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TREATMENT OF DOMESTIC WASTEWATER BY VERMIFILTRATION TECHNIQUE

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Abstract - *Due to increase in human population demand for fresh water have been in rise for domestic consumption. But due to interference of human beings, available water is being polluted and has been limited for use. Reuse of domestic wastewater for non-potable purpose is another option available for water deprived regions and to developing countries. In order to encounter such a scenario treating of wastewater and reuse is necessary. Developing countries like India treatment of wastewaters are expensive. In order to overcome the treatment cost most developing countries opt for a low cost treatment. One such method is vermifiltration giving better efficiency in removal of pollutants from domestic wastewater and can be adopted for various wastewaters. In the present study an attempt is made to know the efficiency of vermifilter and non-vermifilter as a devolved treatment for parameters like pH, total dissolved solids, biological oxygen demand, chemical oxygen demand, and phosphates. Domestic wastewater collected from the college campus was treated using vermifilter which consists of earthworms and the efficiency is compared between vermifilter and non-vermifilter. The average removal efficiencies of vermifilter for COD, BOD, and TDS were 72%, 70%, 52%. During this process there was no sludge formation and was an odor free treatment. The combination of earthworms along with microorganisms proves to be very encouraging in fighting against the organic matter and pathogens present in the wastewater.*

Key Words: ***Biological oxygen demand (BOD), Chemical oxygen demand (COD), Total suspended solids (TSS), Total dissolved solids (TDS), Waste water (WW), Vermifilter (VF), Non-vermifilter (NVF), Total coliform (TC), Fecal coliform (FC).***

1. INTRODUCTION

Water is becoming a sparse resource in the world due to increase in population and pollution of natural water resources According to International Water Management Institute (IWMI) the per capita domestic water demand in india is likely to increase [6][9]. This sewage consists of hazardous chemicals and high loads of organic pollutants such as (BOD), (COD), (TSS), etc [4] consequently it is imperative to reduce the ground and surface water use and other alternatives should be considered for the reuse of grey water. There are various methods available for treating wastewater but are time consuming, expensive, maintenance and operating problems. To overcome all these problems a new environmental friendly with low cost has been introduced in developing countries [9]. One such method is vermifiltration. The schematic representation of vermifilter is shown in Figure 1. Vermifiltration is an aerobic treatment which uses filtration technique but along with earthworms incorporated into it. Earthworms are disinfectant, detoxifying and its body acts as a bio-filter which increases the microbial metabolism by increasing their population [7]. Hence it is a collaboration of earthworms and microbial organisms, where earthworms formalize the organics present in wastewater thereby increasing the surface are that is favorable for the microbial activity. These earthworms play an important role in vermifiltration system by consumption, digestion and assimilation [12]. Vermifilter is made up of a simple filtering system made up plastic container. The bottom most layers made of gravels of large size for aeration and storage of water at the bottom covered with a layer of small size pebbles, aggregates, garden soil and a bed for the earthworms.

2. Materials and methodology

2.1 Analytical methods used in the laboratory study Analysis of grey water was carried out in Environmental lab at JSS science and Technology University College, Mysore. It was done to assess the BOD, COD, Suspended Solid, pH value of the influent and effluent grey water obtained from vermifilter and non-vermifilter. Standard method for examining the wastewater (APHA 2005) was adopted for determining the above said parameters.

