A Research Paper on Treatment of Domestic Wastewater using Vertical Flow Constructed Wetland (VFCW)

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Abstract: Constructed wetland was most effective and efficient treatment to treat wastewater. In recent years Vertical flow constructed wetland (VFCW) was used on large scale to treat wastewater due to its less operation and maintenance cost. The macrophyte used in this study were Colocasia esculenta and Ipomoea Carnea. The wetland was fed with HLR of 0.18 $m^3/m^2/hr$. In case of Colocasia removal efficiency for COD, BOD3 and TSS was 70%, 56% and 78% respectively. For Ipomoea Carnea percentage removal efficiency was 82, 76, and 91 for COD, BOD_3 and TSS respectively. For combination of these two plants removal efficiency for COD, BOD3 and TSS was 79%, 74% and 90% respectively.

Keywords: Vertical Flow Constructed Wetland, Domestic wastewater, Colocasia escluenta, Ipomoea Carnea

1. Introduction:

Water is one of the important element in the creation. The exponential growth of population and industrialization will cause a scarcity of water. The domestic waste and effluents from industry, institutional and agricultural sector directly discharged in surface water bodies. As a result of this these water bodies are gets excessively polluted and reduces water quality. In order to avoid this deterioration of water quality and to maintain or improve water quality index there is necessity to treat this sources of wastewater.

Conventional wastewater treatment methods requires high operation and maintenance cost, high energy requirement and also land requirement is more. Hence, in recent years conventional wastewater treatment methods are not preferred. To treat this wastewater low operation cost, low maintenance and low energy treatment methods are preferred. Decentralised wastewater treatment methods near its sources are more suitable. Hence, they are preferred on large scale in developing countries. Reuse of domestic wastewater is an emerging field in developing countries.

Constructed wetlands (CWs) are most reliable and low cost treatment method among various methods. Hence, constructed wetlands gets more recognition in recent years. Constructed wetland systems evolved over period of time to improve water quality. Through combination of complex physical, chemical and biological processes pollutants were removed and quality of water gets enhanced. For VFCW, vegetation and substrate are two main components. Substrate acts as a filter media and composed of locally available materials like sand, gravel and soil. Plant species used are locally available and able to withstand against local adverse conditions. Vegetation is the important factor to eliminate TSS, COD, BOD_5 and NH_4. Presence of vegetation improves removal rate of COD, BOD_5, TSS, Total kjedhal Nitrogen (TKN) and Total Phosphorous (TP).

Vertical flow constructed wetland requires less area and high oxygen transfer capacity inside the bed also it has simple hydraulics. VFCW requires less operation and maintenance cost. Hence it is feasible and used widely all over the world. More is oxygen transfer capacity more is the pollutant removal from wastewater. Removal efficiency of pollutant was more in case of VFCW than that of HFCW.

2. Materials and Methodology

The wastewater was collected from nallah by grab sampling. The fig. given below shows the experimental setup of VFCW. VFCW bed includes below mentioned layers from top to bottom: Alluvial soil (particle size: slag (particle size: 0.6- 4.75mm), Fine Aggregate (particle size: 10-20mm), and Coarse Aggregate (particle size: 20-40mm).

2.1. Experimental Setup:

Retained on 0.18 mm), River sand (particle size: 0.18-4.75mm), Crushed sand (particle size: 0.6-4.75mm), Blast Furnace

The thickness of coarse and fine aggregate layer was 0.075m each and remaining all layers were 0.15m each. The species used in wetland were Ipomoea Carnea and

Colocasia. For single species analysis 16 species each were planted and for multispecies analysis 8 plants of each species were used.

