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INFLUENCE OF TWO DIFFERENT FLOW RATE ON POLLUTANT REMOVAL CAPACITY OF AQUATIC PLANTS FOR TREATING THE SEWAGE EFFLUENT THROUGH CONSTRUCTED WETLAND TECHNOLOGY

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ABSTRACT

A lab-scale model constructed wetland designed with horizontal flow system with 45×21.5×30 cm (L×B×H) for treating the primary sewage effluent. Three efficient aquatic plants viz., Canna indica, Xanthosoma sagittifolium, and Typha angustifolia were selected and utilized for the lab-scale study. Seven different retentiontime 1st, 2nd, 3rd, 4th, 5th, 6th and 7th day after the beginning of the experiment with two average flow of 5 ml/min and 10 ml/min maintained. The results of the experiment state that pollutants and a salt load including was significantly reduced at the 7th day of retention time. Canna indica and Xanthosoma sagittifolium performed better in a model constructed wetland for treating sewage effluent with the flow rate of 5 ml/min at the retention time of the 7th day compared to the flow rate of 10 ml/min.

KEYWORDS: *Flow Rate, Aquatic Plants, Pollutant, Constructed Wetland*

INTRODUCTION

The limitation of water resources and sustainable use of alternative water sources have to lead to demand for the development. There are many technologies like Active Sludge Process (ASP), Rotating Biological Contactor (RBC), Stabilization ponds, oxidation ditch and Trickling Filter (TF) for the wastewater treatment (Tanner & Sukias, 2003); (Sayadi et al., 2012). Similarly, there is a natural wastewater treatment process named as constructed wetland technology.

During the last four decades of 20th century constructed wetlands are the most widely used ecological wastewater treatment systems. The constructed wetlands are several types which could be distinguished according to distinct criteria such as presence/absence of free water surface, macrophytes used or direction of flow (Vymazal, 2010). Constructed wetland as environmentally friendly, natural process and eco-friendly with simple construction and low maintenance is one of the interesting technique when compared to mentioned conventional technologies (Vymazal, 2010); (Madera-Parra et al., 2015); (Shelef et al., 2013)

Plants play the main role in the wetlands by creating attachment sites for microorganisms and to release oxygen. The effectiveness of the desired treatment will be increased based on the selection of suitable plant species (Jethwa & Bajpai, 2016). Nutrients obtain by the aquatic plants from the sediment as well as directly from the water itself (Schulz et al., 2004), (Shelef et al., 2013). Plants that are rooted in standing water with leaves emerging from the water, plants completely submerged rooted in the sediment with leaves floating on the surface, and plants that are free-floating in the water with leaves either submerged, or partly or fully emergent. Free-floating phytoplankton and attached algae growth are the algae growth forms. For food, landscape improvement, and purification, the local people of Dong Ha city grow Colocasia esculenta and Canna indica. They can be cultivated easily in the constructed wetland system (CWs) and adapt to wet conditions (Nguyen et al., 2017). The physical effects of root structure combined with aeration are the most important mechanism by which plants contribute to the CW process (Vymazal, 2010). Filtering, flow velocity reduction, improved sedimentation, decreased resuspension, distribution of water and prevention of clogging are the physical effects of roots.

One of the primary factors in controlling wetland functions is hydrology, and a satisfactory treatment performance is achieved by the regulation of flow rate (Lee et al., 2009). The optimum contact time is reduced by the greater HLR which promotes quicker passage of wastewater through the media. In addition, at a longer HRT, an appropriate microbial community may be established in CWs and it can possess adequate contact time to remove contaminants (Zurita and White, 2014). Therefore in the present study, an attempt has done to evaluate the pollutant removal capacity of aquatic plants for treating the sewage effluent in a model constructed wetland.

