Holistic Household Waste Management at Source- An Experimental Study

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Abstract— **This paper addresses the twin domestic problems of grey water and kitchen solid waste management. Simple sand filter bed method of treatment and the sand filter with reeds are experimented and compared for Waste water management. It also suggests the method of using PVC pipes for making compost from the kitchen waste. Phragmites australis (locally known as nanal) and canna Indica (locally known as cannas) were used as reed plants for waste water treatment . This paper presents the method of construction of reed bed and the effectiveness of removal of various contaminants using root zone treatment process. The quality parameters of raw water and treated water samples were compared and discussed. The waste water generated from the kitchen, school hostel and college hostels of B.S.Abdur Rahman University campus, Chennai, Tamil Nadu are treated in the campus sewage treatment plant (STP) and used for watering the garden. The primary treated water from STP is taken for experimentation by the reed bed system. From the experiment it is found that the Reed bed system using cannas gives the best quality treated water compared to others. Along with reed bed if a pipe composting is adopted, the house hold waste can be holistically managed at source itself and if each household practices this concept, the waste management problem can be eliminated at the same time self cultivated healthy vegetables can be obtained as a byproduct.**

Keywords*—*wastewater, Reedbed, rootzone, contaminants, Phragmitis australis, Cannas Indica, composting

I. INTRODUCTION

Reeds are coarse grasses growing in wet places. Reed beds are aquatic plant based systems mimicking the natural wetland which allow bacteria, fungi and algae to digest and clean the sewage. Waste water trickling through the reed bed is cleaned by microorganisms living on the root system and in the litter. This system utilises the sewage for growth of microorganisms responsible for pollutant removal and thus makes the effluent clean. The process is very similar to aerobic conventional sewage treatment, as the same organisms are used, except that the conventional treatment systems require artificial aeration. It is also referred as constructed wet land system. Reed bed is considered as an effective and reliable secondary and tertiary treatment method where land area is not a major constraint (Wood and Hensman, 1988).Generally reed bed is made in shallow pits, installed with a drain pipe in a bed of pieces of lime stones and filled up with pebbles and graded sand (Crites, 1994). In this sandy body, reed plants generally with hollow root which bring oxygen into the filter bed, are planted. Application of root zone technology for waste water treatment (RZT) is finding wider acceptability in developing and developed countries, as it appears to offer more economical and ecologically acceptable solution to water pollution management problems. These are the most suitable for waste water treatment for schools, hospitals, hotels and for smaller communities, where waste water generated is more and land value is less. The objective of this work is to treat the waste water with the help of filter bed alone and separate filter beds with reed plants *cannas* and *phragmites australis* and find out the best method of treatment by analyzing the water quality parameters before and after the treatment process. A lab scale study on *phragmites australis* is conducted and reported(Ram Prasad, 2012). Many other researchers like Pendleton et al(2005)Basker et al(2009), Jan Vymazal et al (2011) Devendra Kumar Patel et al (2012) have investigated the feasibility of reedbed system for domestic waste water treatment.

Fig 1(a): Initial stages of reedbed- cannas

Fig 1(b). Initial stages of reedbed- phragmites australis

A. Materials, Methods & Procedure

1) Wastewater Parameters:

Wastewater contains a variety of inorganic and organic substances from domestic sources. The wastewater parameters namely BOD, COD, TDS, TSS and pH were analyzed. The procedure followed for calculating the parameters are the standardised methods (APHA, 1992).

2) Reed bed system:

The various reeds include aquatic reeds, common reeds, and aquatic plants. The main properties of reeds include:

- Common reed has the ability to transfer oxygen to the root zone
- Large population of microorganism is found in root zone of the reed plants
- In a reed bed, pollutants are digested and rendered innocuous by a range of organisms similar to the one in
- conventional sewage treatment plants.

3) The phragmitis australis and cannas indica

Species used in the system are *phragmitis australis* and *cannas indica*. This species have a hole from the leaves throughout the stem to the root zone. It takes the oxygen from the atmosphere and supplies to the root zone. The bacteria in the root zone consume the oxygen leaked out from the root and break the organic compounds. As the existing conditions in and around the root zone are favourable to the growth of the bacteria, they multiply easily. As the anoxic zone in the system is comparatively low, the nuisance due to the anaerobic decomposition is also low. The plants are regenerative type and multiply easily.