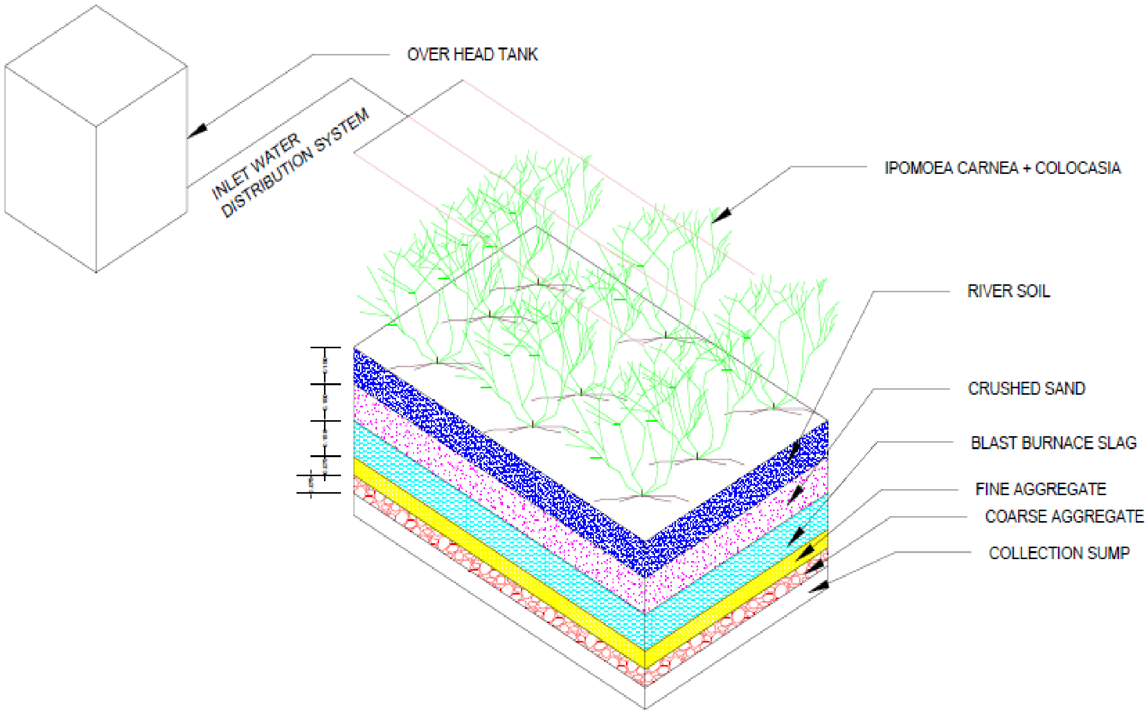


Fig. schematic diagram of experimental setup

2.2. Operation of VFCW model:

2.2.1. Initial Loading:

Initially VFCW basin was loaded with tap water for period of 3 months. Root zone was developed over a period of time.

2.2.2. Pre- treatment:

Before loading wastewater in overhead tank screening of wastewater was carried out to remove plastic, paper and vegetable peels. Flow adjusting valve was closed and wastewater was allowed to settle for period of 2 hrs. This detention removes BOD_5 and TSS.

2.2.3. Loading of wastewater:

Wastewater was loaded on VFCW bed intermittently. Wastewater was loaded with HLR of 0.18 $m^3/m^2/hr$. Perforated PVC pipes uniformly distributed wastewater over a bed. When full drainage was done proper resting period was provided to restore aerobic conditions and oxidation of organic matter arrested in media pores due to which nitrification process improves and possibility of clogging declines.

Fig. On site actual experimental setup

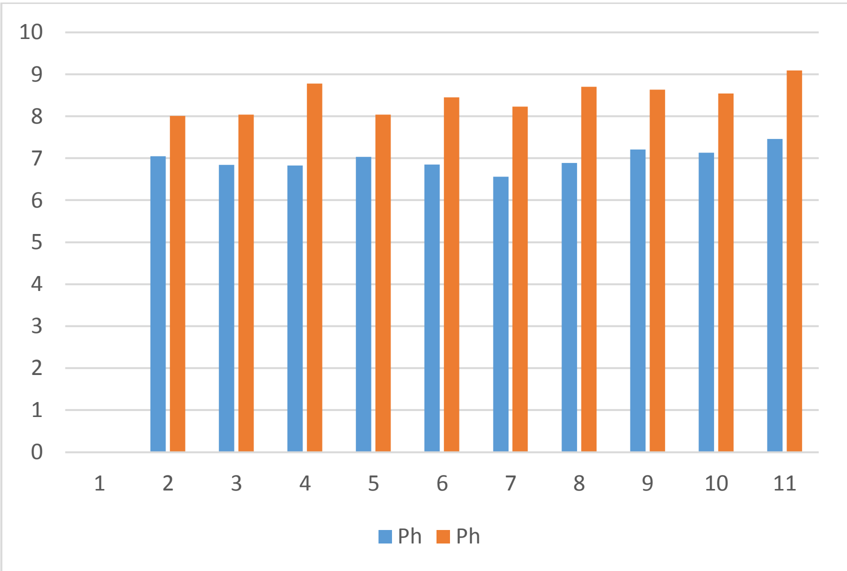
3. Results and Discussion

The influent and effluent were tested for various parameters such as TSS, BOD_3, COD and pH.