MATERIALS AND METHODS

A lab-scale model constructed wetland was designed with horizontal flow system. All the six reactors were in a uniform size of 45×21.5×30 cm (L×B×H). The media used in the experiment was gravel, coarse sand and garden soil. The size of gravel 20 mm and the porosity of sand 50% and soil was 32% for each reactor. Inlet was arranged manually with saline tubes to optimize the average flow rate passing through a constructed wetland system. An outlet for the treated effluent collection was arranged at bottom of the reactor with silica tubes. Total of six model constructed wetlands was designed with two different flow rates for each of three selected aquatic plants were planted. The suitable efficient aquatic plants were utilized for the constructed wetland system viz., Canna indica, Xanthosoma sagittifolium and Typha angustifolia of uniform sizes were selected and washed thoroughly. The initial weight of the plants was recorded and later, (3 nos.) of plants of each species were placed in the model constructed wetland. The collected sewage effluent was placed at an elevated position and the effluent was passed with an average flow of 5 ml/min and 10 ml/min in each of two constructed wetlands. The sewage effluent was passed into the model constructed wetland system for a period of (1^{st}, 2^{nd}, 3^{rd}, 4^{th}, 5^{th}, 6^{th}, and 7^{th} day) retention time with the average flow being maintained in each constructed wetland. The treated effluent was collected after the retention time of 1^{st}, 2^{nd}, 3^{rd}, 4^{th}, 5^{th}, 6^{th} and 7^{th} day. The lab scale experiment laid out in the factorial completely randomized design. The collected treated effluent was subjected to various water quality analysis following the standard analytical procedures.

RESULTS AND DISCUSSION

Characteristics of Sewage Effluent

The initial sewage effluent used for model constructed wetland was alkaline with a pH of 7.77 and an Electrical conductivity of 3.03 dS m^{-1}. The total dissolved solids in the effluent were 2328 mg L^{-1} and the total suspended solids was 400 mg L^{-1}. The Biological oxygen demand and Chemical oxygen demand of the initial sewage effluent were 580 and 2180 mg L^{-1} respectively. The total nitrogen and total phosphorus in the effluent were 0.25 and 0.21 % respectively. Heavy metals observed were Nickel (4.81 mg L^{-1}), Lead (8.01 mg L^{-1}), chromium and Cadmium were below the detectable level in the sewage effluent. The total coliforms were 1600 MPN/100 ml. The maximum amount of BOD and COD indicate the high amount of both organic and inorganic pollutants. BOD and COD values exceed the prescribed levels of 100 and 250 mg L^{-1} (CPCB) to discharge into public sewers. Hence the sewage effluent should be treated before its usage for crop irrigation (Suganya et al., 2017).

pH and EC

The present investigation to access the influence of plants, retention time and two different flow rates in the pH of the sewage effluent, through the model constructed a wetland, reveal that the pH got decreased from D_1 and D_7 at 5 ml flow rate than 10 ml shown in Fig 1. Among the aquatic plants, Canna indica was significantly superior to other plants. The decrease in the pH in the lower HLR may be due to more contact time of the effluent with the plant and the medium used in the study. Lihua et al. (2010) also reported that HRT plays a major role in the reduction of pH based on the plants and substrate utilized for the study. The EC of the sewage effluent after treating through the model CW using the three aquatic plants viz., Canna indica, Typha angustifolia, Xanthosoma sagiitifolium seems to follow the same trend as that of pH of the effluent shown in Fig 2. Sorption is a process which involves the transfer of ions or charges from the aqueous phase to solid-phase. Here, in this study, soluble salt responsible for EC may get adsorbed to the medium and roots of the plant growth in the model CW.

Removal of Suspended Solids

TSS of the effluent reduced from the retention time of 1 to 7 days at the flow rate of 5 ml/min and 10 ml/min showed in Fig 3. There was clear evidence in the reduction of TSS at a flow rate of 5 ml/min than 10 ml/ min at the 7^{th} day of retention time. This might be because of filtration, interception or flocculation of suspended particles in the medium i.e. sand, gravel and pebbles and aquatic plants used in the study. Karathanasis et al. (2003) also observed the positive effect of TSS removal of the effluent by aquatic plants Typha latifolia. EWRG (2017) also stated Colocasia esculenta can be used for a constructed wetland. Xanthosoma sagiitifolium belongs to the same family of Colocasia esculenta i.e., Araceae seems to have the same property in removing solids and other particles in a constructed wetland.

