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***Abstract*— Domestic wastewater treatment in decentralized manner incorporated with natural systems of treatment is cost effective. 45 kLD integrated and decentralized treatment system was installed in Walchand College of Engineering, Sangli (Maharashtra, India) for the treatment of wastewater generated from residences, hostels and food courts. The system consists of Anaerobic Baffled Reactor (ABR), Baffled and Floating Hybrid Constructed Wetland (BFHCW) and Vertical Flow Constructed Wetland (VFCW). Floating constructed wetland (FCW) which is a part of BFHCW was developed by using the cost-effective floating mat (plastic tray and waste thermocol sheets) vegetated with multispecies wetland plants. Floating rack also has wetland plants vegetated in charcoal bed. *Canna Indica* and *Typha Angustata* were used as vegetation in construction wetland due to their abundance and easy availability. The final stage of treatment system consisted of vertical flow constructed wetland filled with mix media of aggregate and coal and vegetated with C*anna Indica and Typha Angustata*. This integrated system was assessed for its potential to remove COD during July to October, 2018. Anaerobic Baffled Reactor and Floating constructed wetland contributed 35% and 20% for COD removal respectively. Vertical Flow Constructed Wetland contributed 30% for COD removal. The overall COD removal was found to be 70% to 75%.**

Keywords—Decentralized Treatment ; Domestic Wastewater ; ABR ; FCW ;VFCW.

I INTRODUCTION

Domestic wastewater is generally contributed by many sources in both rural and urban areas. The wastewater generated from the sources such as public building, educational institutes, and commercial establishment is significant apart from residential sources. Wastewater treatment for such establishments is important else it will lead to isolated pollution. The development of an appropriate and cost effective system is essential. Constructed wetland (CW) technologies are natural treatment system with coal and aggregate as substrate material and planted vegetation [1]. CW technology can be applied to treat different types of wastewaters. Initially they were used to treat phenol, dairy and livestock wastewaters as well as domestic effluents. The mechanisms of treatment in constructed wetland are complex process which can happen simultaneously or sequentially involving microbial degradation, plant uptake, sedimentation, filtration. The wastewater load (volume and strength) can be reduced to some extent if the sources other than residential sources are segregated and provided with a separate treatment. The concept of constructed wetlands applied for the purification of various wastewaters has received growing interest and is gaining popularity as a cost-effective wastewater management option in both developed and developing countries [2]. CW systems are easy to operate with low maintenance, and are cost effective. Macrophytes are the main biological components of CW. However, it is important in determining the appropriate macrophytes species that can survive in the wastewater environment, because only suitable macrophytes can treat a high concentration of pollutant in the wastewater.

In this context, the concept of Decentralized Wastewater Treatment System (DWTS) can be implemented for treating wastewater from such isolated sources. The provision of DWTS will increase the potential for reuse and recycling at source of generation. The benefits derived are lesser load on municipal water supply as portion of non-potable water demand is met from reuse/recycled water. The possible non-potable purposes for which the reuse/recycled water can be used include gardening, flushing, cleaning, and washing. The groundwater recharge is also a potential option for disposing treated water from DWTS [3].

CWs have not gained much popularity in India majorly due to large area requirement and possibility of clogging of wetland beds due to high suspended solids in the wastewater, microbial biomass sedimentation through various processes, filtration and growth of microorganisms blocking pore volume [4]. The modified versions of CW such as vertical flow CW (VFCW) and floating CW (FCW) can also be applied as a part of DWTS. VFCW for wastewater treatment are preferred due to their high oxygen transfer rate and effectiveness in reducing organic carbon and nitrogen. The area requirement in VFCW is less. FCW are made up of an extremely simple structure of synthetic buoyant mat supporting vegetation with their roots hanging into the free water [5]. Pollutants removal is carried by nutrient uptake through macrophytes and microorganisms, which grow on submerged portion of the plant and floating mat. Combination of Baffled Subsurface Flow Wetland (BSFW) along with FCW, termed as, Baffled and Floating Hybrid Constructed Wetland (BFHCW) can be the better alternative for conventional CW.

In the present study, an Integrated Decentralized Wastewater Treatment System (IDWTS) incorporated with anaerobic baffled reactor, BFHCW and VFCW was developed in the campus of Walchand College of Engg., Sangli (WCE), and operated to assess its performance to remove organic carbon in terms of COD over a period of four months.

II MATERIAL AND METHOD

A. Source of Wastewater

Wastewater generated from residences, hostels, and food courts was collected and treated in IDWTS. The flows reaching treatment system were greywater, and septic tank effluent. Oil and grease traps were provided at the source for the removal of floating mater. The maximum flow observed for the system was 6000 L/h.

