Effect of Feeding with Aeration System on COD removal in Vertical Flow Constructed Wetland

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December 1, 2019

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Abstract: Constructed Wetland (CW) is a part of Decentralized Wastewater Treatment System (DWTS) and used to treat domestic wastewater. Vertical Flow Constructed Wetland (VFCW) and its feeding cum aeration system as part of field-scale Integrated Domestic Wastewater Systems (IDWTS) at Walchand College of Engineering (WCE), Sangli (Maharashtra) planted with *Canna indica* and *Giant reed* was assessed in the present study. The performance of VFCW was evaluated for Chemical Oxygen Demand (COD) removal and Dissolved oxygen (DO) enhancement. The study showed that COD removal efficiency of 34% to 43% and DO enhancement upto 1.26 mg/L is possible. Thus feeding cum aeration system developed in the present study significantly improves feed water quality and thereby improving the performance of VFCW for COD removal.

Keywords: Aeration**,** Decentralized Treatment, Dissolved Oxygen, Domestic Wastewater, Feeding System, Vertical Flow Constructed Wetland.

1. Introduction

The most significant environmental problem and a threat to public health is the generation of wastewater and its treatment. Collection, treatment, and discharge of domestic wastewater can be done either through centralized or decentralized systems. There are many centralized systems but they require large infrastructure, expensive and require complex operations along with maintenance issues. Decentralized Wastewater Treatment Systems (DWTS) therefore is an alternative way to treat the wastewater. DWTS can be incorporated with primary, secondary and tertiary units of treatment. Constructed Wetland (CW) can be a part of DWTS either at secondary or tertiary level. CW has become an essential unit of DWTS in India for treating domestic wastewater. CWs are of many types viz. sub-surface horizontal flow, vertical flow, bio-rack, surface flow and hybrid CW. Vertical Flow Constructed Wetland (VFCW) is normally a secondary/tertiary treatment and a part of DWTS has been widely used in recent years for the treatment of municipal wastewater, due to its good efficiency, low cost and low maintenance.VFCWs require smaller area results in higher oxygen transfer capability and has simple hydraulics**.** The main advantage of VFCW systems is the ability to transfer high amounts of oxygen inside the bed. Oxygen transfer is more important in VFCWs for the removal of organic material and also plays an important role in the nitrification process (Zou *et al.*, 2011). Various studies were conducted on VFCWs using different arrangements and methods. [Cooper (1999), Brix *et al.*, (2002), Weedon (2003), Zhao *et al.*, (2010), Wu *et al.*, (2015), Foladori *et al.*, (2013), Jing Li *et al.*, (2019)]. These studies showed that VFCW effectively helped to remove the organic matter and nutrients. The feeding system and aeration within bed in VFCW plays a significant role in system performance. There are various methods used for aeration such as aeration in beds, continuous aeration, intermittently aeration, aeration with the help of spray, aeration using diffusers, etc. (Ding *et al.*, 2014). But feeding system aided with aeration improves VFCWs performance. There are very few studies addressing this issue. In the present study, feeding cum aeration system is devised on innovative concept and implemented on field-scale Integrated Domestic Wastewater Treatment System (IDWTS) functioning at Walchand College of Engineering .(WCE). The objectives of the study are to assess i) the effectiveness of this feeding cum aeration system to improve feed wastewater quality in terms of dissolved oxygen and Chemical Oxygen Demand (COD); and ii) performance of VFCW.

2. Materials and Methods

2.1 Source of Wastewater

The wastewater generated from boy's and girl's hostel, and residential facilities from WCE campus and contributed by 320 residents. It primarily consists of greywater and effluent from septic tank. This wastewater is fed to DWTS where it undergoes preliminary treatment through bar screen, primary treatment through Anaerobic Biofilm Reactor (ABR) and hybrid CW. Treated effluent from hybrid CW is collected in sump and then pumped to VFCW. The secondary effluent from the sump is the feed water source for this study.

