Grey Water Treatment in Vertical Flow Constructed Wetland

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ABSTRACT

In These Paper Firstly Gery Water Treatment Was Carried Out Design Of Two Stage Vertical Flow Constructed Wetland System including: vegetation (the presence of common reeds ''Canna Indica").Grey water is water from bathroom, sinks, showers and washing machines. Reusing grey water for irrigation reconnects urban residents and our backyard gardens to the natural water cycle. Constructed Wetland treatment system has proved to be an effective method of recycling the grey water. In this paper, the effectiveness of the wetland plant Canna indica and waste biomass in the treatment of Grey water by Vertical subsurface flow root zone system were studied. A laboratory scale Two Stage Vertical flow reed bed was constructed, the media were biomass adsorbent from newspaper along with coarse aggregate and nine numbers of Canna indicia species were grown. The system was fed at the flow rate of 500 liters/day. Consequently adsorption, filtration and root zone treatment takes place. The raw Grey water and treated water were collected periodically and tested for quality by standard methods. It is seen that reed bed unit is reducing the concentrations of TSS,TDS,BOD,COD by 63 % ,79% , 86%, 53% respectively on an average. The treated Grey water can be used for gardening or for flushing the water closet.

Keyword: - *Root Zone, Constructed wetland, Reed bed,Vertical sub surface flow, Canna indica.*

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1. INTRODUCTION

Waste water generated can be treated by technical as well as semi natural system. Treatment of waste water by pond and vegetation comes under semi natural system. Vegetation treatment system is classified into land treatment and wetland. The wetland is an artificial wetland formed to recycle wastewater generated and nutrients and it's of two types: Free water surface constructed wetlands and sub-surface constructed wetlands. In free water surface constructed wetlands, waste water flows as a shallow water layer over a soil substrate while in Sub-surface constructed wetlands may be subsurface horizontal flow or sub-surface vertical flow or hybrid wetland. In the sub surface horizontal flow constructed wetlands, waste water runs horizontally through the substrate. In sub surface vertical flow constructed wetlands, waste water is treated intermittently onto the surface of sand and gravel filters and gradually drains through the filter media before collecting in a drain at the base. Hybrid systems comprised most frequently of vertical flow wetland and horizontal flow wetland system arranged in a staged fashion. The root zone method (RZM) is generally established and used as the basis for the design of SF wetland systems. Wastewater generated flows vertically through the media filled channel where it is treated by physical, chemical and biological manners. These processes are supposed to take place in the rhizosphere region, which is composed of the plant roots, the plant rhizomes, and the linked microbial communities. After treatment, the wastewater is collected in the outlet zone and then directed to further treatment processes or to discharge into a waterway. In the root zone system, nutrient removal from waste water occurs due to different mechanisms:

1. Plant uptake
2. Microorganisms residing on the plant roots which transform nutrients (mainly nitrogen) into inorganic compounds (ammonium and nitrate)
3. Physical processes like filtration, sedimentation etc… In this paper Grey water is treated using Modified Rooty zone system in Wetland Column. Grey water is the wastewater
4. generated from sinks, showers, washing machine and bathrooms. The Grey water generated is in large quantity when compared with black water; therefore treating grey water reduces water scarcity.

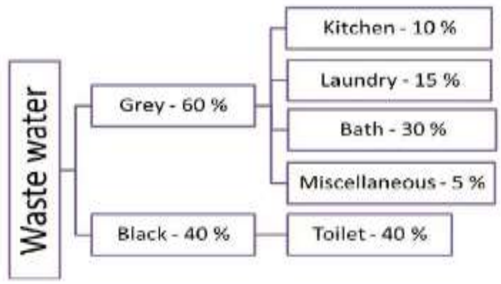
5. 

Fig .1: Component of Domestic Waste Water Use

Water is becoming a rare resource in the world. It is therefore essential to reduce surface and ground water use in all sectors of consumption, to substitute fresh water with alternative water resources and to optimize water use efficiency through reuse options. These alternative resources include rainwater and grey-water. This project will focus on grey-water treatment and its use as an alternative water resource in Residential House. Grey-water is commonly defined as wastewater generated from bathroom, laundry and kitchen.

