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Research paper

Domestic Wastewater Treatment Using Vermiculture

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Abstract

The organic matter helps in various bioprocesses. Management of organic waste is challenging because of the improper disposal causing hazards to the environment. The sludge from the sewage treatment plant is dumped as landfill and used as fertilizer in agricultural operation. This action may solve the disposal of quantity of sewage sludge but the environment is highly affected by the pathogens. Nowadays vermicomposting is used for the removal of pathogens in organic matter. It includes accelerated treatment of nutrients in which waste end products are put to useful end products. When this method of vermicomposting is used in domestic wastewater management considerable reduction in pathogens was found in the organic waste so that the end product can be safely applied safely to land. This work gives a view of the management of domestic waste water utilizing vermiculture. The process can be used for household waste treatment and rural or urban waste management in a small scale.

Key words: *Waste water, vermiculture, earthworms, treatment*

1. Introduction

The waste water is generated from all sources in large quantities and reasonable part of this waste water is collected and recycled. The untreated wastewater discharged from the households and industries is being a harmful agent to nature and humans in developing areas and causes eutrophication and transmission of diseases spreading through water. The scenario is worsening with the rapid urbanization without proper sanitation.

More number of new technologies are being used towards the handling of disposal of organic wastes. Hence the dumping of organic wastes affect the habitat lifeline and environment. Vermi culture technology is a branch of biotechnology using earthworms as a bio filter. The earthworms use the soil food chain principle for stabilizing the soil nature which can be used for processing of organic wastes. This technology helps to give economic value for organic waste and makes cleaner environment by using the bio-energy of organic waste.

The wastewater from domestic area is made to apply on vermiculture soil. The impurities in the water are absorbed in the soil and the excess water percolates and drained. Vermi culture soil have the property of large specific surface for bacterial activities and also good drainage conditions.

The objectives of this project are to assess the suitability of vermification process for wastewater of hostel mess, to evaluate the treated efficiency by using the two plants (Canna and Ginger) with the combination of vermin culture soil and to study the effect of variation in terms of removal of BOD as well as COD by differing the organic loading.

Taylor & Francis (2001) studied the effectiveness of the Canna plant in the treatment of waste water for the removal of Nitrogen, Carbon and Phosphorous under subtropical conditions. S Gajalakshmi and S Abbasi (2003) studied the effect of vermicast on the growth of the plant and found that this composting supports in significant reduction of the percentage of pathogens in organic matter. Cheng, Zhao B et al (2004) made a research on the cleaning of organics and toxins in the waste water by using Ginger plant.

Nitin Prakaskpandit, Nabeel Ahmad (2012) found that the treated effluent results in reduction of pathogens when recycled through vermicast soil. Amouei A.I., Yousefi Z., Khosravi T. (2017) studied the comparison of products formed by using earthworms for the treatment of waste water and domestic solid waste.

2. Materials and methods

2.1. Sample Collection and Testing

The main concept of this project is to recycle the water from the domestic need and hence the type of waste water that has been selected is the waste water that has been constantly collected from the daily activities such as washing of utensils, clothes, shower or bath water and other water except excreta. This water is known as sullage water. In this project college mess is chosen as a source point for sullage water. The water collected here is of washing utensils which contains food waste and soap content. The following tests has been done in the pH, Temperature, Biochemical Oxygen Demand, Chemical Oxygen Demand, Turbidity, Total solids and Odour.

2.2. Formation of Filter Beds

The experimental setup consists of two tubs used for growing canna and ginger plants. Drain holes are provided at the bottom for the collection of water. 25 mm size coarse gravel is laid for 7.5cm at the bottom. A 4.5cm thick layer of 12mm gravel is laid above the coarse gravel over which a 3.5cm thick layer of silt free sand is laid. These layer do not have any vital role in the process of vermification. But they support for upper vermification and provide drainage above the sand layer of 20cm thick.

2.3. Vermicomposting

Vermicompost is the composting process using various species of worms by which a mixture of decomposing vermicast is created. Approximately about 30 to 40 earthworms has been added on each of the experimental set. Necessary manure is added to the soil along with earthworms. The soil is completely in wet condition is provided for the comfortable environment for the earthworms.

2.4. Plantation of Canna and Ginger

Canna and Ginger plants have been planted in each of the tubs separately and is daily watered and made sure that there is a comfortable environment for the plant growth. Red soil is found suitable for the plant growth and is made sure that the plant has a healthy growth for the water purification.

2.5. Treatment of waste water:

The sullage water is collected and poured into the treatment plant regularly. The volume of sullage water that is poured is been noted. The sullage water that is poured should be made sure that is free from solids since it may lead to death of plants and earthworms. The filter bed is completely saturated initially and then the sullage water is poured or else there will not be any proper results.

