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Treatment of Textile Waste Water by using Vermifilter and Non Vermifilter

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ABSTRACT: Textile industries are one of the major industries in the world. The textile industry utilizes various chemicals and large amount of water during production process. The waste water produced during this process contain large amount of dyes. If a textile mill discharges the waste water into the local environment without any treatment, it will have a serious impact on natural water bodies and land in surrounding area. In this project we aim to adopt Vermifiltration and Non-Vermifiltration technique for treatment of textile waste water. And to find the efficiency of vermifilter in reducing the quantities of following parameters like, BOD, Color, pH, Hardness, Alkalinity, Chloride content, and TDS in both techniques are done.

KEYWORDS: Vemifilter, Non Vermifilter, Eisenia fetida, Hydraulic Loading Rate.

I. INTRODUCTION

With the development in technology the world is reaching to new horizons. Among the consequences of rapid growth are environmental disorders & pollution problems. Besides other needs the demand of water for industries has increased & resulted in the generation of a large amount of waste water containing large number of pollutants. Textile industries are among the manufacturers which produce the highly polluted waste water large consumption of water and complexity of chemical substances usage in textile processing, leads to environmental pollution in this industry.

Textile industries consume large quantities of water & chemicals, especially in dyeing and finishing processes. Water demand in textile industries has been estimated 100-200 litres per kilogram of products. Consequently, recovery and reuse of waste water after employing appropriate treatment methods is very important in present scenario. On average 60 – 90 % of total water consumption is spent in washing processes. High concentration of dyeing agents, Total Dissolved Solids (TDS) and Chemical Oxygen Demand (COD) and also high potential of toxic substances presence are the major problems associated with textile waste water.

Dyes are one of the important classes of industrial effluents released along with textile waste water. It is estimated that around 10 – 15% of dyes were lost during the dyeing processes. The discharge of highly colored synthetic effluents can be very damaging to the receiving water bodies. These compounds are highly visible & undesirable because they alter the natural appearance of rivers & lakes which impact on aquatic life like water plants and phytoplankton, interfering in transmission of sunlight, reducing photosynthesis and oxygenation of water reservoirs.

Dyes used in textile industry may be toxic to aquatic organisms & can be resistant to natural biological degradation. These dyes cause various diseases especially allergy, dermatitis, skin irritation, and also provoke cancer & mutation in humans. Therefore, low Concentrations (less than 1 ppm) of dyes in waste water and water is highly demanded due to their undesirable effects on environment.

Dyes are a kind of organic compound with a complex aromatic molecular structure that can bring a bright & firm colour to other materials. However, the complex aromatic molecular structures of dyes make them stable & difficult to bio-degrade. Most of the dyes used in the textile industry are monoazo, diazo and triazo dyes and considering their chemical stability and negative influence on the ecological systems. Synthetic dyes are commonly used in most of the textile industries.

The currently existing techniques used for removal of dyes are chemical coagulation, ozonation, oxidation, chemical precipitation, ion exchange, reverse osmosis & ultrafiltration methods. The removal of dyes from dye containing waste water has serious restrictions such as high cost, formation of hazardous by products and intensive energy requirement. Therefore, the development of efficient, low cost & eco-friendly technologies is needed to reduce the dye content in waste water.

Biological processes are gaining prominence in the presence scenario because of their simplicity in application, cost effective construction and formation of non-toxic bio-degradable by-products. In this project we have adopted vermifiltration technique for treatment of textile waste water. The main advantages of this technique is that since earth worm can act as bio-filters because of their direct absorption of organic contents to their body walls and through ingestion process, the COD of waste water could be greatly reduced and no sludge formation occurs here. Earthworms were first applied by Toha in Chili University in 1992 for waste water and sludge treatment so called vermification.

Earthworms use waste water as their energy source and are adaptable to contaminated environments and facilitate growth of useful bacteria involved in waste water decomposing. They also stimulate and increase microbial activity by creating favourable conditions for bacteria and improving soil aeration. The earthworms has been found to eliminate up to 80-90% of COD, 90% of BOD, and 90-95% of TDS from waste water by ingestion mechanism, shell absorption and biological decomposition of biomaterials, heavy metals and solids. This process is odour less and remains no sludge. Effluent from this process is suitable for parks and gardens irrigation because of its clarity. Some other advantages of this process include needing less space and needless of pumping devices. Eisenia fetida, Eisenia adrei, Perionyx excatavus, Eudrilus Eugenia, and Lumbricus rubella's are the best type of worms for purification purposes.

