

Design Recommendations for Constructed Wetland Treatment Unit at Household Level

S.Vanitha, C.Sivapragasam, Shaik Unoos Ahamed

Abstract: In this study, small scale simple Constructed Wetland is developed for treating wastewater at household level. For this purpose different laboratory based constructed wetlands are developed by changing size of soil, thickness of soil and by changing type of plants. Water quality parameters namely pH, Turbidity, Total Dissolved Solids, Electrical Conductivity, Total Alkalinity, Total Hardness, Ammonia, Nitrite, Nitrate Chloride, Fluoride, Phosphate, Chemical Oxygen Demand, Biochemical Oxygen Demand and Fecal Coliforms are tested before and after treatment. It is evident that Fecal Coliforms, Ammonia, Biochemical Oxygen Demand and Chemical Oxygen Demand removal is maximum as 98%, 92%, 86% and 75% respectively. Inorganic matters are not removed effectively. Design recommendations are also given for household constructed wetland. It is suggested *Canna Indica* plant is the most suitable option of wastewater disposal at household level.

Keywords: CONSTRUCTED WETLAND, CANA INDICA, HOUSEHOLD, DESIGN RECOMMENDATION.

I. INTRODUCTION

Of late, Constructed Wetlands (CWs) are widely used because of cost effectiveness and considerably much lesser demand on energy ([1], [2], [3], [4] [5], [6], [7]). Usually centralized method of CW treatment is implemented in many part of the world. Design of centralized CW faces many design issues because of population, variation in wastewater characteristics, nature of pollution etc. There is a chance of de- functioning of CW or functioning with lesser efficiency which leads to more operational and maintenance cost. In long run, large scale CW based treatment system may not be a sustainable solution. It will be a better option to go for CW based treatment at a much smaller scale such as a community level or even at household level.

In this study it is proposed to design simple Household Constructed Wetland (HHCW) which can treat effectively domestic wastewater and it can be reused. This study also suggests some simple design recommendation for implementation of HHCW in field.

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* Correspondence Author

Dr.S.Vanitha, Department of Civil Engineering, Kalasalingam Academy of Research and Education, Krishnankoil-626126, India. Email:svanithacivil@gmail.com

Dr.C.Sivapragasam*, Center of water technology, Department of Civil Engineering, Kalasalingam Academy of Research and Education, Krishnankoil, India..Email: sivapragasam@klu.ac.in

Shaik Unoos Ahamed, Civil Engineering, Kalasalingam Academy of Research And Education, Krishnankoil,. Email: sunoosahamed21412@gmail.com

II. METHODOLOGY

The domestic sewage is collected and the water quality parameters such as pH, Turbidity, Total Dissolved Solids (TDS), Electrical Conductivity, Total Alkalinity, Total Hardness, Ammonia, Nitrite, Nitrate Chloride, Fluoride, Phosphate, Chemical Oxygen demand (COD), Biochemical Oxygen Demand (BOD) and Fecal Coliforms (FC) are checked .

Domestic wastewater coming from dwellings are taken to HHCW unit. The water is passed through first tank (sedimentation tank) for settling of suspended impurities. During the experimental study, the head of water is varied between 50 cm to 80cm. Further, the experiment is conducted by varying size of soil, height of soil and types of plants etc. Water is stored in the plant filtration unit for one day detention time. Figure 1 shows the line sketch of HHCW unit for single family (in elevation) and Figure 2 shows the plan view of the proposed treatment unit. The number of sedimentation units and the number of CW units can be decided as per the need allowing about 100 litres/capita/day to each unit. The treated water can be collected and pumped to a separate storage for further reuse.

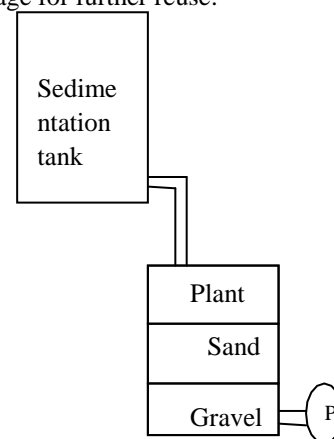


Fig 1. Line sketch of HHCW unit

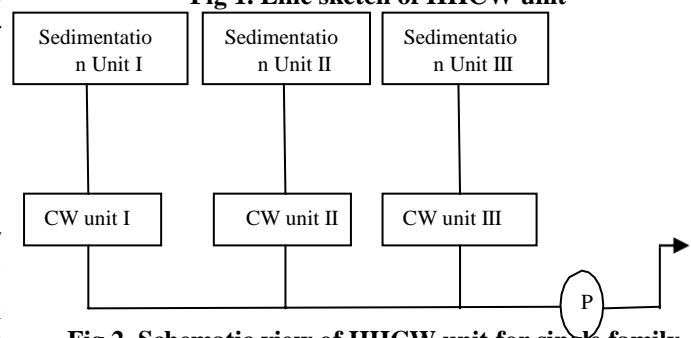


Fig 2. Schematic view of HHCW unit for single family.