4) Functions of phragmitis australis and cannas indica

First the very existence of root zone system creates channels for the water to pass through. Secondly the roots introduce oxygen down into the body of soil and provide an environment where aerobic bacteria can thrive. These organisms are necessary for the breakdown of many types of compounds in particular in the oxidation of ammonia to nitrate which is the first step in the biological breakdown of nitro compound. Thirdly, the process of nitrification takes place i.e. the plants themselves take up a certain amount of nutrient from the wastewater

The plants are also capable of accumulating certain heavy metals (Babbit and Baumann, 1960). In essence, Reed beds can help to achieve a better standard of water quality through:

- High level of bacterial and viral removal
- Decreased biological oxygen demand
- Reduction of suspended solids
- Reduction of nitrogen concentrations
- Removal of metals

5) Type of Reed beds

There are two types of reed beds horizontal reed bed and vertical reed bed. The horizontal reed bed is the one in which the filtered water moves horizontally from one end and is collected at the other end along the length of the reed bed. The vertical reed bed is the one in which the influent is sent through the top of the reed bed and the filtrate is collected at the bottom of the bed. The initial stages of reed bed used in the experiment are shown in figures 1(a) and 1(b) which are horizontal reed beds.

6) Principle of horizontal planted filters

The following are the salient points:

Continuous diffusion of atmospheric air through the upper surface layer.

Anaerobic condition exists only in the lower parts of the filter Roots of reed plants provide favorable environment for bacteria, which take dissolved organic matter and thus the BOD load is further reduced.

The horizontal planted filter is simple in principle and requires almost no maintenance.

Planted filters are suitable for pre-treated (pre settled) domestic or industrial waste water with minimum of 250g BOD per day. (CPCB, 2003)

Waste water must be pre treated especially with respect to suspended solids so as to prevent the clogging of filter media. At house hold treatment, a grease trap may be provided before sending it to the reed bed.

7) Construction and working of reed bed

The design of filter bed generally called as constructed wetland is done based on hydraulic loading and organic loading criteria and is demonstrated in the technical report prepared by Gerald et al (1993). In this report the dimensions(length x width x depth) of a constructed wetland for a family of 4, comes about 68.8ftx6.8ftx1ft for treatment of effluent from septic tank. The loading criteria will vary based on the type of waste water and also in the case of domestic wastewater generated, it depends on the per capita consumption. But a few apartments in Chennai started this treatment method with different types of plants following a thumb rule of about 10 square feet of plant area for every 100 litres of grey water. Long and narrow channel of about 2ft wide 1.5ft deep and 10 to 12 ft long with a slope of about 1 in 40 is found to be sufficient for a house hold and this will be

compact and can be conveniently kept at one corner of the plot. In the pit formed, first a plastic sheet is placed to prevent the loss of water due to infiltration and percolation. The total depth of filter bed provided is kept equal to or within the root zone depth of plants for better purification. The out flow from the bed can be taken to a sump and can be pumped up and used for flushing and gardening purpose. If water is not required to be collected, plastic sheet is not provided and the water recharges the ground water.

The plan area of the treatment unit, a plastic tub, used in this small scale experiment is 0.61m x 0.41m. Since it is a comparative study, an arbitrary dimension is used but it is maintained same for three cases for uniformity. The reed bed is constructed by laying a layer of gravel in the tub. Then a layer of sand is laid and the reed is planted. Grain size of sand is 4.75µ and the bed thickness is 16cm. Gravel size is 20mm and the bed thickness is 9cm. Bed slope of 1 in 40 is provided. Height of canna and phragmites plants at initial stage were 20cm and 30cm respectively. Two of this kind is made for the two plants. Another similar setup without plant is made. Grey water sample is allowed to flow through the above setups made. Water trickling through the reedbed is cleaned by microorganisms living on the root system. The reed bed utilises the sewage for growth of bacteria which results in a clean effluent.

8) Sewage flow

Sewage is let into the reed beds with the same rate of flow. For a measured inflow of 57 litres to the simple filter bed, *cannas* and *phragmites australis*, the total outflow were measured as 24litres, 22litres and 21litres respectively. The outflow started first in *cannas* after 5days from the inflow and then followed by simple filter bed and *phragmites australis* after 6days and 7days respectively. The first sets of treated samples were collected. Then the inflow rate is increased and the next sets of treated samples were collected. As the rate of inflow is increased, the removal efficiency of canna is found to be improved.Water samples before and after treatment are shown in Figure2. Comparison of water quality parameters before and after treatment are depicted in figures 4(a) and 4(b). Figure 5 shows the removal efficiencies of the three filter beds.

Fig 2: Water samples after and before treatment (treated water from *canna* bed, *phragmites australis* bed, simple filter bed and the influent)

9) Growth of reeds

The reed grows quickly. It produces large clumps of thick rhizomes, Oxygen transfers through the roots from atmosphere may be sufficient for the growth. The reeds have many leaf blades which are linear in shape. The final stage of reed bed is shown in figures 3(a) and (b).

10) Advantages of reed bed

The following are the advantages of the reed bed

Fig.3 (a).Final stages of wetland unit tub with *cannas*

Fig.3 (b) Final stages of wetland unit tub with *phragmites Australis*

- Operation does not require electricity or fuel supply and hence not affected by power breakdown
- No mechanical systems are involved.
- Set up is visually unobtrusive (aestheticaly good) and provides growth of microorganisms.
- High treatment efficiency
- No frequent maintenance required
- The plants, especially the species that grow naturally and under harsh environment conditions, offer a simple and economic method of wastewater treatment.