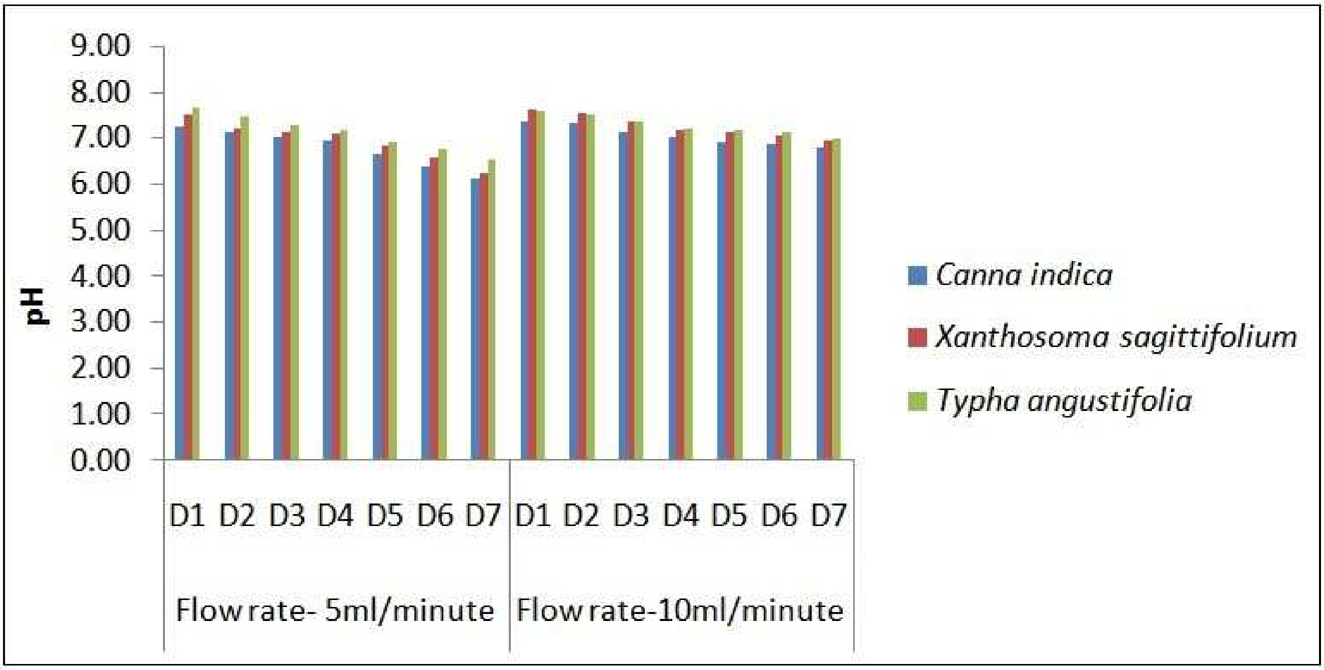

Figure 1: Effect of Aquatic Plants and Flow Rates on the Removal of pH of Sewage Effluent

