

Study on Application and validation of Vermi-filtration in Dairy Effluent Treatment

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ABSTRACT: The large amount of highly turbid effluent generated from the dairy industries was discarded as it is because of the difficulties in its treatment. Dairy waste water contains higher quantity of dissolved or colloidal organic matter and hence higher BOD and COD values. In the present study, the dairy effluent was treated through Vermifiltration system with *Eudriluseugeniae* earthworm species. Vermifilter bed of 20cm thickness, sand of 10cm and gravel media of 21cm depth was used in the Vermifiltration unit and Hydraulic Retention time was fixed for duration of 2, 4 and 6 hrs. The hydraulic conductivity and natural aeration was enhanced by the earthworms, which granulates the clay particles. They also enhance the absorption ability by grinding the slit and sand particles into smaller size. From the study, variation in pH due to activity of earthworms lies within the ISI standard. Vermifiltration using *Eudriluseugeniae* earthworms removed 87 % of Total suspended solids, 97.8% of oil and grease, reduced 95% of BOD and 83% of COD. This is an odor-free process and no sludge formed in the vermin-filtration unit during the dairy wastewater treatment. The treated waste water was clear and good enough for irrigation purpose or parks and gardens.

KEYWORDS: Vermifiltration, vermin-filter unit, *Eudriluseugeniae* earthworm, Dairy Effluent.

I. INTRODUCTION

The humans depend on dairy products to a larger extent and today dairy industries achieved a remarkable growth worldwide. According to Fonterra, a global dairy nutrition company, Approximately 735 billion litres of milk produced per annum around the world. Due to its larger size, numbers and production of variety of products, there is bulk quantity of effluent generated by the dairy industries and has become one of the most polluting industries [1]. The effluent generated from the dairy industries contains large amount of organic matter along with dissolved and suspended solids. The organic matters present in the dairy effluent cause's higher chemical and biological oxygen demand i.e., COD and BOD values. Discharging untreated dairy effluent to the water bodies is threat to the aquatic organisms and to the environment. The aerobic bacteria consumes more dissolved oxygen from the water bodies like river or oceans in order to degrade the high volume of organic matter discharged from the dairy effluent [2].

In order to meet the requirements of environmental conservation, the developing countries like India have to accelerate their economic developments. The existing effluent treatment units are of "disposal-based linear system" which is less concerned over environmental conservation. There is need to transform traditional liner treatment systems into cyclical treatment systems in order to promote the efficient management of water and nutrient resources. There is much waste water or effluent treatment techniques are available, but biological methods are more environmental friendly, in which vermifiltration has got much popularity.

Earthworms are efficient in bioprocessing of organic matter present in effluent generated from domestic as well as industrial refuse and proved themselves as master bioprocessing agents [5]. Earthworms play a major role in management of wastes present in solid as well as liquid form. One of the best natural and traditional methods of treating the organic wastes, vermicomposting is carried out through the earthworms. They degrade the bulk organic wastes into smaller particles and forms a stable nutrient rich product called as compost, which can be used for the

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amendment of soil fertility. Hence they are also called 'unheralded soldiers of mankind' by Charles Darwin and 'Intestine of earth' by the great philosopher Aristotle [6].

The treatment of dairy effluent involves different steps in which the effluent treated with physical, chemical and biological processes to remove the various contaminations present in the effluent [7]. The dairy effluent passed through bio-filters in which organic pollutants fed to *Eudriluseugeniae* earthworms and decomposed by them and after treatment an organic fertilizer named vermin-compost produced as a final product. The biofilters also reduce the load of unwanted organic matter from the effluent and the soil and gravel particles present in the vermifiltration bed absorb the pollutants present the effluents in their surface. The combined action of soil and gravel particles along with earthworms reduces dairy effluent contaminants and water treated through vermifiltration process can for irrigation purpose [17].

