# DAIRY WASTEWATER TREATMENT OPTION FOR RURAL SETTLMENTS BY VERMI-BIOFILTRATION

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**ABSTRACT:** The treatment of dairy wastewater using traditional wastewater treatment plants such as the activated sludge is not feasible as it will require high energy rate to provide the required oxygen. This paper presents experimental results of using Vermi Bio-filtration to treat wastewater from dairy industry. Samples of wastewater were collected from Prasanthi Farms located in a small village of Kollam district, India. The sample characteristics of pH, Total Dissolved Solids, Total Suspended Solids, Chemical Oxygen Demand, Oil & Grease and Dissolved Oxygen were measured before and after vermi bio-filtration treatment. The characteristics were measured at different time intervals of 12 hours (12, 24, 36, 48, and 60 hours). The percentage changes of the above parameters after 60 hours are -18, 79, 75, 67, 69 and -31% respectively. the method is inexpensive, it can capture all organic materials, capital and working expenses are low, there is no foul scent, worm biomass would be used as nourishment for the cows, fish agro-business.

Keywords: Dairy, Wastewater Treatment, Vermi Bio-filtration, Vermi composting.

### 1. INTRODUCTION

The dairy industry generates different sorts of drain items from dairy processing. The largest part of wastewater is generated from cleaning activities. The industry produces between 0.2to 10 liters of effluent per liter of processed milk with an average distribution of around 2.5 liters of wastewater for every liter of the milk prepared [1]. The planned volumetric load is 1 m<sup>3</sup> of waste for each ton of produced milk [2].

The composition, concentration and effluents volume emerging within dairy plants remain reliant on the nature of products that is handled, plan of the production, operating techniques, processing plan patterns, and the level of management of water use for cleaning the equipment [3]. In general, the dairy wastewater comprises higher biological loadings denoted as BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), and total solids that might be in liquefied or colloidal forms. It also has high amounts of nitrogen and phosphorus that are, to a great extent, connected with milk proteins [4]. Hence, discharge of untreated dairy wastewater into the stream will cause severe dissolved oxygen (DO) problems.

Aerobic & anaerobic techniques are usually used in treating dairy wastewaters because the contaminants are biodegradable. A review on different aerobic and anaerobic treatment methods in dairy industry wastewater can be found in [5]. However, conventional treatment procedures of dairy wastewater are costly, since they need constant supply of power, which is an issue in most developing countries. Thus, several alternatives are proposed for sustainable wastewater treatment of dairy wastewater such as stabilization ponds [6] and constructed wetlands [7]. Nevertheless, these methods require large area of land. Thus, several researchers have been investigating the use of vermi-bio-filtration treatment for dairy wastewater like [8], [9].

The use of night crawlers in wastewater or sludge treatment is called *vermi-bio-filtration* [9]. In this process, dissolved and suspended natural and inorganic solids are caught by adsorption and adjustment through complex biodegradation forms that happen in the "living soil" possessed by worm and the vigorous microorganisms [10]. Microorganisms that are present inside the earthworm helps in biochemical degradation of organic matter present in the wastewater [9].

Thus, *vermi-filtration* have several advantages. These include low energy dependency; 100% capturing of the organic materials is certain; less capital and working expenses, and with the addition of high valued additional finished product (*vermi compost*); there is no foul scent while the worms capture decomposing and decay of every single putrescible matters in the wastewater; large amounts of worm biomass would be accessible as nourishment for the cows, fowls, and fish agrobusiness, after the principal year of vermi-treatment; sludge is released in the vermi-filter bed as excreta (*vermi compost*) which is a valuable soil added substance for farming and cultivation [11].

Hughes, Nair, and Ho [12] also reported that *Vermi-technology* is reasonable for dispersed wastewater treatment. It is very efficient in regard to eliminating COD, BOD, SS and some N and P. It

was also observed that there was no foul odor throughout the treatment.

Arora, Rajpal, and Kazmi [13] reported that *vermi-filtration* showed a greater potential for chemical pollutants and pathogen removal from wastewater. Higher percentage of BOD, COD, TSS, FC, FS, *Salmonella* and *Escherichia coli* removal was observed to the accepted level for reuse in irrigation purpose. It was seen that *vermi-filter* (VF) diminished biochemical oxygen demand and chemical oxygen demand by 84.8% and 73.9%, respectively.

Sinha, Bharambe, and Chaudhari [9] examined the vermi-filtration of sewage acquired from the Oxley Wastewater Treatment Plant in Brisbane, Australia. Results demonstrated that the worms expelled BOD heaps of sewage by more than 99 % at water powered maintenance time, hydraulic retention time of 1-2 hours. Normal COD expelled from the sewage by night crawlers is more than 50 %. Worms additionally evacuated the total suspended solids (TSS) by more than 90 %.

