Reuse of Grey Water using Modified Root Zone System

M. Preethi Abinaya *
Asst. Professor / Department of Civil Engineering
Madha Engineering College
Chennai, India

R. Loganath
Research scholar / Department of Civil Engineering
Indian Institute of Engineering Science and Technology
Shibpur, India

***Abstract*— 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. Root zone treatment system has proved to be an effective method of recycling the grey water. In this paper, the effectiveness of the wetland plant *Colocasia esculenta* and waste biomass in the treatment of Grey water by horizontal subsurface flow root zone system were studied. A laboratory scale horizontal flow reed bed of size 0.4 x 0.3 x 0.13m was constructed, the media were biomass adsorbent from newspaper along with coarse aggregate and nine numbers of *Colocasia esculenta* species were grown . The system was fed at the flow rate of 3 liters/day. Consequently adsorption, filtration and root zone treatment takes place. The raw Grey water and treated Grey 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.**

Keywords— ***Root Zone, Constructed wetland, Reed bed, Horizontal sub surface flow,Colocasia esculenta***

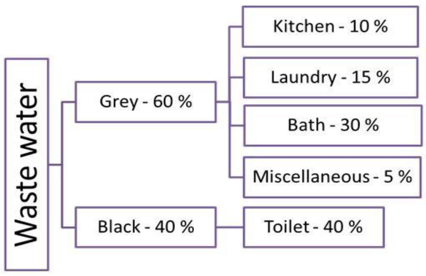
I. INTRODUCTION

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 its 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 horizontally 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 (Conley et al., 1991). 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 :

- Plant uptake
- Microorganisms residing on the plant roots which transform nutrients (mainly nitrogen) into inorganic compounds (ammonium and nitrate)
- Physical processes like filtration, sedimentation etc…

In this paper Grey water is treated using Modified Rooty zone system . Grey water is the wastewater 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.



Objective

The objectives of this research is to

- Analyse and characterize the grey water generated
- To prepare adsorbent from newspaper and activate the prepared adsorbent to increase its pore area
- Investigate the feasibility of applying modified root zone system to treat the grey water generated in laboratory scale
- To determine the efficiency of constructed root zone system for treating grey water

II. MODIFIED ROOT ZONE SYSTEM

A. Arrangement of Modified Root Zone System

The modified root zone system treatment is done in laboratory scale by using plastic tub of dimension 0.4 x 0.3 x 0.13m. It is filled as follows:

- The first layer of 0.07m consisted of coarse aggregate gravel
- The second layer of 0.035m consisted of newspaper which is incinerated at 500 ^{0} C for 3 hrs and activated physically to increase its pore size.
- 0.025 m freeboard
- After arranging the layers the *Colocasia esculenta* were planted

Further the growth of plants were monitored. Then grey water was let into the root zone system and the samples were collected.The reed plant used in this treatment system is *Colocasia esculenta*. This kind of plant species has hole commencement from the leaves throughout the stem till the root zone. It takes up the oxygen from the atmosphere and deliveries to the root zone. Accordingly this oxygen supply in the root zone is sufficient to upkeep the growth of aerobic bacteria. These aerobic bacteria ingest this oxygen and thus break the organic compounds. The prevailing conditions favor the development of the bacteria and they multiply effortlessly.

In the root zone treatment system, Utmost, the very presence of root zone system builds channels for the passage of water to the plant system. Furthermore, the roots of the plant introduce oxygen down into the body of soil and thereby provide an environment where aerobic bacteria can prosper. These bacteria are necessary for the breakdown of several classes of compounds in particular in the oxidation of ammonia to nitrate; this is the first step in the biological breakdown of nitro compound. Next, the process of nitrification takes place , here the plants themselves take up a certain amount of nutrient from the wastewater. In the summer and spring about 15% of the treatment capacity for sewage effluent happens through this root zone treatment.

Most degradation of nutrients is commenced by the microbes. These reed plants were also capable of accumulating certain heavy metals, a sector where there is presently a great deal of research (Babbit and Baumann, 1960). In essence Reed beds can help to attain a better standard of water quality through

1.High level of bacterial and viral removal
2.Decreased biological oxygen demand and reduction of suspended solids
3.Reduction of nitrogen concentrations and removal of metals

Colocasia esculenta has the ability to transfer oxygen to root zone. Large population of microorganism found in root zone. Pollutants digested and rendered innocuous by a range of organisms similar to conventional sewage works.

B. Advantages of Modified Root zone system

- The newspaper biomass acts as adsorbent which is removes the pollutant present in the grey water using adsorption mechanism
- The newspaper is a waste biomass as a result environmental remediation
- This operation does not involve fuel supply or electricity
- Reed beds do not breakdown
- Set up is visually unobtrusive (aesthetical good) and provides growth of microorganisms
- The plants, especially the species that grow naturally and under harsh environment conditions, offer a simple and economic method of wastewater treatment.
- The Root zone system doesn't give off any sort of smell therefore odorless
- No frequent maintenance is required
- It has high treatment efficiency

III. PROCEDURE FOR TESTING GREYWATER PARAMETERS

A. Grey water parameters

Wastewater contains a variety of inorganic and organic substances from domestic sources. The Grey water parameters like pH, TDS, TSS, BOD and COD were examined. The procedure followed for calculating the parameters are the standardized methods .