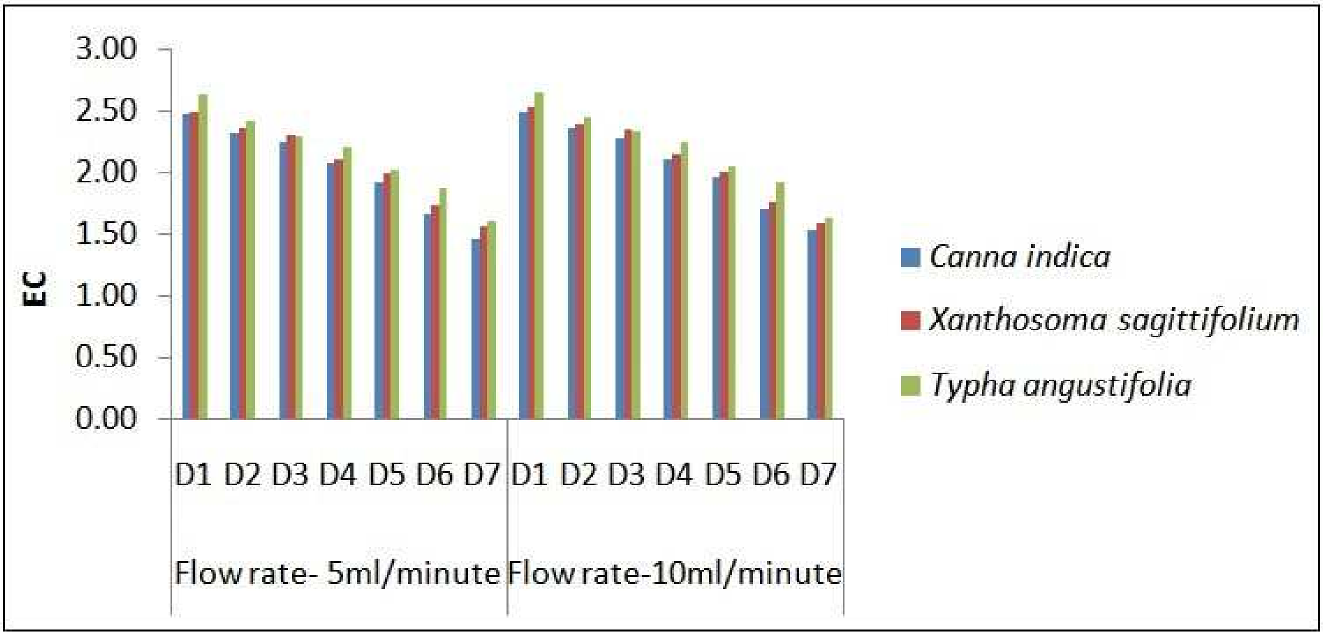

Figure 2: Effect of Aquatic Plants and Flow Rates on the Removal of pH of Sewage Effluent

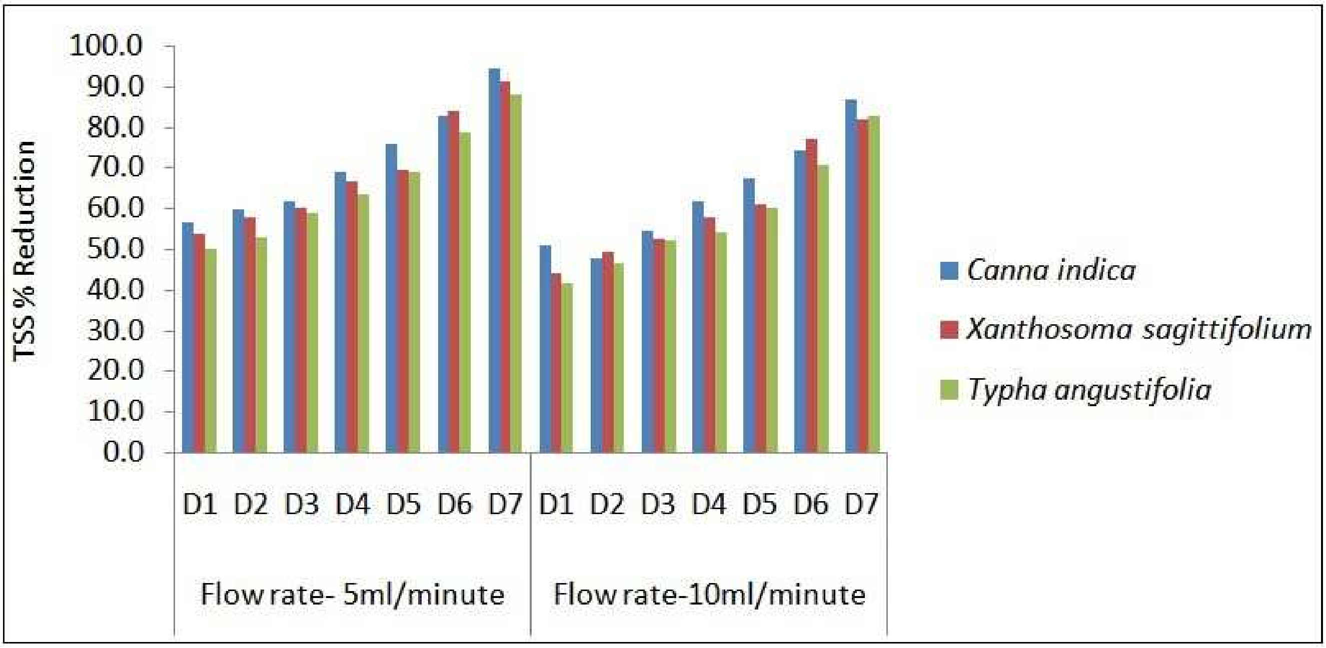

Figure 3: Effect of Aquatic Plants and Flow Rates on the Removal of TSS of Sewage Effluent