Today most of the developing countries neglecting the treatment of effluent generating from various industries and effluents are discharged directly into water bodies like river and oceans. This is due to lack of efficient, economic technologies. The vermifiltration is economic and environmental friendly method of wastewater treatment and reduces the challenges faced by the developing conditions to buy expensive effluent treatment plants. The vermifiltration is also an alternative to existing chemical wastewater treatment methods and can reduce other adverse affects caused by the chemicals used for the effluent treatment. The efficiency of vermicompost also depends on the proper design and ideal environment for the survival of earthworms used for the biofilter [1].

II. RELATED WORK

There are some related works have been done on the applications of earthworms in effluent treatment. The study was carried out by Rani et al. 2013 to get optimum Hydraulic loading rate for vermi-filter in order to achieve the requisite quality of effluent having nutrients like nitrate, phosphate etc., which can be used in agriculture. Kaviani and Ghatnekar (1999) were studied bio management of dairy effluents using an *L. rubellus* culture and identified that the sludge cake could support the growth of earthworms without any further processing. The research by Sinha et al, 2010 proved that Vermifiltration removes trace metals, solid and liquid organic contaminants in the effluent. Taylor et al (2003) showed that the treatment of domestic wastewater using vermifiltration can reduce BOD and COD loads, total dissolved and suspended solid up to 70-80 %.

III. IDEAL ENVIRONMENT IN VERMIFILTER FOR EARTHWORMS

Earthworms cannot survive at all environmental conditions, the major environmental conditions like temperature, moisture content and pH should be maintained for the breeding, cocoon production and hatching of earthworms.

The most of the earthworms used in vermicomposting or vermifiltration units need a moderate temperature from 10-35°C for their growth and activities. The tolerance limit of worms may vary with the species but higher temperature or dry condition makes difficult their survival. Earthworms are very sensitive to sunlight, dryness or touch, but some species of worms can survive at colder conditions. Seasonal variation also plays a major role in earthworm's activity, the low temperature during winter significantly decreased earthworms activity but excess of heat during summer instantly kill them.

The earthworms also require balanced moisture condition and oxygen supply for their activity. Excess of water content inhibits the oxygen supply and creates an anaerobic condition, which makes the earthworms move out of the bed. The most favoured range of moisture content for the efficient activity of earthworms is 60-75%.

Earthworms are also sensitive to the pH of the worm bed. Higher acidity or basicity both affects the earthworms. The pH of the worm bed should maintain within 4.5-9, since change in pH occurs during the degradation of organic matter [8].

IV. FACTORS AFFECTING VERMI-FILTRATION OF DIARY EFFLUENT

The efficiency of vermifiltration of effluents mainly depends on Hydraulic retention time (H.R.T) and Hydraulic Loading Rate (H.L.R) of the effluent under treatment [8].

The time of flow of wastewater or effluent through the vermifiltration unit is called as Hydraulic retention time (H.R.T). In order to purify the effluent should remain inside the vermifiltration unit for certain period of time. The

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hydraulic retention time depends on several parameters like flow rate of effluent through the vermifiltration bed, volume and quality of soil used for the vermifiltration bed. During the H.R.T the earthworms present in the filtration unit eat organic pollutants present in the effluent and decompose it. This biological activity of earthworms along with sand and gravel media reduces the BOD and COD values of the effluent and also total suspended or dissolved solids present in it.

The efficiency of the vermifiltration unit depends on the H.R.T., longer the contact time greater will be the purification efficiency. Hence the flow rate of the effluent through the vermifiltration unit is a major factor, which decides the efficiency of purification through the vermifiltration process. Fast flow rate reduces the absorption of suspended organic pollutants and solids. The efficiency of vermifiltration can also be enhanced by increasing the length of filtration bed.