B. Determination of pH

Initially pH meter was calibrated using pH 9.2 and pH 4 buffer solution. In a clean dry 100ml beaker the water sample was taken. The electrode was immersed in the beaker containing the water sample and the reading of the pH meter was checked. Thus the pH of the collected sample was determined using pH meter.

C. Determination of Biological Oxygen demand

Dilution water is required in order to determine Biological oxygen demand. Therefore dilution water was made ready by adding 5ml of calcium chloride, Magnesium sulphate, Ferric chloride and phosphate buffer to 5 litres of organic free aerated distilled water. To begin with, four 300ml glass stoppered BOD bottles (two bottles for the sample and two bottles for blank) were taken. In that bottle 10 ml of the sample was added to each of the two BOD bottles and the remaining quantity was filled with dilution water. The remaining two BOD bottles are for blank and to these empty bottles, dilution water alone were added. One blank solution then one sample solution bottle were named Blank $_5$ and Sample $_5$ respectively. These named bottles were preserved in incubator at 20 °C for five days . The other two bottles i.e one blank and one sample were analyzed immediately.

2ml of Manganese sulphate and 2ml of alkali iodide azide regent were added to the BOD bottle . As soon as the floc has settled to the bottom, the contents were shaken thoroughly by turning the bottle upside down. Then to the same content, 2ml of conc. Sulphuric acid was added using a pipette held just above the surface of the sample and at that moment the bottle was inverted several times to dissolve the floc. From that 200 ml was transferred to Erlenmeyer flask for titration purpose. For the titration the burette was filled with Sodium thiosulphate solution, sample as the pipette solution and was titrated till yellow colour of liberated iodine was almost faded out. To end, 1 ml of starch solution was added and the titration was continued till blue colour disappears to colourless. The volume of Sodium thiosulphate consumed was noted and it's the DO (Dissolved oxygen) in mg/l. The same titration was repeated for concordant values. After 5 days of completion, the same procedure was repeated for the Blank $_5$ and Sample $_5$. Blank Correction (BC) was calculated by subtracting 5^{th} day blank DO from the Initial Blank DO. By using the following formula the Biological Oxygen Demand was determined.

$$BOD(mg/l) = \frac{(D_0 - D_5 - BC) \times Volume\ of\ Diluted\ Sample}{Volume\ of\ sample\ taken}$$

D_0 = Initial DO of the sample
D_5 = 5^{th} day DO of the sample
BC = Blank Correction

D. Determination of Chemical Oxygen demand:

20 ml of the collected sample was added in 500ml refluxing flask. 5 to 7 glass boiling beads were added to serve as anti-bumping aid followed by the addition of 1g of mercuric sulphate. 10ml of potassium dichromate was added and mixed; while mixing these solution ,30 ml of silver sulphate solution was added. The solution was refluxed for 2 hrs and then the apparatus was then cooled to room temperature after the refluxing period. Finally the solution was titrated with ferrous ammonium sulphate using ferroin indicator and the colour change from blue green to red indicates the end point. The volume of ferrous ammonium sulphate consumed was noted. The same procedure is repeated for blank solution.

$$COD = \frac{(A - B) \times N \times 8000}{ml\ of\ the\ sample}$$

A = Volume of ferrous ammonium sulphate consumed for Blank
B = Volume of ferrous ammonium sulphate consumed for Sample
N = Normality of ferrous ammonium sulphate

E. Determination of TDS and TSS

A clear porcelain dish was taken and weighed (W_1). Then 20 ml of the sample were taken in the porcelain dish and it was maintained at 103 ^{0} C till the water gets evaporated .The weight is noted (W_2).

$$Total\ Solids(mg/l) = \frac{(W_2 - W_1) \times 1000}{\text{Volume of the Sample taken}}$$

Another porcelain dish was taken and weighed (W_3). 20 ml of the sample was filtered through a double layered filter paper and the filtrate was taken in the porcelain dish and it was maintained at 103 ^{0} C till the water gets evaporated. The weight is noted (W_4).

$$Total\ Dissolved\ Solids\ (mg/l) = \frac{(W_4 - W_3) \times 1000}{\text{Volume of the Sample taken}}$$

$$Total\ Suspended\ Solids\ (mg/l) = Total\ Solids - Total\ Dissolved\ Solids$$

IV. RESULTS AND DISCUSSION

A. Characteristics of Grey water

The Grey water sample was analyzed to determine general characteristics for about 1 month. The results obtained are shown in Table I

TABLE I. CHARACTERISTICS OF GREY WATER

Sl. No.	Parameter	Minimum	Maximum	Mean
1.	pH	7	8.6	7.8
2.	BOD(mg/l)	50	350	200
3.	COD(mg/l)	254	618	436
4.	TDS(mg/l)	712	990	851
5.	TSS(mg/l)	42	540	291

B. Concentration of various parameters before treatment

The Grey water is collected and before letting to the Horizontal subsurface flow root zone the various parameters are tested . The values so obtained are tabulated in Table II and it is represented graphically in Fig.1.