2.2 Description of Feeding cum Aeration System

VFCW (of size 6 m x 5 m x 1m) is vegetated with *Canna Indica* and *Giant reed* in grit-charcoal support medium. Influent to the VFCW is pumped (with an auto-operated pumping system) as shown in Fig. 1 (a). The feeding cum aeration system is shown in Fig. 1 (b). It consists of a centrally located circular tank that was kept at an elevation of 0.6 m above the bed of VFCW. The inside view of circular tank is shown in Fig. 2 (a) and (b). A grid of cross-connected discarded plastic bottles is placed at various levels. The pumped influent falls on this grid of pipes from a height of 1 m. The water droplets ejected due to impact on the grid surface and subsequent fall within the tank provides contact between influent and air. This is visible in Fig. 2 (b). The falling and percolating water is collected at the bottom of the tank. The tank has eight outlet ports which are connected to 50 mm diameter sloping PVC pipes (Fig. 1 (b)). The agitation within the tank and layered flow these eight PVC pipes are termed as first stage aeration in this study. Further each of these PVC pipes conveys water to multiple tray aerators. There are four perforated trays and placed with charcoal. The total depth of tray aerator is 1 m. The charcoal in the tray enhances turbulence thereby aiding aeration. Multiple aerators filled with charcoal are termed as Second stage aeration in this study. VFCW is fed uniformly at eight locations through this aerated feeding system. VFCW treated effluent is collected and analyzed.

Fig. 1(a) Auto-operated pumping system of VFCW

Fig. 1(b) Feeding cum aeration system of VFCW

Fig. 2(a) Grid of cross-connected discarded plastic bottles

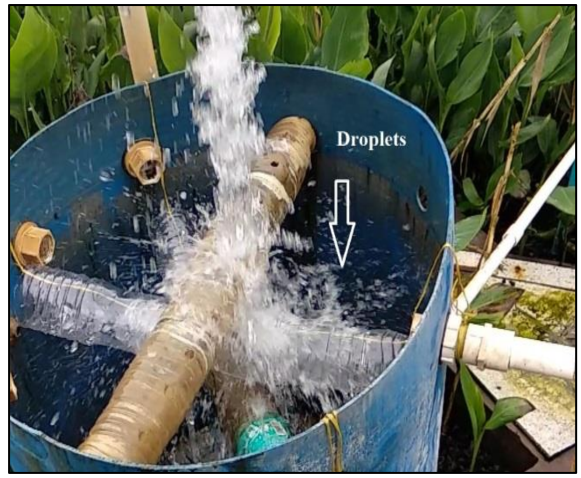

Fig. 2(b) Water droplets formation due to grid surface

2.3 Sampling and Methods

Grab samples were collected in the morning (8.00 AM), afternoon (12.00 PM) and evening (4.00 PM). The samples were collected from inlet and outlets of first stage aeration, outlet of second stage aeration and effluent of VFCW (fig 2.1) to assess the effectiveness of feeding cum aeration system. DO concentration was measured on the site using portable multi-parameter (HACH, HQ40D) and COD was measured in a laboratory using close reflux (COD digester).

3. Results and Discussion

3.1 Effect on COD removal

Fig. 3 shows COD and COD removal efficiency at various stages of feeding system and VFCW effluent value at different times in a day. COD value at 1st stage aeration, 2nd stage aeration and outlet of VFCW was observed to be 124.28 ± 22 mg/L, 106.59 ± 24 mg/L and 82.66 ± 30 mg/L at morning, 122.15 ± 40 mg/L, 93.33 ± 32 mg/L ,72.46 ± 25mg/L at afternoon and 147.98 ± 18 mg/L, 118.67±15 mg/L, 85.65 ± 17 mg/L at evening respectively(Fig. 3(a)).The feeding cum aeration system contributes to 15% to 25% for COD removal. VFCW is effective to an extent of 20% to 25% for COD removal. The overall COD removal efficiencies by feeding cum aeration system and VFCW were 34.24%, 40.68%, and 42.12% (Fig. 3(b)). These results show that COD removal is temporally varying with more during afternoon and evening time. Further, feeding cum aeration system significantly contributes to COD removal. Bacterial activity enhanced during afternoon is resulted by moderate and maximum COD removal as compared to morning.