3.1. For combination of plants Colocasia and Ipomoea Carnea

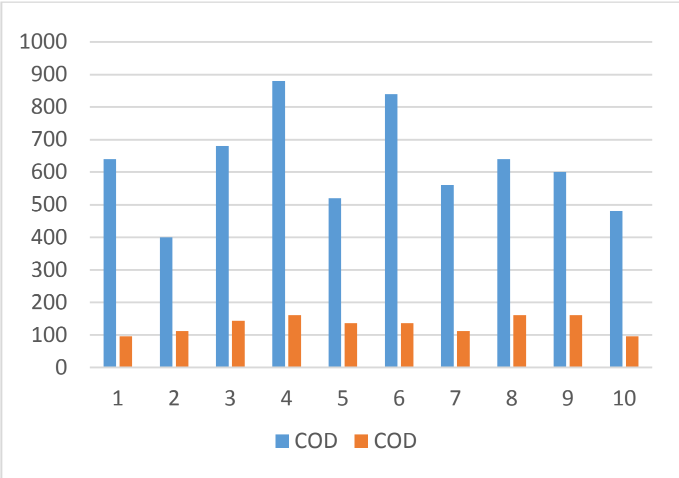
3.1.1. pH

The inlet pH of wastewater was about 7. After treatment the pH of effluent wastewater was increases.

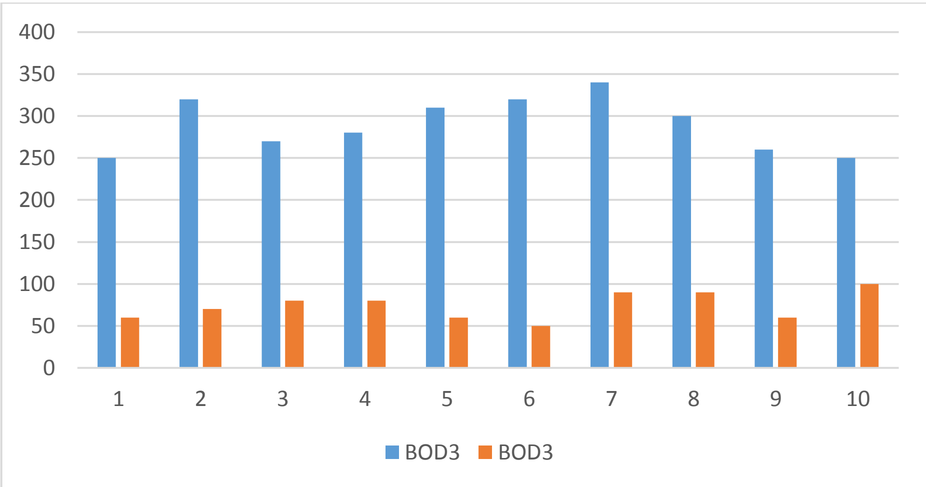


3.1.2. COD

The COD of influent wastewater was much higher due to presence of slaughter house near the nallah. The VFCW system efficiently remove COD. Hence, outlet COD was much lesser than that of inlet one.