2. METHODOLOGY

2.1 Materials

A. Source of waste water:
Greywater was collected from at Post Saikhindi Tal-Sangamner. Grab sampling was done to collect wastewater sample. As per the experimental requirement 40 L of wastewater was collected from the treatment plant.
B. Components of VFSSCW:
The important components of constructed wetland systems are vegetation, wetland media, inlet & outlet arrangement and bottom Liner. The two major components of VFSSCW, i.e. vegetation and wetland media are discussed below.
C. Vegetation in VFSSCW:
Vegetation is among the most important components in VFSSCW systems. Wetland vegetation (mainly vascular plants) grows in semi-saturated or fully saturated water conditions. In order to be suitable for use in VFSSCWs, the selected vegetation should meet the following criteria:
1. Tolerant against a variety of pollutants present in wastewater
2. Easily available in the local area
3. Transport efficient oxygen into the root zone
4. Strong rhizomes with massive fibrous roots
5. Higher absorption capacity of nutrients

The vegetation that are most often used in constructed wetlands are persistent emergent plants, such as bulrushes (Scirpus), spikerush (Efeocharis), and other sedges(Cyperus), rushes (Juncus), common reed (Phragrnites), and cattails (Typha). All wetland species are not suitable for wastewater treatment. Vegetation for treatment wetlands must be able to tolerate the combination of continuous flooding and exposure to wastewater containing relatively high and often variable concentrations of pollutants. In VFSSCW or HFSSCW Common reeds (Phragmitesaustralis) are more often used followed by cattails Canna indica is commonly used plant for wetland establishment in China and other countries as it has rapid growth rate, large biomass and beautiful flowers with great capability of nutrient removal.

2.2 Role of vegetation in VFSSCW

Vegetation provides series of benefits and contributes to the creation of the necessary conditions which directly or indirectly affect the system efficiency. Some of the major effects are discussed below,
1. Physical Effects
2. Hydraulic conductivity
3. Bio-film development
4. Oxygen supply
5. Direct constituent uptake

Fig.2: Canna Indica

Wetland Media in VFSSCW:

The selection of the substrate in a VFSSCW system represents a very important design parameter which might significantly affect the performance of the bed. The synergetic effects of sufficient pore volume and gradual development of plant roots manage to maintain the hydraulic conductivity of the bed. It provides filtration effects.It ensures a high permeability, i.e., hydraulic conductivity, for the unhindered downward passage of the wastewater, thus diminishing the appearance of possible clogging problems. It provides an attractive attachment surface area for various microorganisms (biofilm creation) which are involved in the pollutant Removal processes.

Design Consideration of VFSSCW:

CWs possess higher surface area requirements compared to conventional treatment plants but VFSSCWs have the advantage of demanding lower surface area, half than the respective requirement for HFSSCW. The important factors to be considered while designing the VFSSCW for domestic wastewater treatment are Unit area requirement, Organic and Hydraulic load, HRT etc. are discussed below.

Unit Area Requirement:

The unit area, i.e., the ratio of area requirement per person (m^2/pe) is the one of the major design parameter that is used in practice. The surface area requirement for the treatment of wastewater in constructed wetland can be calculated from equation

$$Ah = Qd \frac{(InCi - InCe)}{KBOD}$$

Where,
Ah = Surface area of bed (m^2)
Qd = average daily flow rate of sewage (m^3/d)
Ci = influent BOD^5 concentration (mg/l)
Ce = effluent BOD^5 concentration (mg/l)
KBOD = rate constant (m/d)
KBOD is determined from the expression KT,
Where,
KT = K20 (1.06) (T-20)
K_{20} = rate constant at 20 ^oC (d-1)
T = operational temperature of system (^oC)
d = depth of water column (m)
n = porosity of the substrate medium
Organic and Hydraulic loading rate (OLR and HLR):

Other design parameters that also used for CW design are the organic loading rate (OLR; gm BOD^5/m^2/d or gm COD/m^2/d) and the hydraulic loading rate (HLR; m^3/m^2/d or m/d).

$$OLR = \frac{Q \times Ci}{A}$$

Where,
Q = Flow rate (m^3/d)
Ci = Influent BOD5 concentration (mg/L)
A = Surface area of CW
HLR = Q / A
Where,
Q = Flow rate (m^3/d)
A = Surface area of CW

Hydraulic Retention Time (t):
The HRT directly affects the organics, nutrients and pathogens removal efficiencies of VFSSCW systems. The HRT of VFSSCW system can be given as

$$t = \frac{nLWd}{Q}$$

Where,
t = Hydraulic retention time (HRT)
n = Effective porosity of media in (%)
L = Length of bed (m)
W = Width of bed (m)
d = Average depth of liquid in bed (m)
Q = Average flow through the bed (m^3/d)

3. EXPERIMENTAL SETUP

3.1 Laboratory Scale setup of two Stages VFSSCW:

Laboratory scale setup consisting of Two Stage VFSSCW was developed as shown in Figure 3. The first stage VFSSCW is placed on the top surface of second stage VFSSCW, this cascade type arrangement helps to increase the total surface area under the treatment of domestic wastewater. The both reactors made up of plastic, which are circular in shape. The first stage reactor has 32 cm diameter, whereas the second stage reactor has diameter of 58 cm. First stage VFSSCW has 0.08 square meter surface area and second stage VFSSCW has 0.264 square meter surface area. The cascade type arrangement in this case increases the total surface area under the treatment by approximately 30.30 % at laboratory scale setup. Second reactor is provided with acrylic vertical baffle to operate with either vertical or horizontal flow mode. One plastic tank was provided as primary settling tank to feed influent with sufficient height to operate under gravitational force.

