Potential Reuse of Greywater using constructed wetland:Design and Implementation of Vertical Constructed wetland System: A Case Study

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Abstract- In this study, greywater characteristics and treatment possibilities were reviewed using vertical constructed wetlands (VCW) to come up with a schematic of a greywater recycling system designed specifically for non-potable uses. Vertical flow constructed wetland units were designed according to the calculation of Kicked equation, which has been widely used in the research literature. Three types of plants, Canna (*Canna indica*), Ferns (*Matteuccia struthiopteris*) and Cattail (*Typha latifolia*) were used. Retention tank constructed for retaining solid particles in greywater as primary treatment. The experiment was conducted in a Completely Randomized Design (CRD) with three replicates conducted during two months period by using a hydraulic retention time of the system of 24 hours. The quality of the influent and effluent was monitored in two weeks intervals by analyzing water quality parameters namely PO_4^{-3}, NO_3^-, and $SO_4^{\ 3}$. It can be concluded that the pilot scale VCW's are feasible for greywater treatment at the domestic level with Cattail as the wetland plant since Cattail dense fibrous root system cause to remove more pollutants from the influent compared to that with this other two types of plants.

Keywords: Constructed wetlands, Greywater treatment, Wetland plants, Pollutant removal, Recycled-water, Waste-Water

I. INTRODUCTION

As the world's freshwater supply becomes increasingly scarce, increased attention toward alternative water resources has become necessary. In this context, water reuse has gained significant momentum in discussions about sustainable water resource management, green economies, urban planning and agricultural and landscaping. Greywater filtration and reuse has already been recognized as a promising alternative water source particularly for non-potable uses. Moreover, greywater reuse has become an essential component of local and national efforts to adapt to climate change, enhance food security, extend potable water supply, and reduce pollutants in the environment and helps to maintain groundwater level effectively.Greywater treatment by constructed wetlands involves chemical, biological, and physical processes like precipitation, sedimentation, absorption, adsorption, biological degradation, etc. The processes mainly work under the force of gravity without the consumption of energy [1]

The purpose of this research project is to investigate and compare the performance of plants in vertical constructed wetland and investigate the possibility of greywater treatment using vertical constructed wetland. For that Canna plant (*Canna indica*), Ferns plant *(Matteuccia struthiopteris)* and Cattail plant (*Typha latifolia*) used as wetland plants.

II. MATERIALS AND METHODS

Three experimental setups were designed and constructed using canna, ferns, and cattail plants planted in the same density as shown in Fig. 2. Data collection was performed in two phases. Firstly, the greywater quality was tested for a range of physicochemical parameters in the septic tank. Secondly, the water quality of the water passed through each of the wetlands was tested for a range of physiochemical water quality parameters. Fig.1 shows the summary of the methodology.

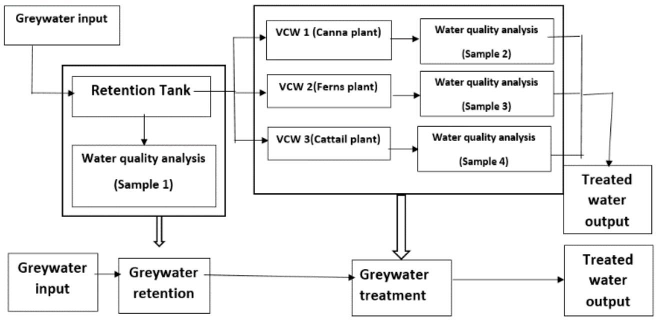

Fig 1.Methodology

The wetland size calculated based on the equation proposed by Kicked [2], 150 cm in length, 66 cm in width, and 70 cm in height. Wetlands were constructed using cement sand blocks and surface was waterproofed using cement mortars. Then wetland was filled with different size of aggregates and materials as shown in Table 1. This study designed for domestic wastewater at a flow rate of 1.2 m^3/d. The Hydraulic Retention Time of the system was 24 hours.

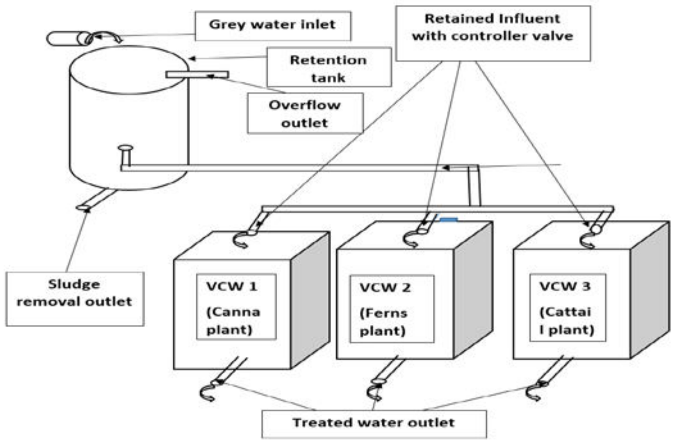

Fig 2.VCW setup

Table 1 : Layer Details

Layer	depth	purpose
64 mm-100 mm(cabals)	10 cm	provide more time and surface for microbiological activities
16 mm- 64 mm(Coarse gravel layer)	10 cm	provide more time and surface for microbiological activities
plastic mesh layered	-	prevent aggregates block below coarse gravel and corbels layers
8 mm-16 mm (Medium gravel layer)	10 cm	provide more time and surface for microbiological activities
Charcoal layer	10 cm	remove toxins from the water
Sand layer	10 cm	facilitate oxidation of reduced toxic metals, support a large rhizosphere as well as filtration purpose

Vegetation layer	10 cm	dominating macrophyte species, deep root penetration, strong rhizomes and massive fibrous root
plants	-	-

III. Results and Discussions

Data analysis was primarily conducted to understand the variation of water quality after passing through each of the VCW. Table 2, Table 3, and Table 4 show the results obtained through the laboratory testing for NO_3^-, PO_4^{3-} and SO_4^{2-} respectively whereas Fig.3, Fig.4, and Fig.5 show the performance of each plant graphically for each of these parameters.