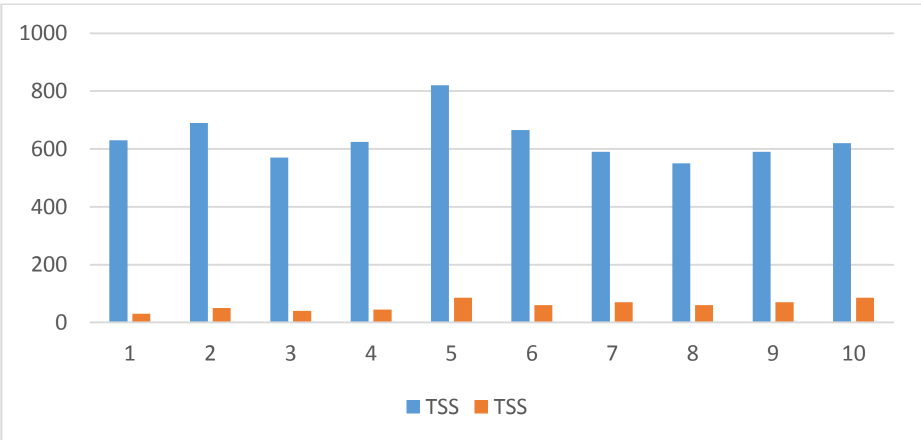


3.1.3. BOD_3



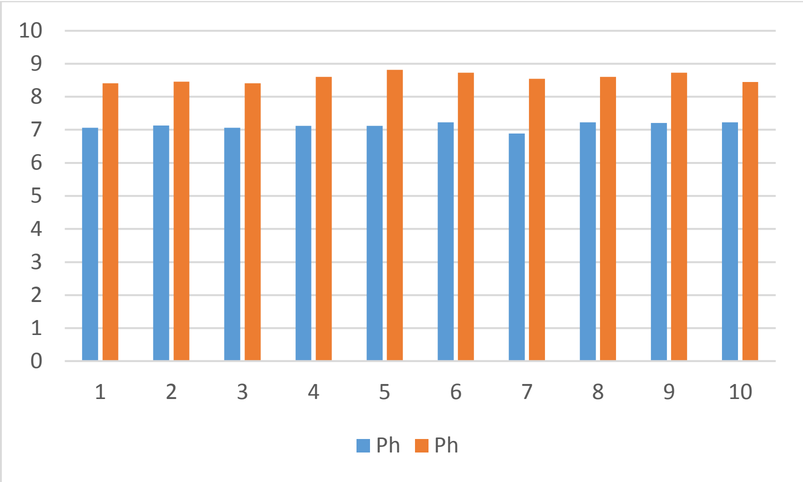
3.1.4. TSS

Presence of suspended solids in outlet was reduced much more due to fact that suspended solids get arrested in pores.