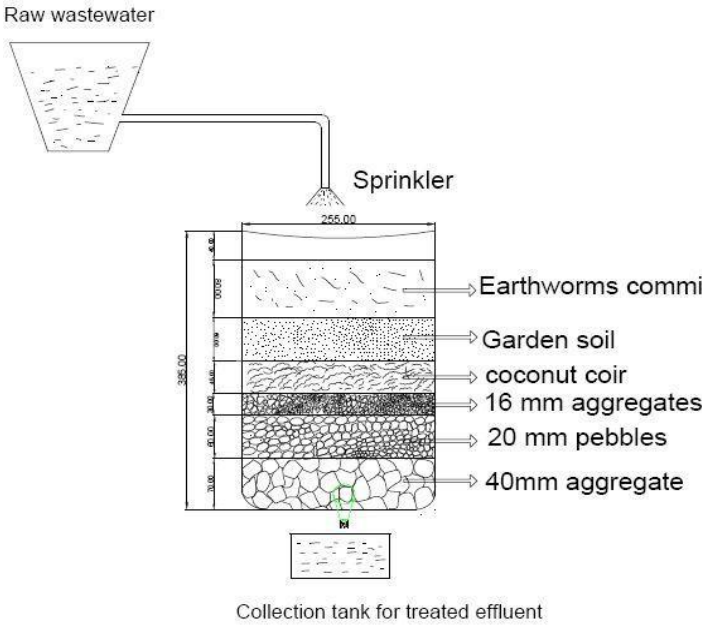

Fig-1: Schematic representation of a Vermifilter

2.2 Collection and analysis of wastewater sample

Raw domestic wastewater for use in vermifiltration experiment was collected from the campus of JSS Science and Technology University, Mysuru. Grab samples were collected in 20L polymer can from the outlet of SJCE girls hostel. Laboratory characterization of samples were carried out and analyzed before use in the vermifiltration experiments.

2.3 Preparation of vermibed

Vermifilter bed was made of pure organic waste in a ratio of 1:3 of cow dung and kitchen waste. The composting bed was prepared prior to one month before the actual start of the experiment. Organic wastes from kitchen were obtained and were mixed and dried along with cow dung which was dried for 3 – 4days. Once the vermibed was ready, 1kg of earthworms were released into this bed. Three species of earthworms were used which was in adult stage, namely Eisenia Fetida, Eudrilus eugeniae, Perionyx Excavatus.

2.4 Experimental setup

Two lab scale cylindrical reactor were set up for treating domestic wastewater having an effective working volume of 20L capacity locally available water can of internal diameter of 255mm was used for the experiment. For experiment two reactors were set up Reactor A as vermifilter and Reactor B as non- vermifilter. Reactor A was filled with filter garden soil, coconut coir, small and large sized aggregates with earthworms and kitchen waste and Reactor B non-vermifilter filled with filter materials such as small and large aggregates, course sand and no earthworms. The experiment was carried out for 90 days monitoring the treated wastewater at regular interval of time. Before the start of experiment the Reactor A, VF was left for acclimatization for about 20 – 25 days for the earthworms to adapt to the new environment created in the filter, during which tap water was used for running of filter. After the acclimatization period wastewater was run through the filter in batch for every 3days in order to avoid too moistened condition of the vermin bed in vermifilter. A plastic net of 2mm in diameter was used in between the layers of different filter materials in order to slow down the flow rate, and also to avoid the earthworm's passage through the filter materials. WW was sprinkled by a perforated pipe so as to avoid the earthworms from dying due to stagnated WW in the filter. WW was allowed to flow through the filter media at a controlled velocity. Treated wastewater was collected at the end of 2days in a week and was further analyzed for wastewater quality parameters. Earthworms of species Eisenia fetida, Perionyx Sansibaricus, Eudrilus eugeniae were used for the study. The size of the filter used was 385 X 255 mm and the filter consists of 6 layers. The filter setup used for the treatment is as shown in Figure 2.

Layer I: (from bottom) consists of large stones of size 10-15cm up to 70mm height which was sieved for 40mm, the stones was it was washed and cleaned with distilled water and sun dried completely before use in the experiment. This layer creates an air chamber and water storage at the base of the filter.

Layer II: consists of thick layer of pebbles of size 5-10 cm up to 60 mm in height which was sieved for 20 mm, and was placed above the large stones. The main goal of this is to distribute uniform flow of water through the main filter media.

Layer III: A thick layer of small stones of 3-6 cm diameter up to a height of 30 mm was sieved for 16 mm. This layer acts as a filtration unit and creates turbulence during the wastewater flow and creates aeration.

Layer IV: This layer consists of coconut coir filled up to a height of 2 cm. This layer of coir acts as a good absorbent and are very effective in removing the impurities present in the wastewater.

Layer V: Garden soil up to a height of 60mm were used and densely packed.