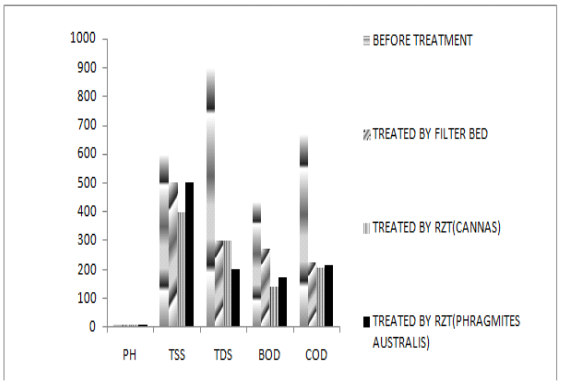

Fig 4(a): Comparison of sample parameters before treatment and after treatment (influent taken on a particular day)

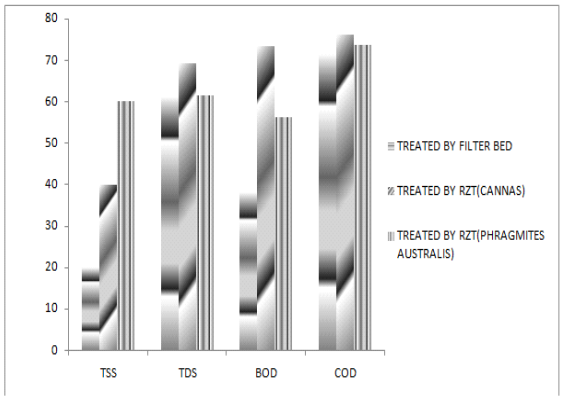

Fig 5: Typical removal efficiency of various treatment methods

B. Integration with Waste composting

Generally household waste is collected and dumped in dump yards in developing countries. This causes the leachate derived from this waste to come in contact with the ground water and pollute the ground water. The idea composting of waste is not practiced generally due to the difficulties associated with its handling, the unhygienic condition and the space constraints. A very convenient way to do composting in a normal house hold of four members is by using two PVC pipes of 1.5m in length as shown in figure (6). The tubes are buried vertically at 1ft below the ground level. Holes can be made on the pipe for air circulation. The organic waste from the kitchen is put daily in the pipe. Immediately after putting the waste, another layer of some leaves and sand is put in. The pipe is thus filled in alternate layers of waste and litter. Once in a week a little cow dung or jangery water can be applied to enhance biodegradation. Pipe is kept open or kept with a net cap and in rainy days a cover is to be provided. For a single household, one pipe will be sufficient for one month and then the next pipe can be used. While the second one gets filled, the first one will be ready with compost. The process can be repeated. The compost so generated can be used for growing vegetable garden along with the treated water. It is very convenient for single households. If the household is at higher floors, two buckets of required size can be filled with sand and the pipes can be inserted in it and can be kept in the balcony. Waste water treatment for an apartment as a whole can be done at a single place in the corner of the plot. A long and narrow filter bed with reed plants can be provided surrounding the compound wall internally. Vegetables can be grown individually in balconies. A separate overhead tank or a tank with partition to be provided for storing treated water.

Fig 6: Pipe composting

C. Results and Discussion

Comparison of properties of samples before and after the treatment and from the parameter removal efficiency study, it is found that the reed bed system using cannas is the best for treatment of all parameters compared to other two as is evidenced from the graphs. There is a remarkable reduction in BOD, COD, TDS by reed bed treatment mainly by cannas compared to phragmites australis and the treated water has become fit enough to be let out directly into a receiving water body as the concentrations are below the allowable limits. The water treatment by simple filter bed, is not fit enough to be discharged to water bodies as the concentrations are above the allowable limits. Integration with solid waste composting is a very efficient method for holistic household waste management. A scientific study on pipe waste composting is to be done to know the soil properties below the pipe.

II. CONCLUSIONS

The wastewater discharged in our campus setting was analyzed to determine its characteristics. The wastewater from campus shows variation in concentration according to student strength. In this study, the root zone treatment method (reed

bed system) was employed on a lab scale to treat the wastewater. The results were compared with the simple filter bed treatment. It is seen that the root zone treatment using cannas is very efficient in reducing the concentrations of all parameters. Thus the root zone treatment can be utilized independently for a small scale unit or as an additional unit to conventional treatment system for complete treatment of wastewater. From the experimental studies, the reed plants (cannas) are suggested to be planted in the filter bed of STP of our campus to improve the quality of treated water. As water is precious, every drop of water is to be conserved and this is an attempt to utilize the waste water in a better manner. As this is a simple method, it can be adopted in each household to suit the amount of wastewater generated to save water and establish a home garden. It can be combined with compost generated from kitchen waste and each family can contribute their mite for sustainable development at the same time they can taste a natural and fertilizer free vegetable which will improve their health as well.

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