Removal of Total Dissolved Solids

The percent reduction of TDS in the sewage effluent used in the model constructed wetland was shown in Fig 4. At all the retention time of D_1 to D_7 the reduction of TDS was better at 5 ml flow rate when compared to 10 ml. The reduction of TDS may be due to the more contact time of the effluent with aquatic plants and different medium. Florentina and John White (2014) also observed that the two-stage hybrid ecological wastewater treatment systems can be used to improve the quality of wastewater thereby using them for irrigation purposes.

BOD Removal

An increase in BOD removal efficiency was observed in the model constructed wetland with the flow rate of 5ml/min using three aquatic plants. At the retention time of 7days among all three aquatic plants, Canna indica showed better BOD removal efficiency followed by Xanthosoma sagiitifolium and Typha angustifolia respectively. The organic matter in the effluent may undergo hydrolysis and converts into a soluble form and enters the media and attach to biofilm and then further decomposed. Aerobic bacteria in the biofilm release oxygen through the roots of plants which in turn supports organic pollutant degradation (Faiza rehman et al., 2017). The aquatic plants used in the study especially Canna indica possess thick leaves and large surface area for gas diffusion and in turn, helps in reduction of BOD (Suganya et al., 2017). Xanthosoma sagittifolium is significantly on par with Canna indica. Bindu et al. (2008) also reported that utilization of Colacasia esculenta has higher BOD and COD reduction during domestic wastewater treatment. Morphologically, Xanthosoma sagittifolium is similar to Colacasia esculenta and hence it may also have attributed to BOD removal in a constructed wetland.