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The possible mechanism for COD removal can be a feeding system due to surface aeration within the central tank (presence of grid of plastic bottles) as well as cascade aeration through the multilevel trays. The attached growth aerobic bacteria in grid of pipes, charcoal, and aerobic/anaerobic in bed of VFCW are involved in the process of degradation. The anaerobic conditions also prevail due to lesser DO (less 1.5 mg/L) present.

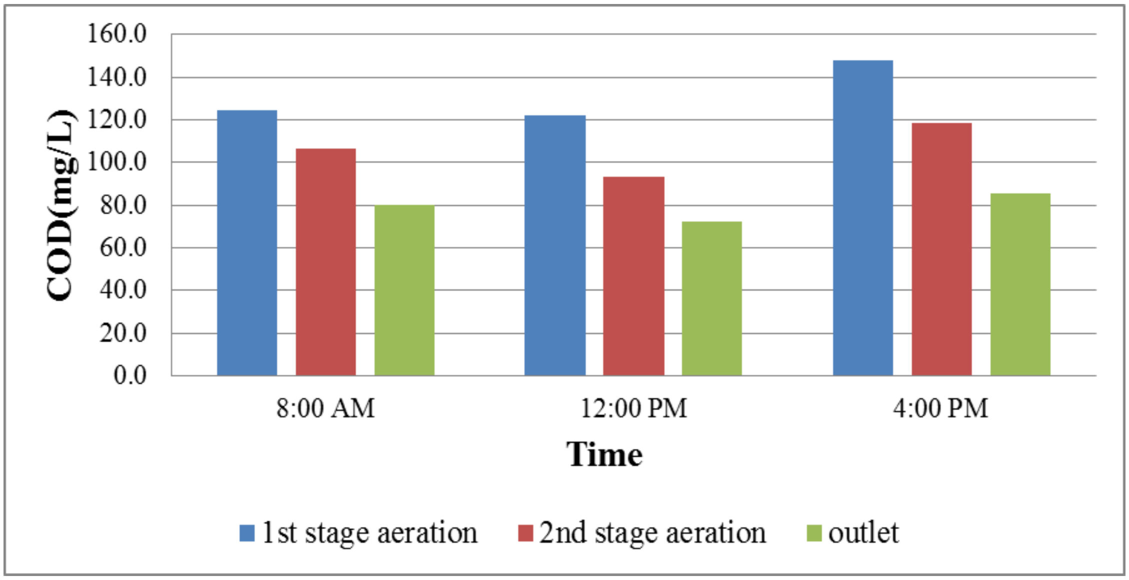

Fig 3(a) COD variation throughout the day

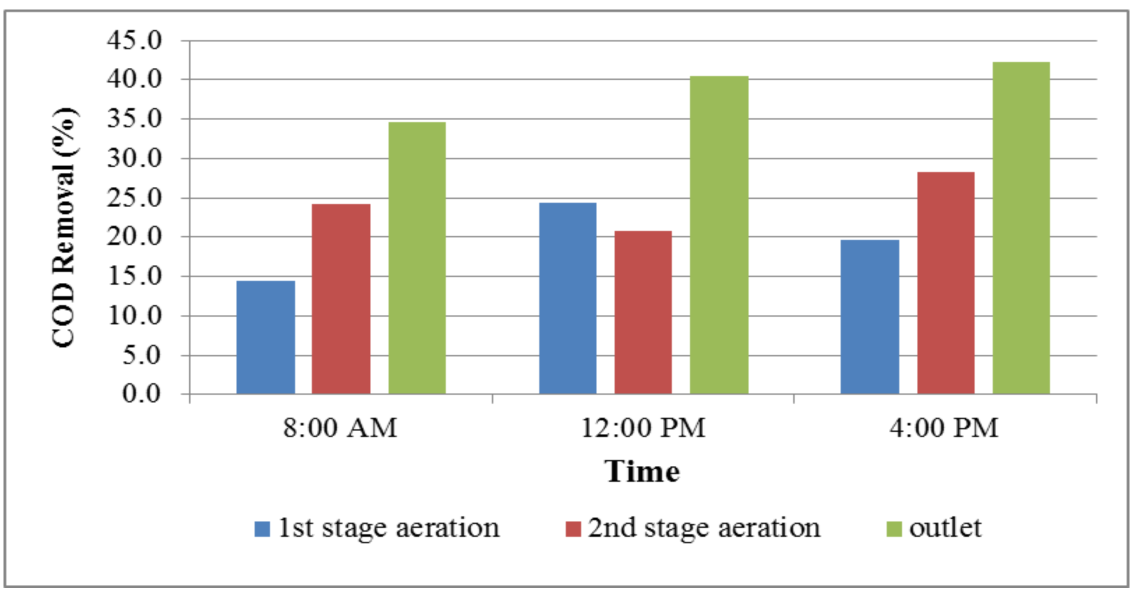

Fig. 3(b) Variation in COD removal efficiency

3.2 DO variation

Fig. 4 shows the variation of DO at various stages of aeration and VFCW. The results show that two-stage aeration system contributes significantly to DO enhancement. This is possible due to the formation of fine droplets through the surface aeration within the tank as well as cascade aeration due to the multilevel trays. The fine droplets increase the contact time between atmospheric air and effluent droplet which could be a possible reason for trapping DO. VFCW also contributes to DO primarily due to multispecies vegetation of *Canna