TABLE II. CHARACTERISTICS OF GREYWATER BEFORE TREATMENT

Parameters	DATE				
	23.09.13	3.10.13	10.10.13	24.10.13	13.11.13
Samples	1	2	3	4	5
pH	7.3	8	8.2	7.2	7.46
BOD(mg/l)	120	187	284	256	350
COD(mg/l)	439	482	536	516	420
TDS(mg/l)	720	841	835	920	734
TSS(mg/l)	324	399	536	489	462

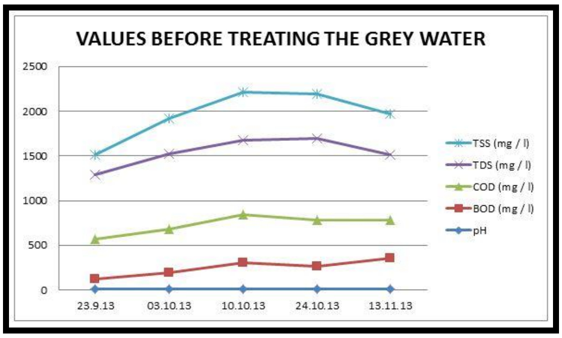


Fig. 1. Characteristics of Grey water before treatment

C. Concentration of various parameters after treatment

The treated water obtained from the Horizontal subsurface flow root zone were collected and then various parameters are tested . The values so obtained are tabulated in Table III and it is represented graphically in Fig.2.

TABLE III CHARACTERISTICS OF GREYWATER AFTER TREATMENT

Parameters	**DATE**				
	23.09.13	**03.10.13**	**24.10.13**	**15.11.13**	**26.11.13**
Samples	**1**	**2**	**3**	**4**	**5**
pH	7	7.35	7.6	6.9	7.0
BOD(mg/l)	30	27	29	28	27
COD(mg/l)	221	218	237	250	204
TDS(mg/l)	321	392	278	298	192
TSS(mg/l)	84	97	103	91	82

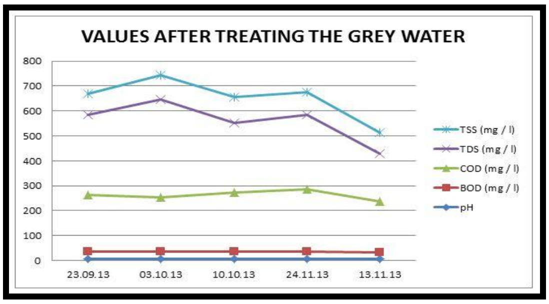


Fig. 2. Characteristics of Grey water after treatment

V. CONCLUSIONS

The Grey water was analyzed to determine its characteristics. The Modified root zone method (constructed wetland) was employed on a lab scale to treat the Grey water. From the experimental results, the subsequent inferences are made.

1. This study validated that the designed sub-surface horizontal flow constructed wetland system could be used for treatment of the Grey water. A constructed wetland system can be an effective treatment and reuse facility for Grey water.
2. Since the top layer is of newspaper residue , it acts as adsorbent and thus pollutants are removed to a extend in the initial stage.Thus the system undergoes adsorption, filtration and root zone treatment.
3. Regarding the performance attained, the sub-surface horizontal flow constructed wetland was able to reduce further the level of the main physicochemical pollution parameters. The reed plants do play an important role in the treatment of grey water.
4. The overall experimental results demonstrated the viability of applying sub-surface horizontal flow constructed wetland unit to treat Grey water. Thus the Modified root zone treatment can be utilized independently or as an addition to conventional treatment for complete treatment of Grey water.

The results indicate the concentration of five parameters for Grey water treatment by Horizontal subsurface flow root zone. It is clear that there is a noteworthy reduction in pH, B.O.D, C.O.D by Root zone treatment system. The treated Grey water has turn out to be fit enough to give out directly into a receiving water body. This is possible since the concentrations of the pollutants were beneath the allowable limits. As a result , the root zone treatment can be used independently or as an addition to conventional treatment so as to make the final output fit enough for discharge into a natural water body. During the preliminary phase ,the root zone system shows quite low efficiency in B.O.D and C.O.D due to minimum growth of the plant. In the later stage the root zone bed showed greater efficiency. Further efficacy can be enhanced by using aerators to rise the oxygen supply or else hybrid root zone system (an arrangement of horizontal and vertical root zone system) can be used for zero discharge efficacy.

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