HRT of vermi-filtration system can be calculated as:

$$\text{HRT} = \left(\frac{V}{Q}\right) \times P$$

Where,

HRT = Theoretical hydraulic retention time (hours);

V= volume of the soil profile and sand profile through which the wastewater flows (cum);

P= Porosity of the entire medium (gravel, sand, and soil) through which wastewater flows;

Q= Flow rate of wastewater through the vermi-filter bed (cum/h).

The hydraulic retention time (H.R.T) is directly proportional to the volume of soil and sand profile and is inversely proportional to the rate of flow of wastewater in the vermi-filter bed [8].

The Hydraulic Loading Rate (H.L.R.) is the volume of wastewater or effluent that loaded to the vermifiltration bed which can be purified to a reasonable extent in a given time. The Hydraulic Loading Rate calculated based on the area and length of soil medium used in the vermifiltration unit. H.L.R is thus defined as the volume of effluent applied per unit area of soil profile (vermi-filter bed) per unit time. Hence H.L.R depends mainly on the population of adult earthworms per unit area of the vermifiltration bed and their functioning rate. Hence for efficient treatment of effluent it requires healthy earthworms.

The Hydraulic Loading Rate of vermifiltration unit can be calculated using the formula,

$$\text{H.L.R} = \frac{V}{(A \times t)}$$

Where,

H.L.R = Hydraulic loading rate of the effluent (m/h);

V= Volumetric flow rate of effluent through the filter bed (cum);

A = Area of soil profile exposed for filtration of effluent (sqm);

T = Time taken by the effluent to flow through the filter bed (hrs) [18]

For the higher efficiency of vermifiltration process Hydraulic Retention Time should be higher and Hydraulic Loading rate should be low.

V. EXPERIMENTAL SECTION

The species of earthworm used in this study was collected from Tharalabalu Krishi Vignan Kendra, Davanagere district, Karnataka state, India. In the study, Eudriluseugeniae earthworms, commonly known as African Night Crawler are used in the vermifiltration process. Earthworm species used are shown in the Figure 2.1 (e); about 200-300 worms were used in the present study. The dairy wastewater sample was collected from Karnataka Milk Federation (KMF) Dairy Industry, Bathi situated near Davanagere in Karnataka.

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The study was carried out in a vermi-filtration unit of size 0.45m x0.45m x0.75m. In the vermi-filtration bed, the lower layer made up of sand and gravel covered with garden soil at the top. Outlet was fixed at the bottom of vermi-filtration unit for the collection of treated effluent. Different sized gravels are used in the filtration bed i.e., around 20 mm at the bottom, 10mm at the centre and less than 10 mm at the top layer. The topmost layer consists of bedding materials for a depth of about 20cm in which the earthworms were released; this is shown in Figure 2.1 (a).

The inflow was given with the help of plastic bucket containing dairy wastewater kept on an elevated platform just near the vermi-filter kit, as shown in Figure 2.1(b). The plastic bucket had tap at the bottom; it consisted of 0.5 inch pipe with holes for trickling water that allowed uniform distribution of wastewater on the soil surface; it is shown in the Figure 2.1 (c). Dairy wastewater from the influent tank flows through the pipes by gravity.