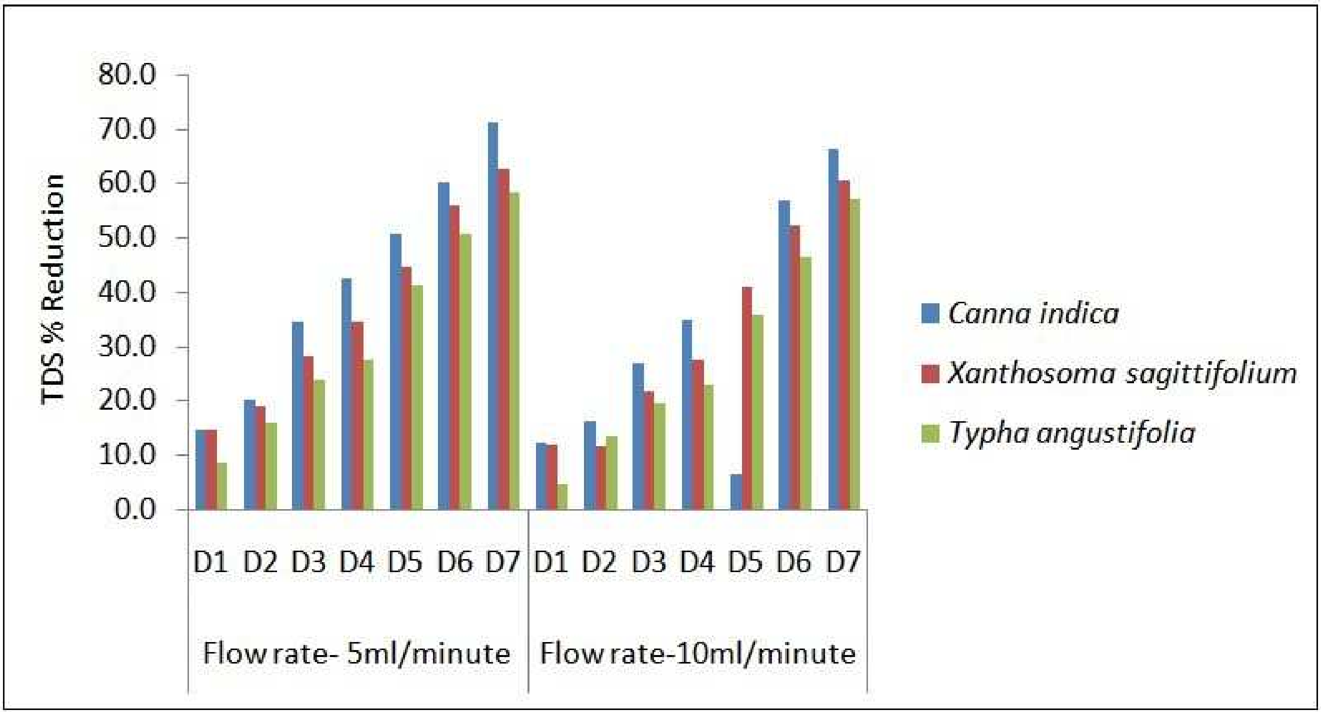

Figure 4: Effect of Aquatic Plants and Flow Rates on the Removal of TDS of Sewage Effluent

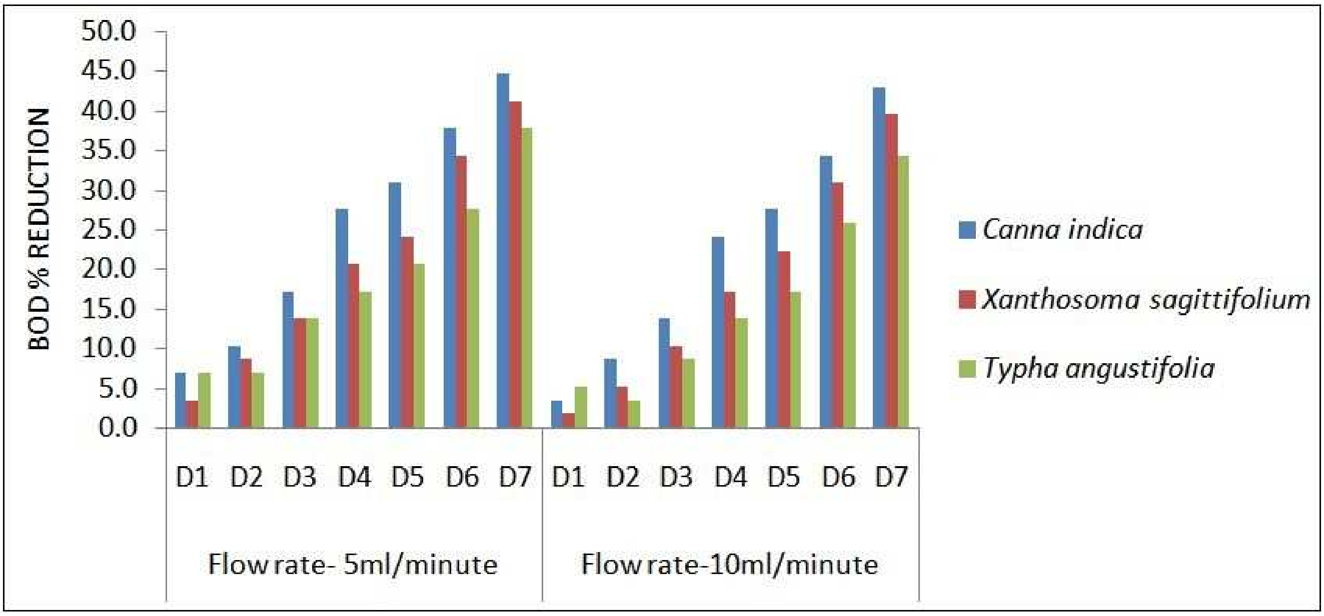

Figure 5: Effect of Aquatic Plants and Flow Rates on the Removal of BOD of Sewage Effluent

