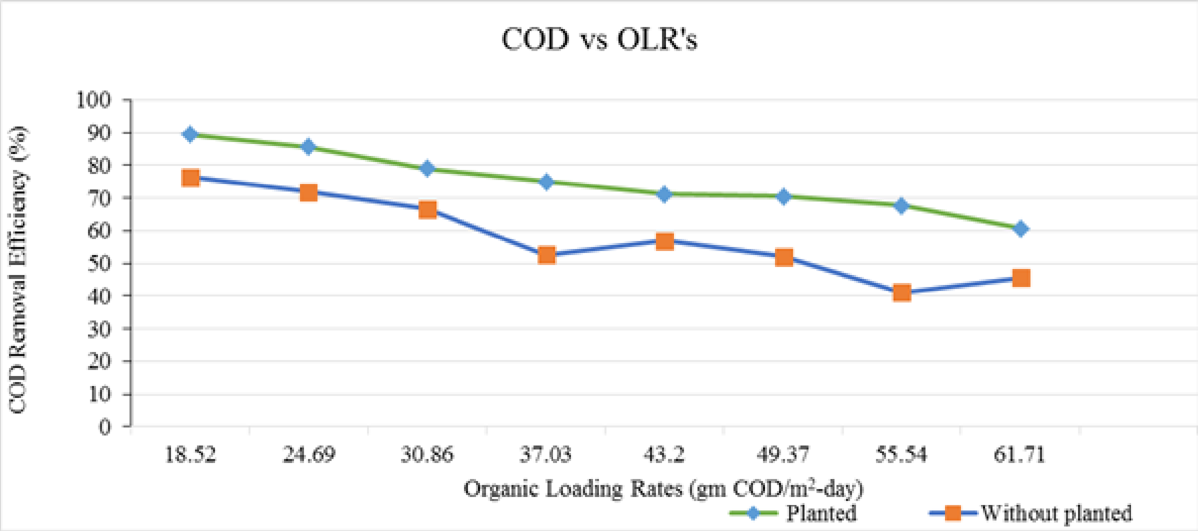

Figure no 2 Graphical representation of COD vs organic loading rates

After conducting an experiment on synthetic wastewater domestic sewage was brought from Matunga pumping station on 12/05/2014 and on the same day it was analysed for the following parameters COD and BOD before feeding into the system. The same procedure was repeated for two more weeks and hence decided to stop the study

Table no 2 and 3 shows the results obtained from domestic sewage which was brought thrice, once in every week and effluents were drawn after 3 days. Figures 3 and 4 represent COD and BOD removal efficiency for the applied sewage.

Table no 2 COD removal efficiency for different concentrations

Inflnent Concentration	COD Removal Efficiency	
	Planted	Without planted
180	69.71	50.26
235	72.08	56.67
264	73.02	56.30

Table no 3 BOD removal efficiency for different concentrations

Inflnent Concentration	BOD Removal Efficiency	
	Planted	Without planted
60	75.00	50.00
77	68.83	42.86
85	70.59	55.29

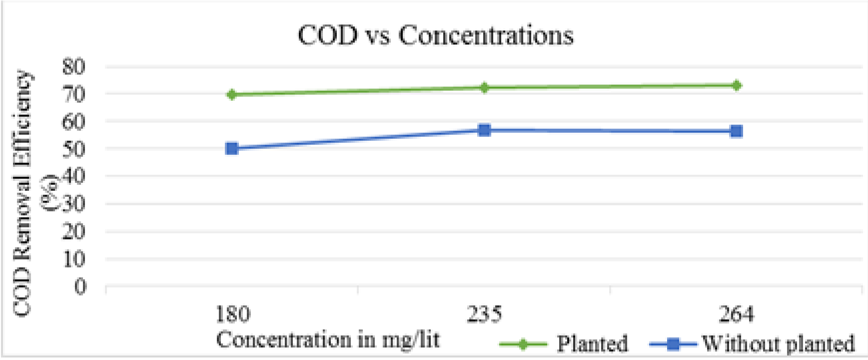

Figure no 3 Removal efficiency graph for COD

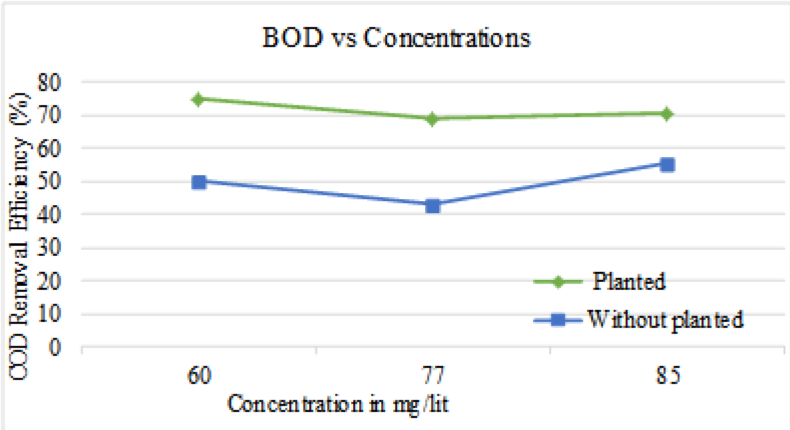

Figure no 4 Removal efficiency graph for BOD

IV. CONCLUSION

Two parallel subsurface flow constructed wetlands (CWs) one with planted and another without planted model were made & operated under same condition.

For planted system efficiency were around 90% for the initial organic loading and then keep on decreasing so it shows that plants are optimum at low organic loading and ever since the OLR's was increased then the efficiency keep on decreases it shows that the plants play role in removal of organic matter as well as without planted system also play a role in removal of organic matter because the microorganisms which exist in the system, they absorbed the organic matter a bit. The planted system was always higher in removal of COD than without planted system throughout the experimentation

It was observed that the domestic sewage which was applied to the system can be treated upto 70% for COD and 75% for BOD in planted system and without planted system it was observed 50% in both COD and BOD respectively. Therefore, appropriate organic loading in the influent could achieve optimal removal of organic matter.

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