Layer VI: The top most layers consisted of composting material along with earthworms. The compost material consists of a small quantity of dried cow dung with kitchen wastes that are organic and were left to decompose. Plastic net of 2mm diameter was used between all the filter media in order to slow down the

flow rate and to avoid the earthworms pass into the next layer.

The experiment was performed during the month of February 2019 to June 2019. Before the run of the experiment wastewater was analyzed for physicochemical parameters. The physicochemical characteristics of the domestic wastewater are given in Table 2. The initial stage of the vermifiltration process was performed in batch mode for 2hrs/ day. The treated effluent sample was collected twice in a week and tested for physico-chemical parameters like pH, Chemical oxygen demand (COD), three day Biological oxygen demand (BOD), Total suspended solids (TSS), Total dissolved solids (TDS), Phosphates.

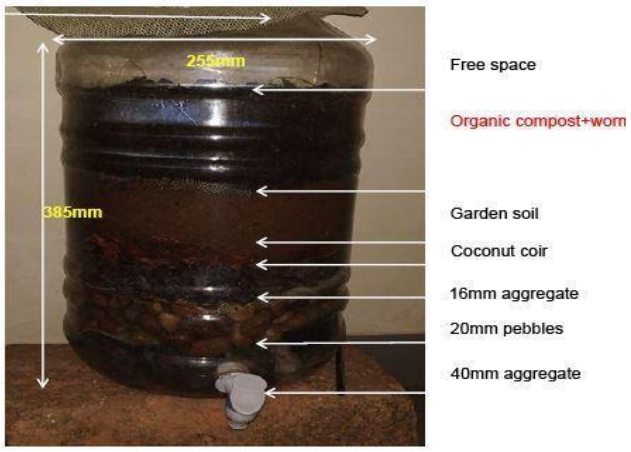

Fig-2: Experimental setup of a vermifilter

3. Results and discussions

3.1 pH

Chart 1 shows the variation in pH during treatment by VF and NVF. The initial pH of the raw wastewater was 7.73, when treated with vermifilter the pH decreased from 7.73 to neutral value of 7.07. In Non vermifilter also the pH was decreased from 7.73 to 7.2. As the first 30 days was adaptation period for the filter and earthworms due to which there was variation in pH. After the filter and earthworms were adapted to the new environment the results shows that there is gradual decrease in pH level of the sample. The reduction of pH of domestic wastewater was due to the swift mineralization of organic materials present in the wastewater that are consumed by the earthworms.

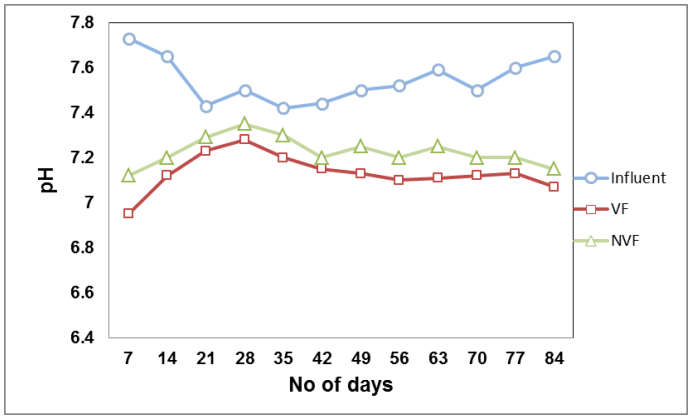

Chart-1: Graph shows the variation in pH during the treatment by VF and NVF

3.2 TDS

Total dissolved solids (TDS) consists of inorganic salts such as calcium, sodium, magnesium, and few small amounts of organic matter that are dissolved in the water.. TDS test provides a qualitative measure of the amount of dissolved ions which is used as a measure to determine the quality of the water. Water with high amount of TDS may cause luscious problems such as taste, staining etc. chart-2 shows the variation of TDS during the treatment by VF and NVF. TDS removal from the wastewater using vermifiltration was 470 mg/L from its initial concentration of 720 mg/L. and for non-vermifiltration it was observed to be 515 mg/L. removal of TDS differed marginally for both vermifilter and non-vermifilter.