B. IDWTS

In the present study, IDWTS was studied for its potential to treat 45 kLD wastewater. The total system was divided into three parts where primary and two stage secondary treatment. The preliminary system consisted of bar screens (Coarse and fine), and primary in the form of ABR. And the two stages of secondary treatment were BFHCW and VFCW. Fig. 1 shows photographic view of field scale IDWTS.

Figure 1: Photographic view of IDWTS at WCE, Sangli.

ABR has six baffled compartments connected by down take pipes inducing upflow and down flow movement of wastewater. BFHCW is a brick masonry structure made up of twenty compartments comprising of an inlet chamber, alternate compartments having brickbat vegetated with *Canna Indica* and *Typha Angustifolia* and FCW. Thermocol sheets and perforated baskets were used to support vegetation in FCW. Fig. 2 shows photographic view of vegetation in FCW.

ABR treated effluent undergoes further treatment in FCW and collected in a sump. Then it is pumped to VFCW for second stage secondary treatment. The pump operation was sensor based and feeding VFCW is auto-regulated. VFCW has bed made up of brickbat at the bottom and mixed media of coarse aggregates and charcoal. It was vegetated with *Canna Indica*. HBBCW effluent was applied uniformly on the surface of VFCW through the feeding system.

C. Operation and monitoring of IDWTS

CBCW was monitored from July to October, 2018. Initially, flow measurement was carried out to determine the fluctuations in the flow rate. Flow was measured by time-volume technique and was found to range between 532 L/h and 6000 L/h. The wastewater samples were collected at different times (morning and afternoon) and days (Monday to Saturday) from different locations at IDWTS. The sampling locations used for assessment of wastewater characteristics include, screened wastewater, ABR treated wastewater, HBBCW effluent and final effluent from VFCW. The sampling was done in 2 L plastic cans which were thoroughly washed and disinfected. Grab sampling method was used. pH, COD, BOD, EC, and TKN were measured by referring to [1].

III Results and Discussion

A. Influent wastewater characteristics

The influent wastewater characteristics are given in Table 1. No specific variation was observed in pH and EC. It can be seen that biological treatment is effective as BOD_3/COD ratio is more than 0.30. The influent to IDWTS is categorized to be medium strength wastewater as COD is between 500 to 1000 mg/L.

Table 1: Influent wastewater characteristics

	pH	EC (mS/cm)	COD (mg/L)	BOD_3 at 27^0C (mg/L)	TKN (mg/L)
Influent	7.5±0.25	2.41±0.08	500±50	258±10	54±8

Figure 2: Photographic view of vegetation in BFHCW

B. Performance of IDWTS for COD removal

Figs. 3 and 4 show COD variation and its removal at various stages of treatment system at different times (morning and afternoon) in a day. COD values decrease at each stage of treatment system. ABR contributes to an extent of 40% for the removal of COD. Anaerobic condition is more effective for the treatment of medium strength wastewater and hence ABR has significant contribution. BFHCW is supposed to be aerobic partially, however the system was in developing phase with vegetation growth in its initial stage and hence COD removal is relatively lower (15 to 20%). VFCW contributed to COD removal by 20 to 25%. The overall removal for COD is to an extent of 70% to 75% by IDWTS. The vegetation growth in VFCW is better than in BFHCW and support bed is better aerated. Thus VFCW is more efficient as compared BFHCW due to better aerobic conditions.

Figs. 5 and 6 show the variation of COD with time in the morning and afternoon period during 4 months of study. It was observed that there was no signifiant variation in the system performance at different times in a day. The results also showed that effluent COD was not consistently same and it varied with time. The treatment systems based on natural mechanisms of purification have such limitations umlike mechanized treatment systems. However, effluent COD is less than 100 mg/L during major portion of the study period.

The observed efficiencies in BFHCW and VFCW were relatively lesser considering the fact that IDWTS was subjected to high hydraulic (>$1m^3/m^2$.d) and organic loading (2.5 kg COD/m^2.d) rates.

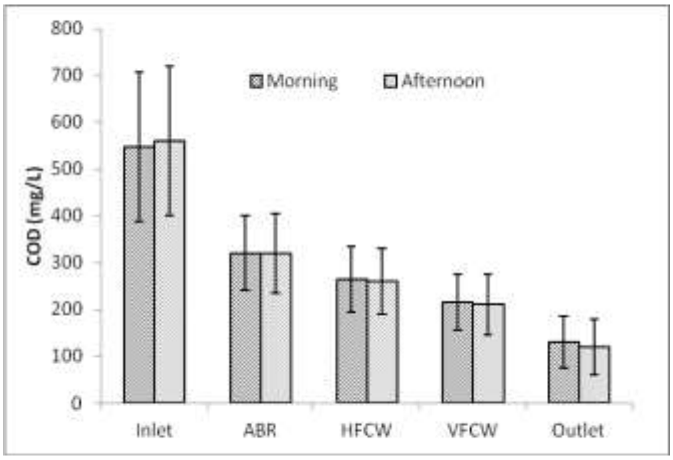

Figure 3 : COD variation in IDWTS at various stages and times of treatment (Average value of 4 months)