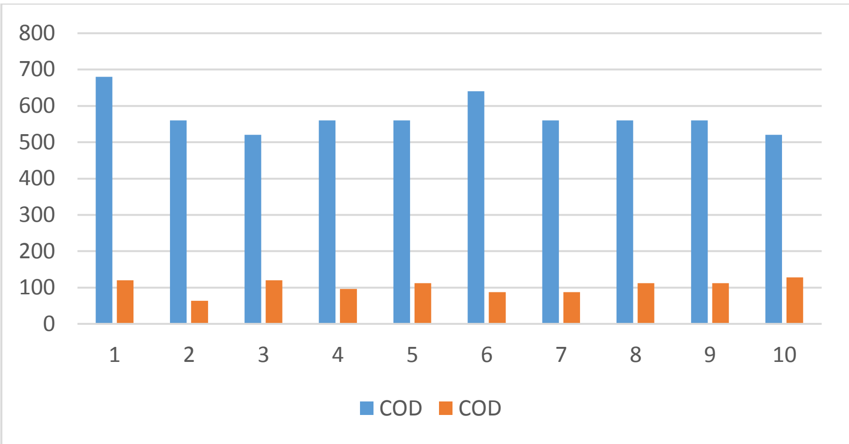


3.2. For Ipomoea Carnea

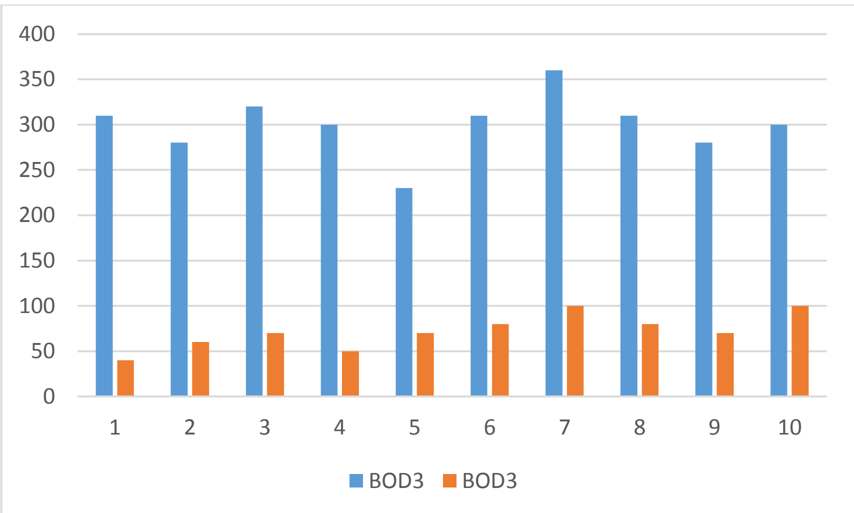
3.2.1. pH



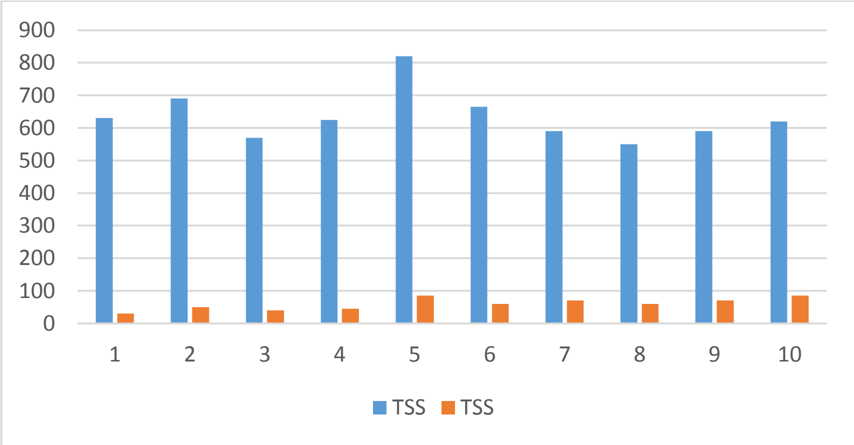
3.2.2. COD



3.2.3. BOD_3

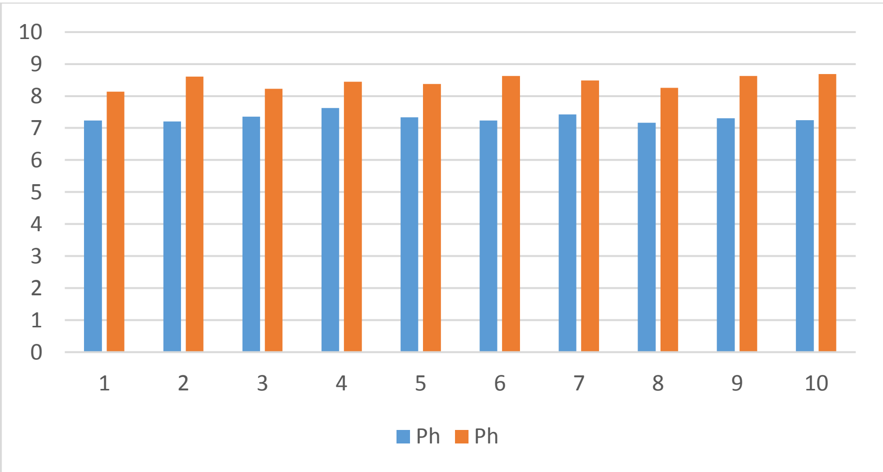


3.2.4. TSS

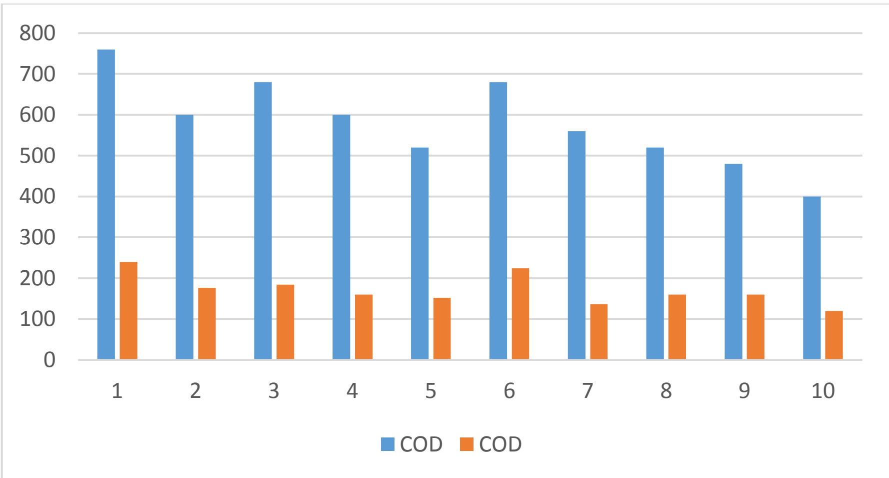


3.3. For Colocasia only

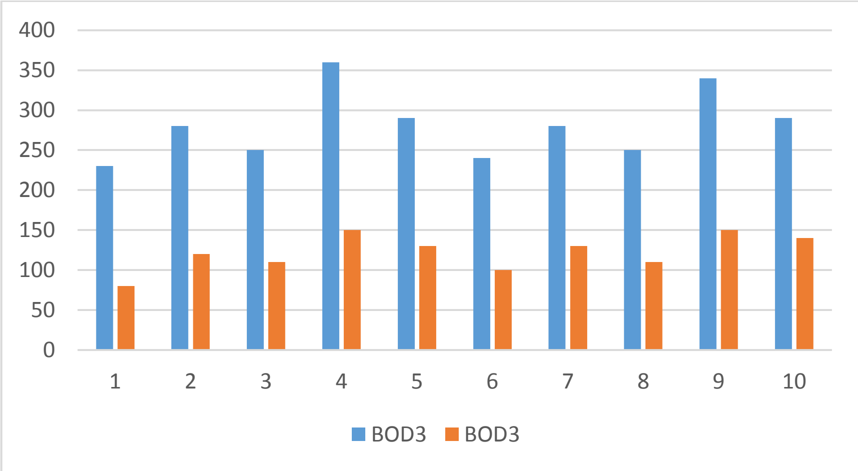
3.3.1. pH



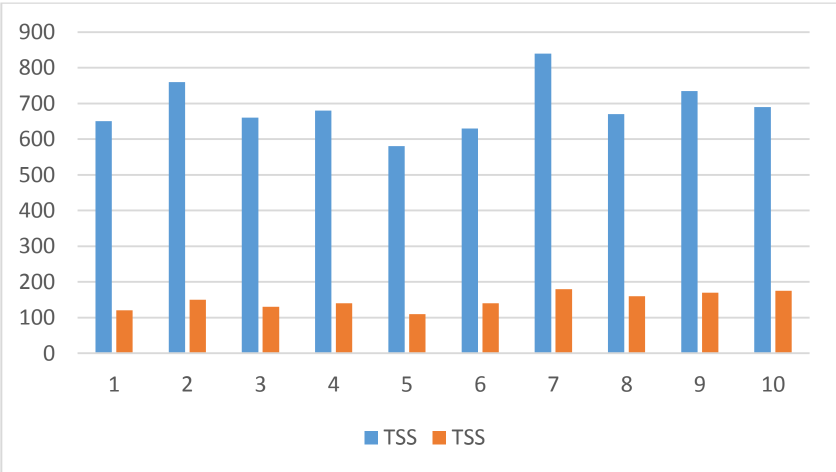
3.3.2. COD



3.3.3. BOD_3

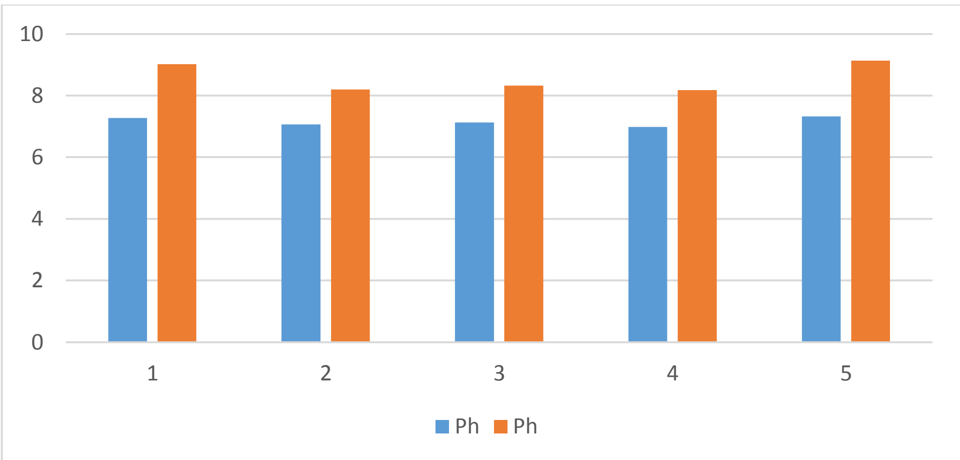


3.3.4. TSS

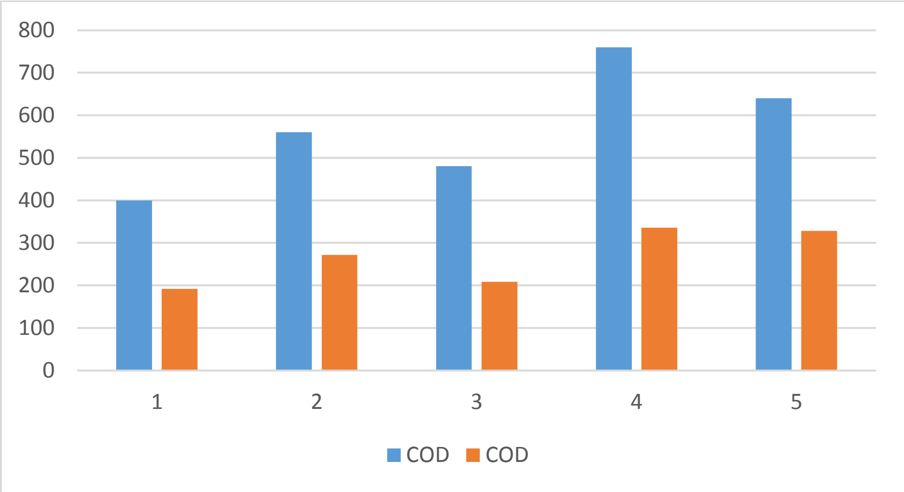


3.4. Filter media only without vegetation

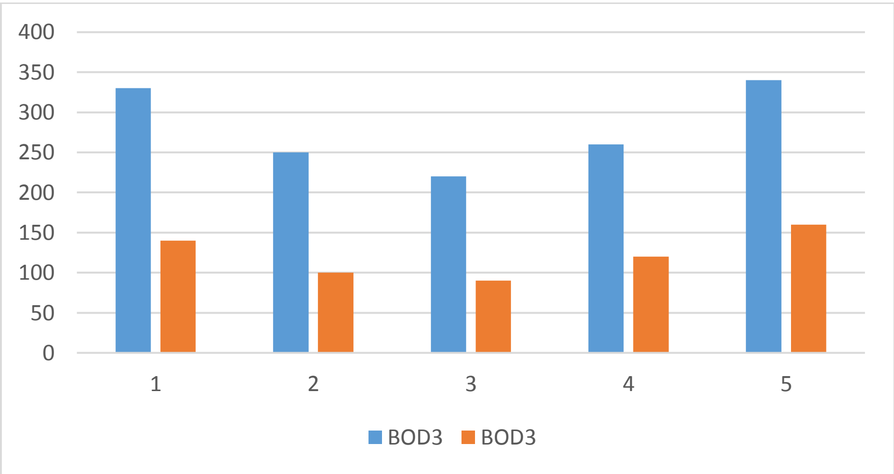
3.4.1. pH



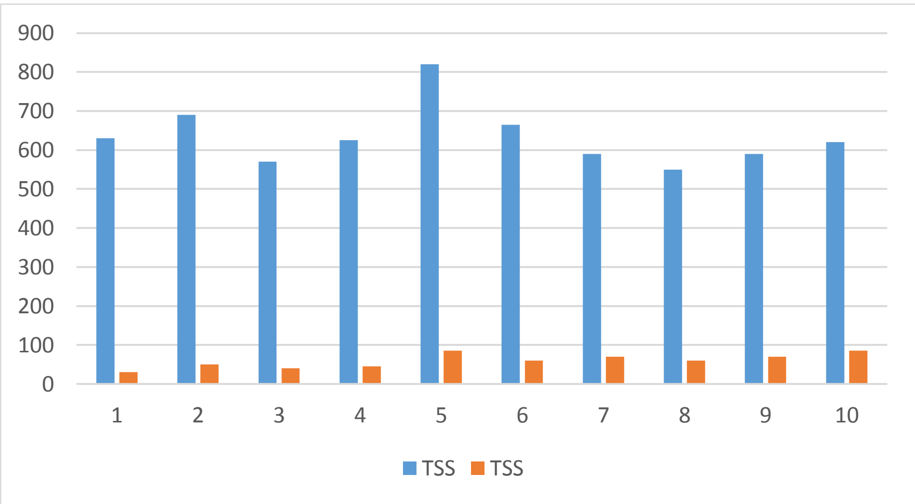
3.4.2. COD



3.4.3. BOD_3



3.4.4. TSS



4. Conclusions

1) Vertical flow constructed wetland with vegetation improves removal efficiency of COD, BOD_3 and TSS over filter media.
2) There is increase in effluent pH than that of influent one.