indica* and *Giant reed* liberating oxygen through their roots thereby enhancing DO in effluent. However, DO values observed are less than 1.5 to 2 mg/L and this may not support aerobic degradation fully.

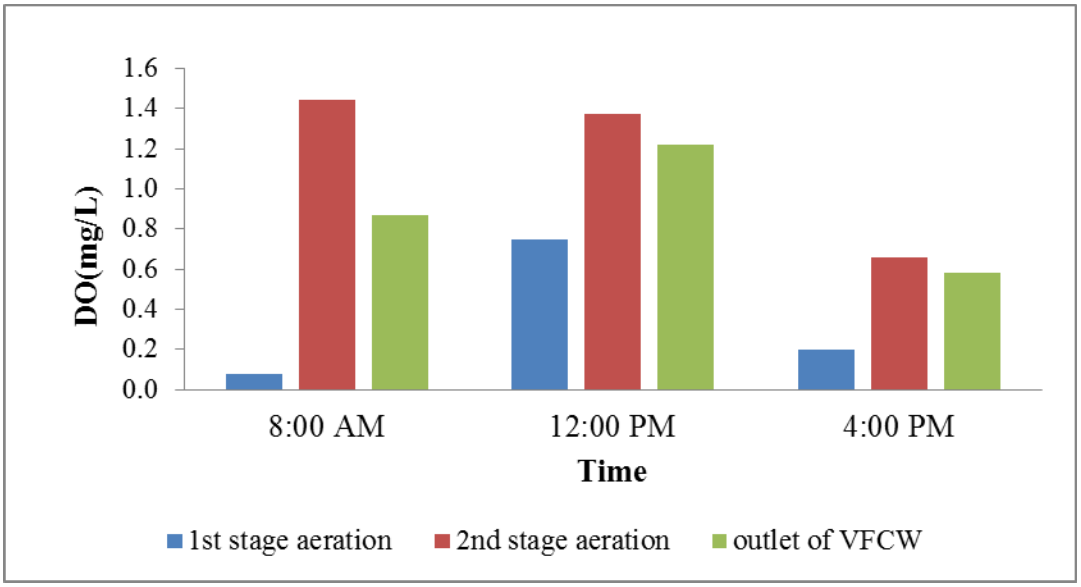

Fig.4 Effect on DO enhancement due to modified feeding system

4. Conclusion

The feeding cum aeration system and VFCW were assessed for their respective contributions in COD removal and DO enhancement. The feeding cum aeration system is found to contribute significantly in COD removal and DO enhancement. The contribution to COD removal by this component is to an extent of 15% to 25%. VFCW with this type of feeding-aeration system is a potential option to treat domestic wastewater. The overall COD removal in VFCW is 34% to 43%. DO enhancement to an extent of 1.26 mg/L is possible but may not support aerobic activity fully.

Acknowledgment

The present study is a part of a research project sanctioned by the Department of Science and Technology (DST) under the Water Treatment Initiative (WTI) programme. The authors sincerely acknowledge and thank DST for providing financial support to undertake this study.

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