COD Removal

The COD of the effluent gradually showed a declining trend as the retention time increased from D_1 to D_7. COD can be decomposed by aerobic and anaerobic microbial processes and also by physical processes such as sedimentation and filtration. The percentage removal of COD better inCanna indica at D_7 at the flow rate of 5ml/min and 10 ml/min followed by Xanthosoma sagittifolium, Typha angustifolia respectively. All the three plants used comes under the category of emergent macrophytes which would have an extensive lacunar system that includes 60% of plant tissue helping in substantial oxygen release to the rhizosphere thereby reducing the oxygen demand for decomposition. These findings corroborated with the results of Maria Merino Solis et al. (2015) who stated that Canna hybrids have higher COD removal efficiency at lower HRT of two days in treating wastewater through Ecological Wastewater Treatment System (EWTS).

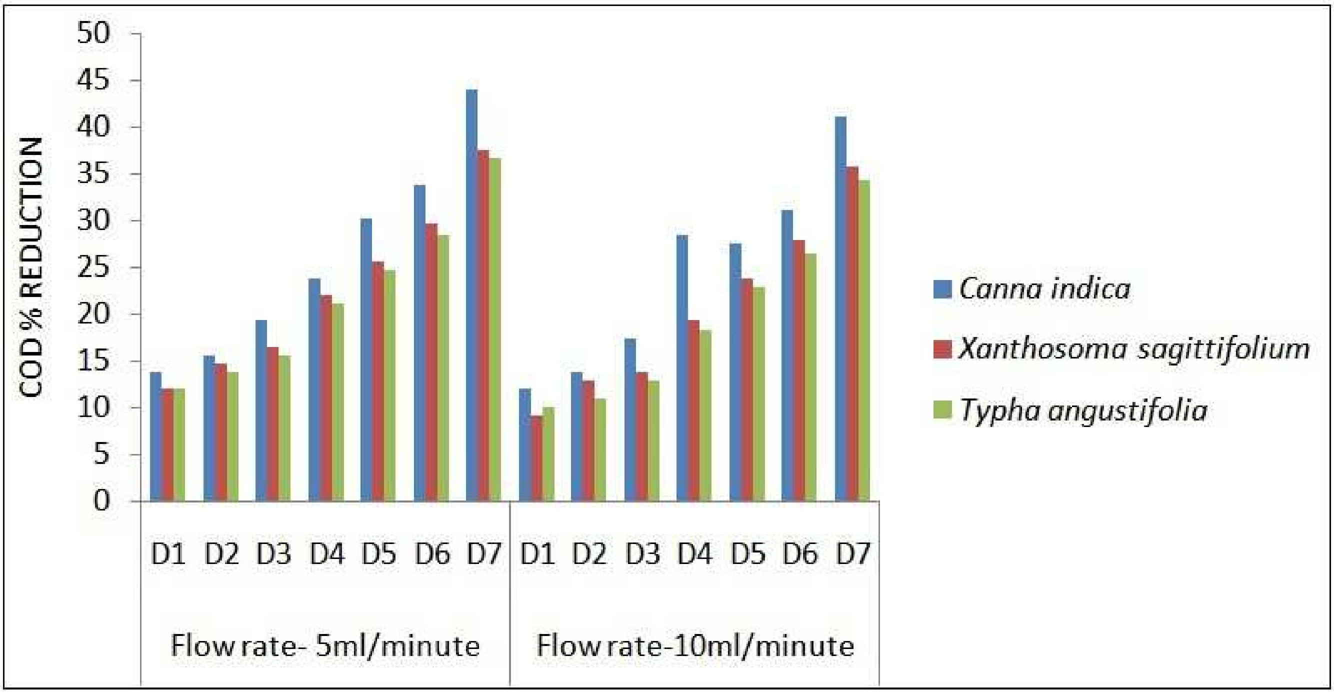

Figure 6: Effect of Aquatic Plants and Flow Rates on the Removal of COD of Sewage Effluent