2.6. Test on treated water

The water that is obtained after the purification from the filter is collected and amount of water collected has been noted down for calculation of the efficiency of the treatment plant.

2.7. Comparison of treated and collected sample:

The samples obtained from the treatment plant using different plants is collected and is tested. The test results for the various tests are tabulated. Comparison is made between the quality of better purification characteristics of the Canna plant and the Ginger plant.

3. Vermiculture technology

i) Composting using Earthworms:
Earthworms are more than 80 percent of soil invertebrate biomass. They produce vermicastings which contains high percent of microorganisms, organic matter and inorganic minerals in the form that can be used by plants.
ii) Space for earthworm culture and size of pit:
Earthworms grow 7.5 cm to 10.3 cm in a week and can be used in indoor and outdoor vermicomposting. One worm can reproduce as many as 99 offerings in 11 weeks hence it must be ensured that the pit does not get over crowded with earthworms since it leads to insufficient spacing for earthworms and causes death of earthworms.
iii)Raw materials:
The pre-digested material can be converted into quality vermi-compost within 30 days. The composite organic wastes are decomposed using diluted fresh cow dung slurry, which is to be sprinkled. The heap has to be kept moist by regular watering, and it will have to be turned two to three times at an interval of ten days.

4. Canna as a plant filter

Canna lilies which work as a filter have thick masses of roots. Cannas remove nitrogen, phosphorous and toxic heavy metals.

Fig 1: Canna plant

5. Ginger as a plant filter

Ginger (Zingiberofficinale) is an ancient plant species that has been harvested for millennia for not only medicinal uses but in many Asian cuisines as well. Raw ginger is composed of 79% water, 18% carbohydrates, 2% protein, and 1% fat. Extract of ginger is found to be a green inhibitor for the corrosion of steel in sulfide polluted NaCl solution. The wastewater is a combination of kitchen waste water, washing and rinsing, bathing water which contains very high concentration of organic substances such as proteins, carbohydrates and lipids. Zingiberaceae have thick masses of roots that work as a filter. Ginger to be grown on reed beds, which help to remove toxicity in the water. Ginger remove toxic heavy metals, nitrogen, phosphorous and radioactive nuclides, among other pollutants. It reduces the inorganic nitrogen and COD from wastewater, it is one of the most important objectives in any water treatment process and is usually used to evaluate the performance of the treatment system.

Fig.2: Ginger plant

6. Experimental setup and procedure

The domestic wastewater obtained after washing the utensils is used as experimental liquid. The experimental setup consists of two plastic tubs having cross sectional dimensional of 600mm diameter and height of about 600mm. the boxes have the holes at the bottom for water recovery. A layer of coarse gravel 25mm size is laid at the bottom. A 30mm thick layer of 12mm gravel supports 20mmthick layer silt free sand passing through 1.70mm.I.S sieve over that. This is the drainage Thick layer of vermification with earthworm are placed. Canna tree is planted in one box and ginger is planted in another box. The vermifier are watered is sprinkled for ten days for acclimatization of the system.
In order to access the performance of vermifier, unit samples were collected from the mess drainage line. This sample was tested for

SS, COD, BOD before feeding to tank. The samples of waste water is then applied over the vermifier at the constant rate of flow so that the rate of infiltration of vermifier was equal to the rate of application of sewage and no ponding occurred. The output from the each vermifier is collected in another tank. Earthworms are versatile waste eaters and decomposers. It promotes the growth of 'beneficial decomposer bacteria' in wastewater and acts as an aerator, grinder, crusher, chemical degrader, and a biological stimulator. The waste water is passed through the experimental setup which contains bottom layer of coarse aggregates having size of 7.5cm and it is filled upto to a depth of 25cm. The second layer contained about 3.5cm to 4cm of gravels it is filled upto a depth of 25cm with a layer of garden soil on top. This formed the vermifilter bed.

The topmost layer of about 10cm consists of pure soil in which the earthworms were released. The earthworms were given around one week settling time in the soil bed to acclimatize in the new environment. It is important to note that the soil and sand particles and gravel also contribute filteration and cleaning of wastewater by adsorption of the impurities on their surface. The root zone of canna and ginger plant acts as a biofilter. It reduces the toxic elements and heavy metals from the waste water. After this process the recycled form of wastewater is get collected in another tank. The recycled wastewater contains less BOD and COD than the raw wastewater. By this process the BOD, COD and TS from wastewater gets reduced. The collected water canbe used for car washing, gardening, and flushing, etc. The sewage and the effluents from vermifier 1 and vermifier 2 were tested for BOD, COD and suspended solids at regular intervals; the results are tabulated in the subsequent tables