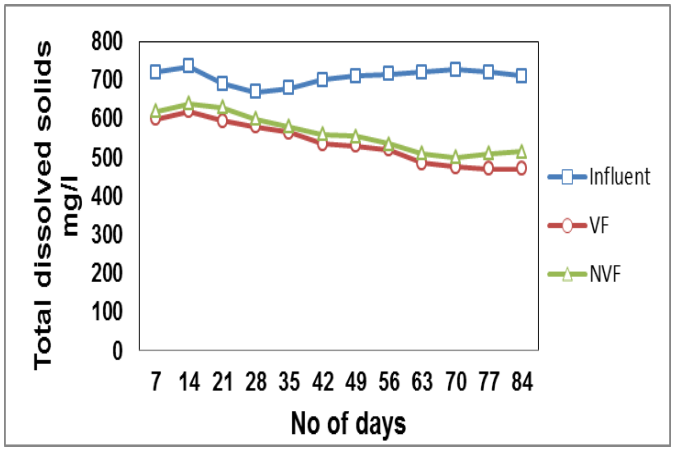

Chart-2: Graph shows the variation in TDS during the treatment by VF and NVF

3.3 BOD

Vermifiltration experiment in the present study from the wastewater has led to reduce BOD_3 significantly. Earthworms act as a biofilter and are found to remove 80

– 90% of BOD [5]. Chart 3 shows the variation in BOD during treatment by VF and NVF. The initial BOD for the collected raw domestic wastewater was found to be 275mg/L. during treatment with vermifilter and Non-vermifilter it was reduced to 85mg/L and 120mg/L from its initial concentration of 275 mg/L. removal of BOD was 70% for vermifilter and 55% for non-vermifilter. Higher removal of BOD in vermifilter was due to controlled flow and uptake of organic matter by earthworms and also no choking in the filter media. Where as in NVF due to formation of biofilms in the system that affecting the filtration rates the removal efficiency of filter was low as compared to VF. Better removal of BOD in VF was observed as the earthworm degrades the wastewater organics by enzymatic action, resulting in the reduction of BOD.

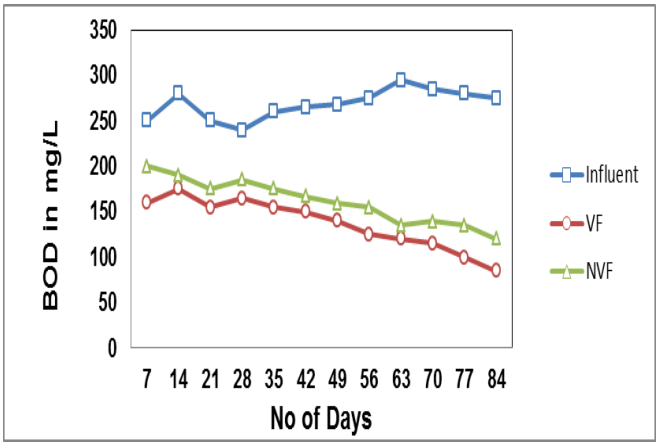

Chart-3: Graph shows the variation in BOD during the treatment by VF and NVF

3.4 COD

Chemical oxygen demand (COD) is a measure of organic and inorganic contaminants present in the wastewater.

High values of COD indicate the pollution load of the wastewater with both organic and inorganic contaminants [4]. Chart-4 shows the variation of COD during the vermifiltration process. The longer the wastewater is made in contact with the earthworms the higher will be the removal efficiency. Initial COD value of raw domestic wastewater was 410mg/L. as the treatment started with vermifilter and non-vermifilter the values were observed to be 100mg/L for VF and 130mg/L for NVF. Removal of COD was efficient in VF as compared to NVF from its initial concentration of 400 mg/L. Removal efficiency of 72% was observed in VF and 60% in NVF.