CONCLUSIONS

The results proved that the three aquatic plants could be beneficial for pollutant removal in constructed wetlands for treating the wastewater. The salt and pollutant load was reduced gradually with increasing retention time from 1^{st} to 7^{th} day at both 5 ml and 10 ml flow rates/min. The BOD, COD, TDS, and TSS were declined to 25, 13.8, 42.2 and 71.4 percent in Canna indica treatments and to 21, 11.9, 37.2 and 68.9 percent in Xanthosoma sagittifolium treatments and 29, 8.4, 32.4 and 65.9 percent in Typha angustifolia utilized treatments at flow rates 5 ml/min. Whereas BOD, COD, TDS, and TSS were declined to 22.2, 24.5, 34.5 and 63.2 percent in Canna indica treatments and to 18.2, 20.3, 32.5 and 60.4 percent in Xanthosoma sagittifolium treatments and 15.5, 19.4, 28.6 and 58.1 percent in Typha angustifolia utilized treatments at flow rates 10 ml/min. The performance of Canna indica and Xanthosoma sagittifolium found to be superior to Typha angustifolia.

Hence, Canna indica, Xanthosoma sagittifolium, and Typha angustifolia are highly recommended for constructed wetland for wastewater treatment with high retention time and lower HLR.

REFERENCES

1. *Jethwa, K. B., and Bajpai, S. (2016). Role of plants in constructed wetlands (CWS): a review Number of Plants in Construction Wetlands per square meter of a sample area Sample area Number. Table, 1(2), 4–10.*
2. *Karathanasis, A. D., Potter, C. L., & Coyne, M. S. (2003). Vegetation effects on fecal bacteria, BOD, and suspended solid removal in constructed wetlands treating domestic wastewater. Ecological engineering, 20(2), 157-169.*
3. *Lee, C. G., Fletcher, T. D., & Sun, G. (2009). Nitrogen removal in constructed wetland systems. Engineering in Life Sciences, 9(1), 11–22.*
4. *Madera-Parra, C. A., Peña-Salamanca, E. J., Peña, M. R., Rousseau, D. P. L., & Lens, P. N. L. (2015). Phytoremediation of Landfill Leachate with Colocasia esculenta, Gynerum sagittatum and Heliconia psittacorum in Constructed Wetlands. International Journal of Phytoremediation, 17(1), 16–24*
5. *Nguyen, X. C., Nguyen, D. D., Thi Loan, N., & Chang, S. W. (2017). Potential of integrated vertical and horizontal flow constructed wetland with native plants for sewage treatment under different hydraulic loading rates. Water Science and Technology, 76(2), 434–442.*
6. *Rehman, F., Pervez, A., Khattak, B. N., & Ahmad, R. (2017). Constructed wetlands: perspectives of the oxygen released in the rhizosphere of macrophytes. CLEAN–Soil, Air, Water, 45(1).*
7. *Shelef, O., Gross, A., & Rachmilevitch, S. (2013). Role of plants in a constructed Wetland: Current and new perspectives. Water (Switzerland), 5(2), 405–419.*
8. *Sayadi, M. H., Kargar, R., Doosti, M. R., & Salehi, H. (2012). Hybrid constructed wetlands for wastewater treatment: A worldwide review. Proceedings of the International Academy of Ecology and Environmental Sciences, 2(4), 204–222.*
9. *Schulz, B., Bombach, K., Pawlig, S., & Britz, H. (2004). Neoproterozoic to Early-Palaeozoic magmatic evolution in the Gondwana-derived Austroalpine basement to the south of the Tauern Window (Eastern Alps). International Journal of Earth Sciences, 93(5), 824–843.*
10. *Suganya, K., and Sebastian, S. P. (2017). Phytoremediation prospective of Indian shot (Canna indica) in treating the sewage effluent through hybrid reed bed (HRB) technology. IJCS, 5(4), 102-105.*
11. *Tanner, C. C., and Sukias, J. P. S. (2003). Linking pond and wetland treatment: performance of domestic and farm systems in New Zealand. Water Science and Technology, 48(2).*
12. *Vymazal, J. (2010). Constructed Wetlands for Wastewater Treatment. Water, 2(3), 530–549.*
13. *Zurita, F., and White, J. (2014). Comparative Study of Three Two-Stage Hybrid Ecological Wastewater Treatment Systems for Producing High Nutrient, Reclaimed Water for Irrigation Reuse in Developing Countries. Water, 6(2), 213–228*