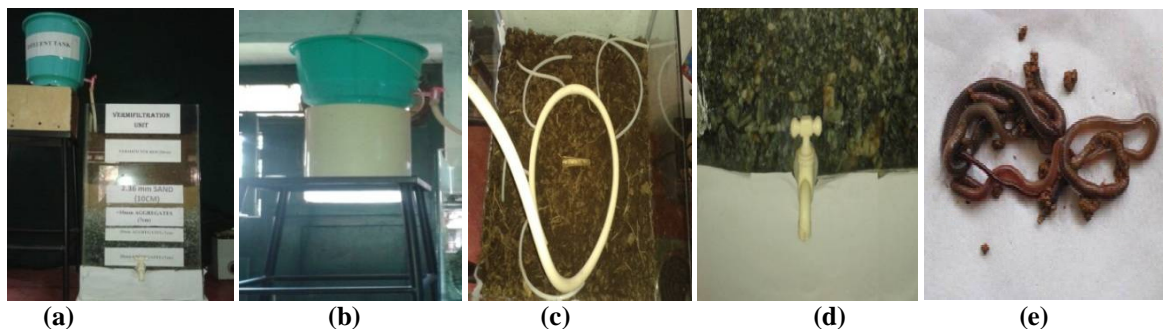


Fig 2.1: (a) Experimental set up of Vermi-filtration unit, (b) Influent Tank, (c) Pipe Arrangement, (d) Outlet Pipe, (e) Earthworms used for the Study

The dairy effluent from the top of vermin-filtration unit percolated through the different layers and through the soil layer inhabited with the Eudriluseugeniae earthworms. The treated effluent was collected at the bottom of the kit through the outlet pipe as shown in the Figure 2.1 (d). This treated Dairy effluent from the kit was collected and analyzed for pH, TSS, BOD, COD and Oil & Grease as per standard methods referring APHA book [9].

VI. EXPERIMENTAL RESULTS

The removal efficiency of Vermi-filtration for dairy waste water at various hydraulic retention time i.e., at 2, 4, 6 hrs where listed in Table 1.

TABLE 1: Removal Efficiency of Vermi-filtration for Dairy Waste water for H.R.T 2, 4, 6 hrs

PARAMETER	UNIT	INFLUENT	EFFLUENT			% REMOVAL		
			2hr	4hr	6hr	2hr	4hr	6hr
pH	-	7.53	7.89	7.84	7.89	-	-	-
TSS	mg/L	147.96	26.5	21.56	19.126	82.08	85.42	87.07
BOD	mg/L	233.33	30	10.8	10.6	87.14	95.37	95.45
COD	mg/L	416	100	96	73.6	75.96	76.92	83.3
Oil & Grease	mg/L	14.706	2.5	1.83	0.312	83	87.55	97.87

From the results obtained from the treatment of dairy effluent by vermin-filtration unit, it is clear that the percentage of organic matter present in the dairy effluent was reduced to a good extent. The reduction in the TSS, BOD, COD, Oil and grease quantity indicates the purification of water by the earthworms present vermi-filtration unit.

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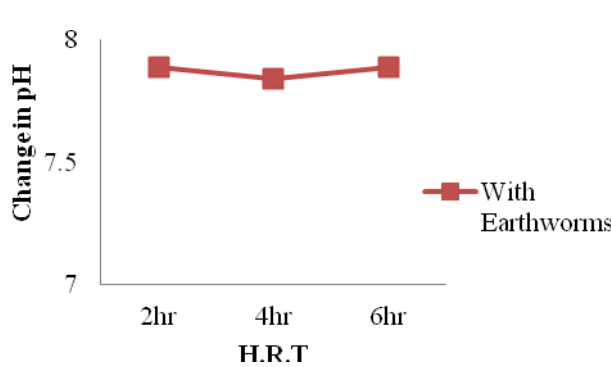


Fig 1: Change in pH

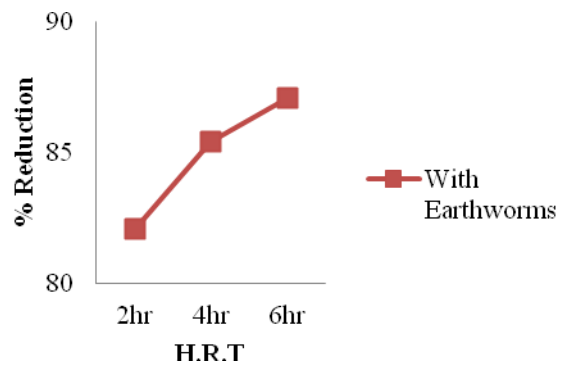


Fig 2: Reduction in Total Suspended Solids (%)