A.Removal of Nitrite (NO_3^-)

As can be seen in Table 2 and fig 3, NO_3^- reduction efficiency of the cattail plant showed a higher performance of 95.45%. NO_3^- reduction efficiency in ferns plants 93.18% is comparatively higher than and canna plants 74.43%.

Table 2: NO_3^- Variation

Week	Retention Tank	Canna plant	ferns plant	Cattail plant
0	0.62	0.35	0.03	0.01
2	0.62	0.01	0.01	0.01
4	0.18	0.01	0.01	0.01
6	0.34	0.08	0.07	0.05
Average No^-_3	0.44	0.11	0.03	0.02
No^-_3Reduction efficacy		74.43%	93.18%	95.45%

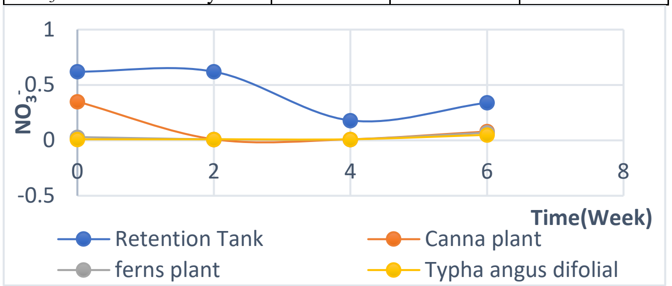

Fig.3. Nitrate Removal

B. Removal of phosphate (PO_4^{3-})

As can be seen in Table 3 and fig.4 PO_4^{3-} reduction efficiency of the canna plant showed a higher performance 86.11%. PO_4^{3-} reduction efficiency in ferns plants 83.33%is comparatively higher than and cattail plants 69.44%.

Table 3. Removal of phosphate

Week	Retention Tank	Canna plant	ferns plant	Cattail plant
0	0.07	0.03	0.06	0.02
2	0.26	0.01	0.02	0.1
4	0.35	0.09	0.03	0.01
6	0.4	0.02	0.07	0.2
Average Po4	0.27	0.0375	0.045	0.0825
PO43- Reduction efficiency		86.11%	83.33%	69.44%

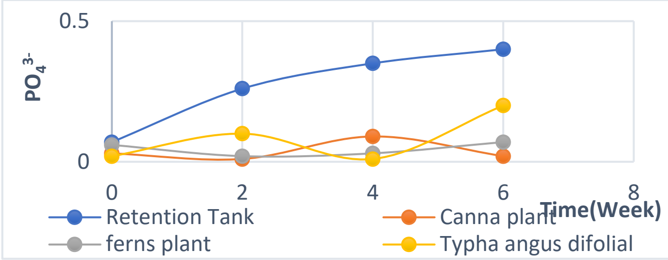

Fig.4 : Phosphate Variation

C. Removal of Sulphate (NO_3^-)

Table 4: Sulphate variation

Week	Retention Tank	Canna plant	ferns plant	Cattail plant
0	17.2	10.6	4.5	3.9
2	4.2	3.3	3.7	2.5
4	32.12	8.22	5.3	25.1
6	21.25	15.35	9.5	1.45
Average SO42-	18.69	9.37	5.75	8.24
Sulphate reduction efficiency		49.89%	69.24%	55.93%

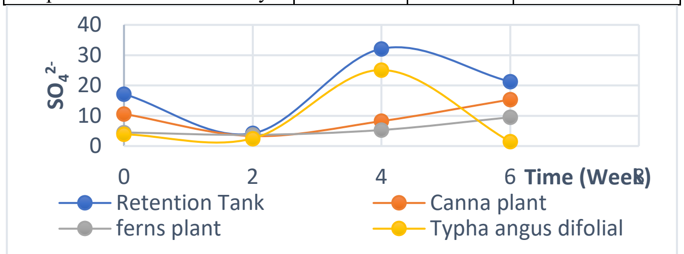

Fig. 5 : Sulphate variation

As can be seen in Table 4 and F.ig.5 SO_4^{2-} reduction efficiency of the ferns plant showed a higher performance 69.24%. SO_4^{2-} reduction efficiency in cattail plants 55.93% is comparatively higher than and canna plants 49.89%.

IV. CONCLUSION

Three plants; Canna, Ferns, and Cattail were tested for their performance in Greywater treatment using small-scale vertical constructed wetland units. Over a two months period, the Cattail plant showed higher performance in, NO_3^- removing by 95.45% compared to Ferns (93.18%) and Canna plants (74.43%). PO_4^{3-} removal efficiency also increased (86.11%) during the treatment process with the Canna plant compared to ferns (83.33%) and cattail plants (69.44%). Ferns plants showed significantly higher performance on the removal of SO_4^{3-} by 69.25% respectively compared to canna (49.89%) and cattail plants (55.93%). Overall, it can be concluded that small-scale VCW units are a viable technology for greywater treatment at the domestic level with the Cattail plant (*Typha latifolia*) plant since its' dense fibrous root system leads to removing more pollutants from the domestic wastewater. This study only investigate the performance of each plant separately. Composite VCW is recommended for further studies.

References:

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