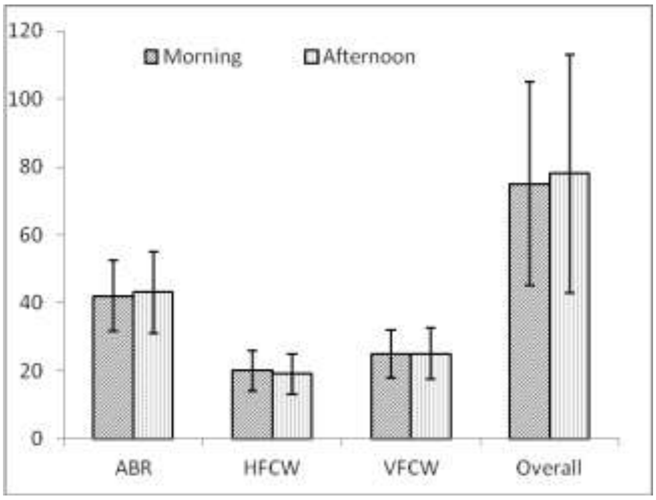

Figure 4 : COD removal in IDWTS at various stages and times of treatment (Average value of 4 months)

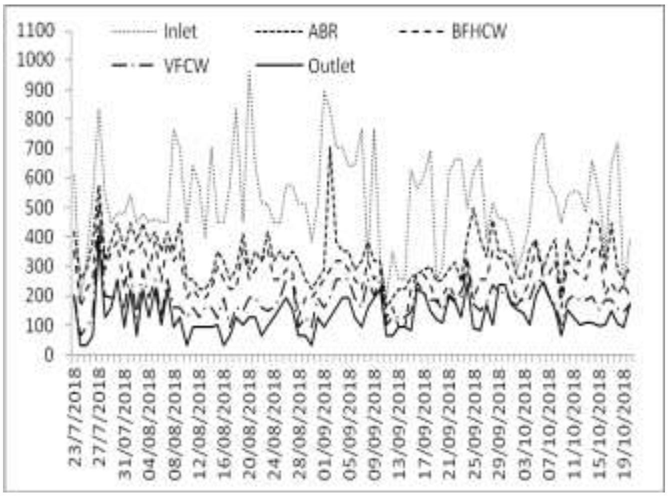

Figure 5: COD variation throughout the study period in morning

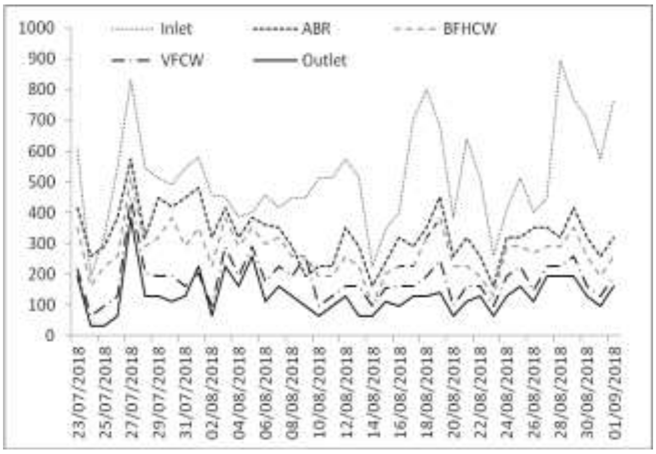

Figure 6 : COD variation throughout the study period in afternoon

Table 2: Effluent wastewater characteristics

	pH	EC (mS/cm)	COD (mg/L)	BOD_3 at 27^0 C (mg/L)	TKN (mg/L)
Effluent	7.5±0.25	2.00±0.08	100±50	50±10	38±8

Table 2 shows summary of effluent characteristics observed for study period of 4 months.

IV Conclusions

IDWTS at WCE was monitored for a period of four months and performance for COD removal was assessed. ABR contributed significantly to COD removal in comparison with other units. The performance of BFHCW and VFCW is satisfactory owing to high hydraulic and organic loading rates. VFCW is more effective than BFHCW systems. IDWTS is found to be an alternative option for decentralized treatment of domestic wastewater with overall COD removal of 70% to 75%.

ACKNOWLEDGMENT

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