Initial characteristics of dairy wastewater and removal efficiency after vermi-filtration treatment are tabulated in the table 1. Figure 1 show the variation in pH and Figure 2, 3, 4, and 5 show the results for reduction in Suspended Solids, BOD₅, COD and Oil & Grease for H.R.T 2, 4, 6 hr. Variation in pH, in both vermi-filtration and non vermi-filtration kit was found to be nearly equal; it lies within the ISI standard of 5.5-9.0

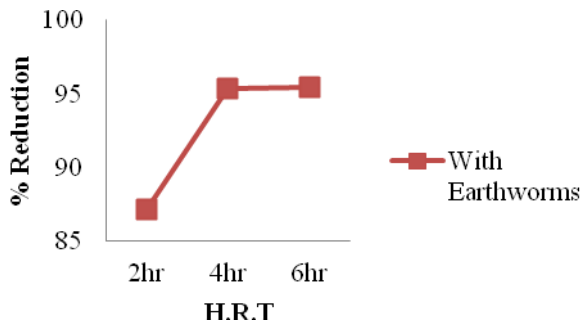


Fig 3: Reduction in BOD (%)

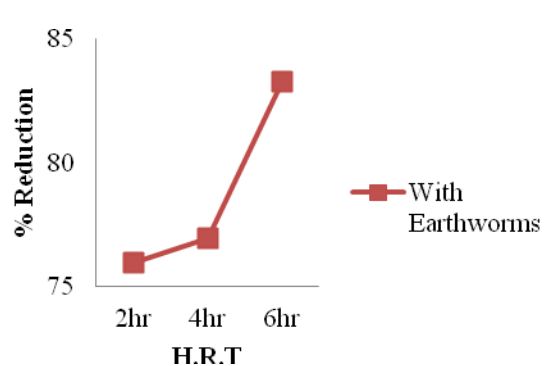


Fig 4: Reduction in COD (%)

The vermi-filtration was found to be more advantageous than non vermi-filtration. Vermifiltration kit the significantly removed 87% of Total Suspended Solids, 95% of BOD₅, 83% of COD, and Oil & Grease by 97.8%. Results specify that, more removal in Turbidity, Suspended Solids, Chloride, Total Hardness, BOD₅, COD, and Oil & Grease with vermi-filtration unit.

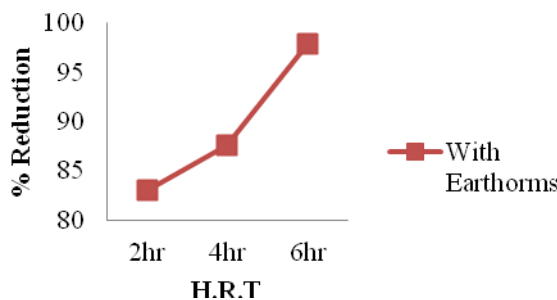


Fig 5: Reduction in Oil & Grease (%)

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. The removal efficiency generally increases with increase in H.R.T up to a certain limit and is also affected by the number of earthworms in the vermi-filter bed. Vermi-filtration keeps the system fully aerated with plenty of oxygen available to aerobic decomposer microbes.

VII. CONCLUSIONS

Pollution caused due to excess organic pollutants present in dairy wastewater disposed to nearest water bodies or land is one of the most critical environmental issues in many developing countries. Vermi-filtration is an alternative, sustainable technology for dairy wastewater treatment. Any non-toxic wastewater from the industries can be successfully treated by the earthworms and technology can be designed to a particular wastewater.

From the study, Vermi-filtration using *Eudriluseugeniae* earthworms was very efficient in the treatment of dairy effluent and was removed 87 % of Total suspended solids, 97.8% of oil and grease, reduced 95% of BOD and 83% of COD. This is an odor-free process and no sludge formed in the vermin-filtration unit during the dairy wastewater treatment. The waste water treated through this method was clear and good enough for irrigation purpose or parks and gardens.

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