Patel [14] conducted the analysis on the waste water generated from dairy industry and found a high removal efficiency for most water quality parameters: BOD - 97.95%; COD - 91.64%; TSS - 76.39%; TDS - 84.27%; Oil & grease - 84.13%.

However, it is necessary for the wastewater to stay in contact with the worms in the filter bed for some time. This time depends on the flow rate and the porosity of the filter. This paper investigates the effects of elapsed time on the performance of *Vermi filter* used to treat dairy wastewater.

#### 2. MATERIALS AND METHOD

For the ease of comparison, the work used almost the same methodology presented Telang and Patel [14]. The *vermi bio-filter* was made by using a plastic bucket of 20-liter capacity for the breeding of the worms. Holes are drilled on the curved surface area of the drum for natural aeration. The schematic details of the experiment is shown in Fig. 1.

Young specimens of *Earthworms*, *Eisiena Fetida* and *Eudrilos eugeniae* were gotten from composting unit kept up at temperature of 25°C in cow dung situated in Kollam, India. Kollam locale is one of 14 regions of the territory of Kerala, India. The region has a cross-segment of Kerala's normal traits; it is invested with a long coastline, a noteworthy Laccadive Sea seaport and an inland lake, Ashtamudi Lake. The area has numerous waterbodies, Kallada stream is one among them, and the east side place where there is waterway is East Kallada and the west side land is West Kallada. As per the 2011 statistics, Kollam area has a populace of 2,629,703[15].



Fig.1 Vermi Bio filter.

The bio filter consisted of four layers through which the wastewater is filtered through. The bottom layer was 6-7 cm of 40 mm size aggregate, over which 20 mm size aggregate was placed at a depth of 4-5 cm. Another layer of aggregate of 10 mm size was set up to a depth of 2-3 cm. The top most layer was the garden soil mixed with earthworms (Fig.2). The different depths of the layers were adopted in order to treat a maximum of 3L of wastewater at a time such that the vermi bed is not submerged. If the vermi bed is submerged, it would prevent the earthworms from obtaining the oxygen they require, since earthworms breathe through their skin.



Fig. 2 Garden soil mixed with earthworms.

To ensure the presence of the earthworms in the bio-filter, dry leaves, dried cow dug, fruits and vegetable waste materials are added to enhance the growth of the worms. The container was protected from direct sunlight and was aerated properly. Black soil and dry cow dug are mixed together and are filled to a depth of 3 - 5 cm along with the earthworms. A layer of kitchen waste is filled as the fourth layer above which the dry leaves are placed.

The influent was conveyed into the bio filter through an irrigation system, which was made to distribute the water over the entire surface area of the bio-filter. The irrigation system was prepared with the help of a polyvinyl hose into which holes of about 3mm diameter at a spacing of 6 to 7 cm. The experimental procedure was carried out using dairy farm wastewater. The samples were collected from the Prasanthi Farms located in a small village of Kollam district, India. This wastewater is produced from the dairy product manufacturing and washing of the milk containers. Th current practice is to simply discard it into the ground without any sort of treatment. The initial characteristics of the wastewater are given in Table 1. The influent characteristics were found out for each trial and then it was subjected to *vermi* bio filtration treatment and the effluent characteristics are noted at different trials. The wastewater samples were retained in the bio-filter for different durations, that is, 12 hours, 24 hours, 36 hours, 48 hours and 60 hours.

Elapsed time (hours)	Influent/ Effluent	рН	TDS (mg/l)	TSS (mg/l)	COD (mg/l)	DO (mg/l)	Oil & Grease (mg/l)
12	INF.	6.5	2440	120	2480	9.5	560
	EFF.	7	1990	100	2280	7.9	470
24	INF.	6.5	2960	140	3600	9.4	340
	EFF.	7.3	1870	80	2120	7.3	210
36	INF.	7	3080	170	3200	9.6	700
	EFF.	7.9	1340	90	1200	11.3	400
48	INF.	6.5	2480	140	2200	9.9	540
	EFF.	7.7	540	40	750	12.7	240
60	INF.	6.3	2680	160	2560	10	610
	EFF.	7.5	560	40	850	13.1	190

Table 1 Influent and effluent water quality parameters

The 20L influent container is placed at a height above bio-filter to ensure continuous flow of wastewater into the filter. The tap was fitted to the base of the influent container and the bio-filter. The irrigation pipe, which allows distributed flow into the bio-filter, is connected to the pipe at the base of the influent container. The effluent is collected in a 20L capacity effluent bucket. About 3L of the wastewater sample was treated for each trial.