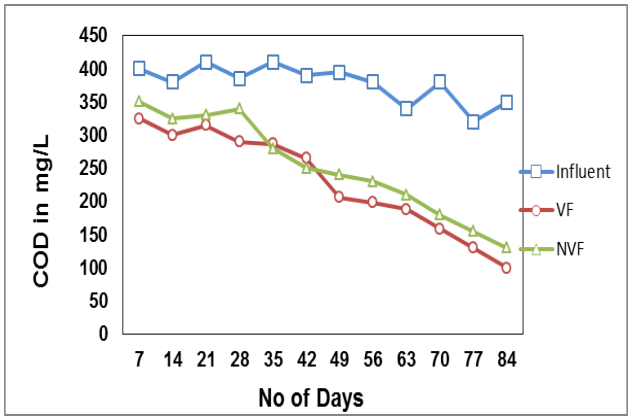

Chart-4: Graph shows the variation in COD during the treatment by VF and NVF

3.5 PHOSPHATE

Phosphorus removal entirely depends on the VF and NVF bed, surface area, sorption capacity and surface area size of the filter bed. Chart-5 shows the graph of variation in phosphate concentration during the treatment by VF and NVF. In the initial stage the value of the raw untreated domestic wastewater as found to be 17.8 mg/L. when treated with vermifilter it was reduced effectively to 9 mg/L and for a non-vermifilter it was found to be 13mg/L. Removal of 60% and 49% was observed for VF and NVF. In the present study an attempt is made to reduce the phosphate and nitrate content by vermifiltration process and it was found to be effective in reducing the phosphate content for up to 60%.

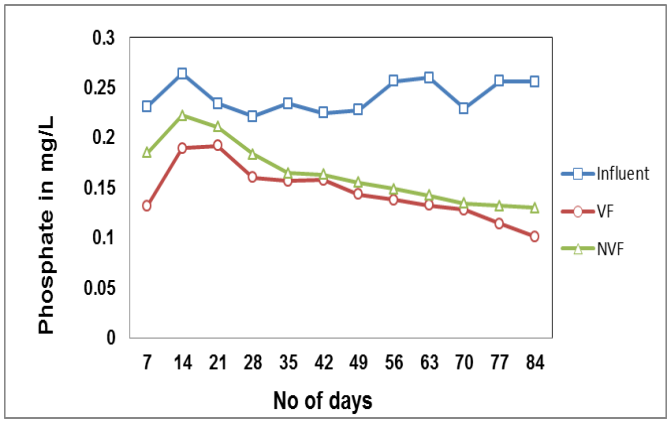

Chart-5: Graph shows the variation in phosphate during the treatment by VF and NVF

3.6. Pathogen removal efficiency

The pathogen removal efficiency for the treatment of domestic wastewater was tested. The influent value of total coliform (TC) and fecal coliform (FC) for the untreated raw domestic wastewater was 2200 MPN/100ml and 483MPN/2100ml.The concentration of

total coliform and fecal coliform after the treatment was found to be 1100MPN/100ml and 225MPN/100 ml for vermifilter and for non-vermifilter TC and FC was 1500 MPN/100 ml and 370 MPN/100 ml. This is mainly due to the intestinal enzymes of the earthworms that are responsible for the removal of pathogens. The earthworms secrete a fluid called coelomic from its body which has the antibacterial properties which inhibit in the growth of other pathogens.

This project looks into sagacious use of verimfilter in treating the domestic wastewater. The best prominent filter was found to be vermifilter, as this technique does not cause any choking, no formation of sludge and gives higher removal efficiency but non-vermifilter was not consistent, although it reduces the pollutant content in the wastewater as it forms chocking in the filter which results in less removal efficiency. Contaminant removal is mainly due to biological activity.

4. CONCLUSIONS

Vermifiltration is an environment friendly, low cost, space saving, chemical free technique to treat the domestic WW. The working of VF and NVF by using 3 different species earthworms for College campus wastewater was studied for selected parameters such as pH, BOD, COD, TDS, phosphate and nitrate. The Vermifilter showed a significant reduction in the parameters. In VF the removal efficiency for BOD was 70%, COD 72%, TDS 51%, phosphate 49%, when compared to NVF BOD 40%, COD 45%, TDS 30%, phosphate 39%. NVF also showed better result but VF was found to be more prominent giving higher removal efficiency than NVF. The overall results indicate that the Earthworms remarkably degrade the waste material without production of sludge. The results obtained are enormously good enough. Henceforth, it can be concluded that vermifiltration technique is economical, eco-friendly with no odor and no sludge formation can be accomplished by common society.

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BIOGRAPHY

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