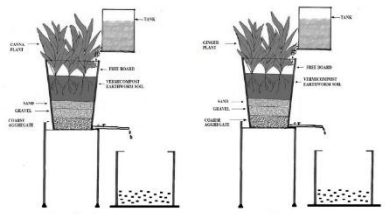

Fig.3: Experimental set up

Table 1: Rate of hydraulic loading

Date	Hydraulic Loading
22/1/18	1 liters. Per day (water)
26/1/18	2 liters per day (water)
30/1/18	3 liters per day (water)
4/2/18	3.5 liters per day (water)
8/2/18	4 liters per day (water)

Table2: Rate of hydraulic loading of sullage water

Date	Hydraulic Loading
15/2/18	3 liters. Per day (sullage water)
20/2/18	3 liters per day (sullage water)
25/2/18	3 liters per day (sullage water)
1/3/18	3 liters per day (sullage water)
9/3/18	3 liters per day (sullage water)

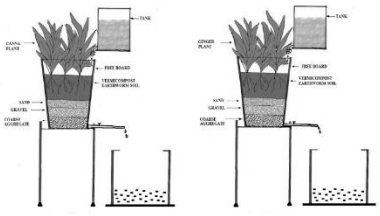

Fig 4: Water Before Treatment and After Treatment

7. Laboratory analysis

All the samples of the waste water which being collected were analyzed into laboratory for important parameters like Biochemical Oxygen Demand, Chemical Oxygen Demand and Suspended solids of the waste water samples.

8. Results of laboratory analysis

The results of the laboratory analysis carried out during the study project are presented in tabular format as well as through curves. The overall quality of waste water from hostel is revealed, which is prepared on the basis of analysis of different samples.

Table 4: The characteristics of treated water using Canna plant

Sl. No	Parameter	Concentration
1.	Colour	Pale yellow
2.	pH	7.32
3.	Temperature	28℃
4.	Suspended solid (mg/lit)	25
5.	BOD5(mg/lit)	9
6.	COD(mg/lit)	190
7.	Turbidity	70 NTU

Table 5: The characteristics of treated water using Ginger plant

Sl. No	Parameter	Concentration
1.	Colour	Yellow
2.	pH	6.8
3.	Temperature	28℃
4.	Suspended solid (mg/lit)	26
5.	BOD5(mg/lit)	21
6.	COD(mg/lit)	212
7.	Turbidity	90 NTU

For each of the organic loading rate applied to the vermifier tables are prepared to depict the pattern of biodegradation of waste in terms of reduction in the concentration of various parameters like

COD, BOD and Total Solids. The pattern of biodegradation of the domestic wastewater through the process of vermification in terms of percentage removal of different parameters is presented.

9. Results

The variation in concentration of COD, Total solids and BOD with respect to time and with respect to different loading rate is analysed. And from the above table can be seen that the percentage reduction in COD for vermifier 1 ranges from a value of 65.00% to 86.00% corresponding to different initial organic loadings. The corresponding reduction in Vermifier 2 ranges from 61.00% to 76.00% thus the overall efficiency of removal of COD is higher in case of Canna Vermifier. The reduction in concentration of BOD in Vermifier1 ranges from 90.00% to 97.00% corresponding respectively different organic loading. The corresponding reduction in Vermifier 2 ranges from 75.00% to 93.00% thus the overall efficiency of removal of BOD is higher in case of Canna Vermifier than Ginger Vermifier.The percentage reduction in concentration suspended solids in VF1 corresponding to different loading varies from 91.00% to 95.00% respectively. The corresponding removal in VF2 ranges from 91.00% to 94.00%. From the above results it is seen that the water quality in terms of BOD, COD and S.S have been reduced considerably as the wastewater passes through the filter. Due the presence of earth worm the soil is broken into smaller units in the form vermicomposed due to which large percentage reduction in S.S is observed.

During the course of experimentation it was found that there were no sign of any development of anaerobic condition in the model as there was no odour or noflies inspite of daily application of sewage. The effluent from both the vermifilter was totally odour free. It shows pale yellow color due to leaching of some dissolved salts. The intensity of this color decreased as the system stabilized with acclimatized over the span of one months. The growth of plants in Vermifier 1 (Canna vermifier) was found to be more as compared to that of plants in Vermifier 2 (Ginger Vermifier) .Canna plants gave birth to new shoots old plants were cut, so that the new plants could grow efficiently. The younger plant consumed the metabolites i.e. nutrients more efficiently and the effluent of better quality was obtained. Also the Canna plant and Ginger plant provided shade for the vermifier.

10. Conclusion

Vermiculture and vermicomposting technology is an easy practice, ecologically safe, economically sound. Recycling is one of the best techniques. Vermifilteration of domestic wastewater is advantageous over the conventional treatment system and they are ecofriendly and economical. This system offers an easy handling and utilization oriented method of bioconversion of wastewater. From experimental setup we can conclude that CANNA is more effective than GINGER in water purification process.

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