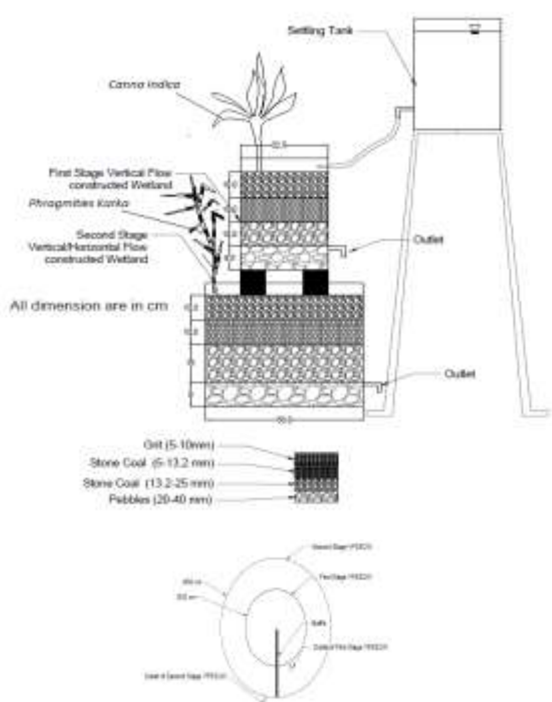


Fig.3: Laboratory Scale setup of two stage VFSSCW

Fig 4: Actual Experimental Setup at location Saikhindi, Taluka: Sangamner, Dist: Ahemednagar

3.2 Actual Experimental Setup:

Primary Head tank is connected to first stage upper reactor with flexible pipe. It is circular in shape with storage capacity of 38 L. It has diameter of 35 cm and height 47 cm. Wastewater collected from treatment plant was allowed to settle for 2 hrs for pretreatment in primary settling tank, before it was fed to Two Stage VFSSCW. This storage was provided for settling out suspended solids in wastewater which otherwise block the media of VFSSCW. Screen was provided on the inlet of settling tank to remove large floating matter from wastewater.

4. RESULTS AND DISCUSSIONS

4.1: Results

The observed performance analysis results of VFSSCW during initial and established phase are presented in this chapter. Characterization study of wastewater from treatment plant located at Post Saikhindi Tal-Sangamner was carried out to assess its suitability for experimental work.

Table No. 1: Parameters and Methods of analysis.

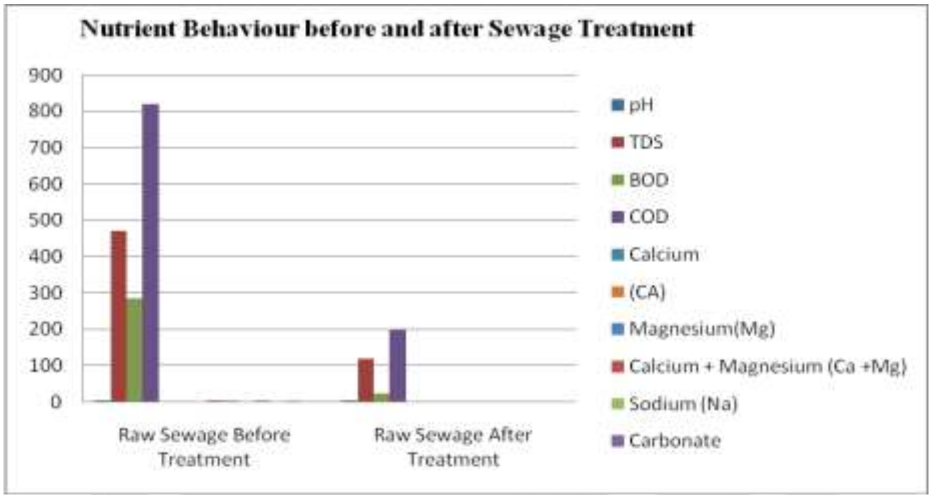
Sr. No	Parameter	Method	Standard
1	pH	Electrometric	SM-4500H^+
2	COD	Winkler Method	SM-4500O
3	BOD	Closed Reflux, Titration	SM-5220D
4	BOD_5	Respirometer	SM-5210B
5	TSS	Gravimetric, Evaporation	SM-2540
6	TKN	Digestion, Distillation, Titration	SM-4500nh_3