## 3. RESULTS AND DISCUSSION

Different parameters have been used to determine the effect of retention time on the removal efficiency of vermi - filter.

#### 3.1 Variation in Hydrogen Ion (pH)

As seen from Table 2 and Fig. 3, the pH values have generally increased after the dairy wastewater passed through the filter, and this increase ranges between 8 and 19%. However, the pH values stay within the range of 7-7.9, and this implies that the earthworms neutralize the dairy wastewater within the vermi bio-filter.

#### 3.2 Total Dissolved Solids (TDS)

The TDS values of the raw data used for this experiment ranges from 2440 to 2080 mg/l. These values have been reduced over time as seen from Table 2 and Fig.3 and the maximum removal efficiency achieved after 60 hours was 79%. This imply that the worms can convert the dissolved solids to suspended solids stay in the filter and hence enhance the removal efficiency of the TDS in the vermi-filter.

## 3.3 Total Suspended Solids (TSS)

The range of TSS values of the raw dairy wastewater introduced to the *vermi-filter* ranges between 120 and 170 mg/l. The results presented in Table 2 shows that the *vermi-filter* reduces the TSS values and this reduction increases with elapsed time and the maximum removal efficiency was 75% over 60 hours. These solids were consumed by earthworms and converted to small particles stayed in the filter or passed with the effluent.

Time	pН	TDS (mg/l)	TSS (mg/l)	COD (mg/l)	DO (mg/l)	Oil & Grease (mg/l)
12	-8	18	17	8	17	16
24	-12	37	43	41	22	38
36	-13	56	47	63	-18	43
48	-19	78	71	66	-28	56
60	-18	79	75	67	-31	69

 Table 2 Removal efficiency (%) of measured parameters

#### 3.4 Chemical Oxygen Demand (COD)

## COD values presented to the vermi filter ranges from 2200 to 3600 mg/l. The overall removal efficiencies of the COD increase over time and reached to 67% after 60 hours as seen from Fig. 3. This results are close to the results found by [9] who have done similar experiment for soaking wastewater and found that the COD reduction using earthworm is more than 50%.

Patel [14] reached almost to the same results (84.27 % removal efficiency), but with a shorter time, 24 hours. However, it is difficult to compare the results as the mass of earthworms has not been determined in both cases, which must have an effect on the removal efficiency of the measured parameters.

Similar removal efficiency were observed by [16] who have also made a research on the up flow anaerobic fixed bed reactor for processing of dairy industry waste utilizing polypropylene pall rings as a pressing media and discovered that regular COD removal efficiency of 87% and highest biogas creation of 9.8 l/d was accomplished. A down flow fixed-film digester was also utilized by [17] for the treatment of deprotinized cheese with a regular chemical oxygen demand of 59,000 mg/L, the digester accomplished a COD decrease of 90–95% at a hydraulic retention time of 2.0–2.5 days.

## 3.5 Dissolved oxygen (DO) Variation

The behavior of DO in the experiment is different from other parameters. The DO is reduced during the initial stages and then started to increase in the later stages. This reduction is due to other microorganisms that use the DO to consume the organic materials in the sample, and since the oxygen is supplied by the atmosphere to the wastewater, the DO concentration started to increase.

## 3.6 Oil & Grease

Like other organic parameters, the removal efficiencies of the oil & grease using the *vermi-filtration* increases with time as indicated by the result presented in Table 2 and the highest observed value was 69% after 60 hours. Similar results was observed by [14] who found that the removal efficiency of Oil and Grease was 84.13% after 24 hours.

#### 4. CONCLUSION

This study presented the results of an experimental study to investigate the effect of retention time on the performance of vermi bio filter used to treat dairy wastewater. The results showed that the removal efficiency of the vermi filter increase over time and the maximum value for TDS, TSS, COD and Oil & Grease after 60 hours were 79, 75, 67 and 69% respectively. The pH buffering ability was attained as the pH of the wastewater was neutralized by the earthworms within the bio filter and increase by 18%. DO value shows some decrease at the first 24 hours and then increases by 31% after 36 hours. Clogs within the filter, due to sludge accumulation, were not witnessed during the experiment. This is due to the action of earthworms that consume the solids and hence clear the path for water. There was no foul smell with vermi-filtration unit all through the experiment and there was no sludge development in the vermi-filtration procedure.

The filtered water can be used for irrigation and the produced *vermi* compost can be used as fertilizer. Other design parameters such as the depth and the surface of the filter should be taken into consideration in the future. Also, the effect of the mass of earthworms need to be investigated further, which is the next step of this research. Thus, *vermifiltration* is a viable technology for the treatment of dairy wastewater.



Fig. 3 Changes at the different elapsed times relative to the influent concentration

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