3) In case of Colocasia removal efficiency for COD, BOD_3 and TSS was 70%, 56% and 78% respectively.
4) For Ipomoea Carnea percentage removal efficiency was 82, 76, and 91 for COD, BOD3 and TSS respectively.
5) For combination of these two plants removal efficiency for COD, BOD3 and TSS was 79%, 74% and 90% respectively.

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References

1) Balachandran,T., Nanthakumaran, A., Devaisy, S., Sivanesan, K.S., 2018. Role of Colocasia esculenta in Constructed Wetlands for Treating Rice mill Wastewater AGRIEAST. Vol.12 (2), 19-26.

2) Borkar, R., Mahatme P. 2013.Wastewater Treatment Using Vertical Flow Constructed Wetland. International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 Vol. 3, Issue 2.

3) Fernando a, Jhanina a, Zhinín-Chimbo F. 2019. Performance of Phragmites Australis and Cyperus Papyrus in the treatment of municipal wastewater by vertical flow subsurface constructed wetlands. International Soil and Water Conservation Research 7.

4) Sani, A., Scholz, M., Bouillon, L., 2001. Seasonal assessment of experimental vertical-flow constructed wetlands treating domestic wastewater. Bioresource Technology 147, 585–596.

5) Fountoulakisa, b., Sabathianakisb, G., Kritsotakisa, I., Kabourakisa, E., Manios, T. 2017. Halophytes as vertical-flow on structured wetland vegetation for domestic wastewater.

6) Jun-jun Changa, Su-qing W, Yan-ran Daia, b., Lianga W., Zhen-bin W. 2012. Treatment performance of integrated vertical-flow constructed wetland plots for domestic wastewater. Ecological Engineering 44,152– 159.reatment.

7) Korkusuz, E., Beklioglu, M., Demirer, N. 2005. Comparison of the treatment performances of blast furnace slag-based and gravel-based vertical flow wetlands operated identically for domestic wastewater treatment in Turkey. Ecological Engineering 24,187–200.

8) Mimis, S. Gaganis, P. 2007. Vertical flow constructed wetland for wastewater treatment-Pilot case study. 10th International Conference on Environmental Science and Technology Kos Island, Greece, 5 – 7 September.

9) Sharma, H., Sinha P. 2013. Performance analysis of vertical Flow constructed wetland to treat domestic wastewater using two different filter media and Canna as a Plant. Indian Journal of Science and Technology of two, Vol 9, 44.

10) Sohair I. Abou-Elea, Golinielli G., Enas M. Abou-Taleb, Mohamed S. Hellal. 2007.
Municipal wastewater treatment in horizontal and vertical flows constructed wetlands. 10th International Conference on Environmental Science and Technology Kos Island, Greece, 5 – 7 September.

12) Zurita, J., Anda D., and Belmont M. 2009. Treatment of domestic wastewater and production of commercial flowers in vertical and horizontal subsurface-flow constructed wetlands. Ecological Engineering 35,861–869.