Table No.2 : Characterization of Grey Water

Sr. No	Parameter	Unit	Raw Sewage Before Treatment	Raw Sewage After Treatment	Permissible Limit
1	pH	-	6.5	6.5	6.5-7.5
2	TDS	mg/l	473	120	160
3	BOD	mg/l	287	25	<30
4	COD	mg/l	820	200	250
5	Calcium (CA)	mg/l	1.6	0.98	0-1.5
	Magnesium(Mg)		2.4		0-5
	Calcium + Magnesium (Ca +Mg)	mg/l	4	2.3	0-6.50
	Sodium (Na)	mg/l	4.3	2.1	0-4.0
6	Carbonate	mg/l	0	0	0-1.5
	Bicarbonate	mg/l	3.2	1.235	0-.1.5
	Chloride	mg/l	1.6	1.5	0-2
	Sulphates	mg/l	3.76	2	0-5
7	Residual Sodium Carbonate	mg/l	0.8	0.95	0-1.25

4.2: Discussions

The influent grey water during this study was weak in terms of organic strength with a maximum BOD measured during the monitoring period. Mean influent water quality parameters for the experimental period are shown in Table 3, which also provides a comparison with separate grey water samples obtained from Kitchen, Bath and Wash Basin locations.In Grey Water pH Conc. Range 8.43 But Permissible Rang For Potable Water. pH Conc.6.5-7.5 So Given Grey water to maintain pH by Using Electrometric Laboratory Method. TDS is high. Range for 473 mg/l Permissible Limit is 160mg/l. so it can be Treat by using Lab. Method are Gravimetric means "by weighing" Balances require gravity to weigh something. You will weigh the total dissolved solids after water is boiled away. This will be done using just one water sample. Find TDS using electrical conductivity. This is rather easy to do. Just dip the TDS probe into the water and the TDS meter will measure how well the water conducts electricity. It then converts that to concentration of total dissolved solids.



Graph No. 1: Nutrient Behaviour before and after Sewage Treatment

Given Sample BOD is High Range for 20-300mg/l Permissible Limit is <30mg/l. It can be Treat By using Lab Method are Closed Reflux, Titration It is most commonly expressed in milligrams of oxygen consumed per liter of sample during 5 days (BOD5) of incubation at 20°C and is often used as a robust surrogate of the degree of organic pollution of water Given Sample COD Range For 375 mg/l, Permissible Range For 250mg/l. So it Can Treat By using The two most common methods for this are titration and colorimetry. Titrimetric Method of COD Colorimetric Method of COD. Calcium is high Range For 1.6mg/l, Prmissible Range For 0-1.5mg/l.So it Can Be Treated By Laboratory Method. Combination of Calcium + Magnesium (Ca+Mg) is Low Range For 4mg/l, Prmissible Range For 4-5mg/l.So it Does Not Required Treatment. So it Does Not Required Treatment. Sulphate is high Range For 3.76 mg/l, Prmissible Range For 0-2 mg/l. So it Can Be Treated By Laboratory Method

4. CONCLUSION

1. The recycled water is of good quality and can therefore be used primarily for flushing toilets and cleaning of the pavements. Other uses will be watering the flower bed surrounding the hostel and improve beautification.
2. This system will also be able to save on the cost of water supplied by the Nairobi water and sewerage company. An estimate of about Kshs 21,600 will be saved on a yearly basis.
3. Given that this system will have an economic of life. It translates that with proper maintenance, the system will be able to serve and improve the sanitation of the home.

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5. ACKNOWLEDGEMENT

I would like to express my special thanks of gratitude to my project guide Prof. S. R. Korke, PG Coordinator Dr. M. V. Jadhav , HOD Dr. M. S. Purkar and our Principal Dr. D.N. Kyatanawar who gave me the golden opportunity to do this wonderful project on the topic “Grey Water Treatment in Vertical Flow Constructed Wetland”, which also helped me in doing a lot of Research and i came to know about so many new things I am really thankful to them.
I would like to express my gratitude towards Prof. Pravin Mehetre for their kind co-operation and encouragement which help me in completion of this project. Also thankful to Prof. P. B. Kanawade for his support to project.
Secondly i would also like to thank my parents and friends who helped me a lot in finalizing this project within the limited time frame.

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