III. RESULT AND DISCUSSION

1) Quality of treated water

The water quality parameters before and after treatment are shown in Table 1. From the Table, it is seen that the 98% of FC is removed. It is found that the removal is attained at greater extent than any other parameters. Next to that, 92% ammonia is removed. BOD and COD removal is 86% and 75% respectively. TDS, Conductivity and Total alkalinity, Fluoride removal are 16%, 20%, 20% and 20% respectively. The removal of phosphate is 43%, whereas nitrite removal is 72%. It is understood that Coliform, BOD, COD, nitrite and ammonia are removed effectively. BOD removal is due to presence of bacteria in the roots that oxidizes organic matter effectively. Removal of FC may be due to filtration of wastewater through soil layer. TDS, conductivity and alkalinity removal is less and it is expected because biological process does not enhance the inorganic matter removal.

TABLE- I:Wastewater Quality Before and After Treatment

Parameters	Before treatment	After treatment	Removal (%)
pH	6.6	6.9	-
TDS (mg/l)	1239	1034	16
Conductivity (µs/cm)	1953	1567	20
Total Alkalinity (mg/l)	590	473	20
Total Hardness (mg/l)	351	384	- 0.1
BOD (mg/l)	220	30	86
COD (mg/l)	352	88	75
Phosphate (mg/l)	4.64	2.64	43
Ammonia(mg/l)	13.20	1.07	92
Nitrate (mg/l)	13	15	-
Nitrites (mg/l)	0.11	0.03	72
Fluoride (mg/l)	1.0	0.8	20
FC (colonies)	40000	500	98
Phosphates(mg/l)	4.64	2.64	43

2) Characteristics of filter media

The top soil used for filtration is collected from filtration unit and tested before and after treatment. The characteristics of soil used for treatment is shown in Table 2. It is evident that the nutrients present in wastewater are absorbed by the soil. The nitrogen, phosphate and potassium are increased to 34%, 62% and 16% respectively because of transferring of nutrients from wastewater to soil layer. The top soil can also be used as manure for growing crops.

TABLE –II:Characteristics of Filter media in VFCW

Parameters	Before treatment (g/m ²)	After treatment (g/m ²)	% increase
Nitrogen	8.64	13.14	34
Phosphate	0.44	1.18	62
Potassium	6.17	7.41	16

3) Design recommendation

i. After many trial and errors the following design recommendations are given for constructed wetland

at household level.

- ii. Gravel of size passing through 20mm sieve is recommended
- iii. Sand of size passing through 1.18mm sieve is to be used for better efficiency in removal.
- iv. Atleast a height of 10cm is to be ensured for sand and gravel media.The recommended plant for CW at household level is *Canna Indica* which is more easily available in abundance.
- v. Water head should be maintained at 50 cm to 80 cm for effective functioning. In this study, it is found to be about 75cm.
- vi. At least one week should be given for plant growth.
- vii. At least two hours retention time is to be given for wastewater in sedimentation tank.
- viii. Depending upon the nature of pollutants, replacement of filtration unit should be carried out on twenty to thirty days period.
- ix. Filter media should be cleaned before use.

IV. CONCLUSION

In this study, a simple CW unit is designed for household level. Water quality is checked before and after treatment. The removal of FC, BOD, COD, Nitrate and ammonia is good. Removal of inorganic parameters namely TDS, conductivity, alkalinity is not done effectively. The FC is removed to maximum of 98% and the TDS removal is minimum of 16%. Design recommendations are also given for CW. It is suggested to give two hours sedimentation time for wastewater. The recommended plant for constructed wetland treatment is *Canna Indica* at household level. The thickness of gravel and sand should be maintained atleast 10 cm thickness each and it is recommended to provide gravel layer at bottom.

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AUTHORS PROFILE



Dr. S.Vanitha has completed her graduation and post-graduation from Government of College of engineering, Tirunelveli and Arulmigu Kalasalingam College of Engineering. She has completed her PhD in Kalasalingam Academy of Research And Education. She has published more than 20 papers in journals and conferences.



Dr. C.Sivapragasam has completed his graduation and post-graduation from IIT-Roorkee and IIT-Delhi respectively. He completed his PhD from NUS, Singapore. He has 2 years of industry experience and more than 17 years of teaching experience. He has completed 3 sponsored research projects from various funding agencies and published more than 70 papers in peer reviewed journals and conferences..



Syaik Unoos Ahamed is pursuing his Undergraduate in Kalasalingam Academy of Research and Education.