Table 1. General characteristics of textile waste water

Parameters	Unit	Typical range
pH	-	5.5 – 10.5
BOD	Mg/l	100 - 4000
COD	Mg/l	150 - 10000
TDS	Mg/l	1500 - 6000
TSS	Mg/l	100 – 5000
Total Alkalinity	Mg/l	500 – 800
Sulphides	Mg/l	5 – 20
Chlorides	Mg/l	200 – 6000

II. RELATED WORK

Kore Priyanka S (2017): Vermifilter- A effective cost technology for domestic waste water: In this study waste water is treated using vermifilter containing earthworms and the results are compared with waste water treatment by traditional method, for the treatment of domestic wastewater. The domestic waste water is collected from hostels, apartment, kitchen food court, wash rooms of collage & school. Treatment of domestic wastewater by vermifilter have been found to remove the pH about 3% to 5%, Turbidity by 80% to 87%, 3 days BOD (BOD_3) by over 80%, COD by 90%, Total dissolved solids (TDS) by 85% to 90%, and the Total suspended solids (TSS) by 90% to 95% from domestic waste water by the general mechanism of biodegradation of organic wastes.

Nirmala Natarajan and N kannadasan (2015): Effect of earthworm on distillery effluent through vermification: Distillery is an important subunit of sugar production industry. Distillery waste water generated from different stages of sugar production contains large amount of pollutants. In this project vermifiltration method is applied to convert liquid effluent into eco-friendly safe water. The results showed that TSS and TDS decreased by 90%, 94%, 88%, and 82% respectively through vermifiltration.

Lakshmi C and Vijaya Lakshmi S (2014): Waste water treatment using vermifiltration technique at institutional level: In this study waste water is treated using vermifilter containing earthworms and the results are compared with waste water treatment by non vermifilter for the treatment of domestic waste water. The results showed that they could remove COD by 65%, TDS by 90%, TSS by 86%, and Turbidity by 93.2%. They also found that reduction in concentration of COD in vermifilter was more efficient than non vermifilter. Also this process was odor free and had no sludge formation.

III. METHODOLOGY

Collection of textile waste water from Sri Superior Dyeing Industry, Tirpur. Preliminary test was conducted. Tests like BOD, pH, Color, total suspended solids, total dissolved solids, chloride and alkalinity were conducted. Preparation of synthetic dye water from the composition obtained was done. Collection of earthworms, gravels, sand, garden soil, sawdust. Construction of vermifilter and non vermifilter. Synthetic dye water passed through both filters at varying hydraulic loading rate. BOD, dye concentration, ect, of the filtered water after filtration is tested at varying hydraulic loading rate. The water obtained after treatment from the filter system is tested for its characteristics. Results are tabulated and graph showing comparison between various chemical characteristics of vermifilter and non-vermifilter are analysed.

Vermifilter: Vermifiltration is a new and innovative technology in which the combined action of earthworm's activity and adsorption properties of other materials like, soil, sand & gravel particles on the organic pollutants are applied for treatment of waste water like effluents from textile industry. Vermifilter is a rectangular shaped of 30×40 cm^2 area and 50 cm depth, which is equipped with a tray having holes to ensure uniform distribution of influent on top. It is divided in to 4 parts of layers in which gravel, sand and vermifilter bed were placed from bottom layer to top. The bottom layer was made of aggregates of 20 mm size and it fills up to a depth of 60 mm. Above this lies aggregates of 10 mm size filling up to 50 mm height. On top of this, 50 mm thick layer of sand passing through 2.36 mm size sieve. The top most layer is about 120 mm height, consists of garden soil passing through 2.36 mm size sieve which mixed with saw dust at a volume ratio of 3:1 forms the vermifilter bed. The earthworms were added to this garden soil in alternate layers. About 100 grams of cow dung was added along with earthworms to facilitate their growth. The earthworms were added to this garden soil in alternate layers. A layer of net of wire mesh was placed below the layer of soil bed to allow only water to trickle down while holding the earthworms in the soil bed because it can crawl down to filter materials. The system has provisions to collect the filtered water from the bottom which opens out in to a bucket.

Fig.1. Filtration process in vermifiltration model

Non vermifilter: *Setup of non vermifilter* is similar to vermifilter except the presence of earthworm.

Fig.2. Non vermifilter

Synthetic dye water preparation: The synthetic dye water was prepared by considering the characteristics of a real textile dyeing effluent. The composition of this waste water is given in the below table. It includes dyes, leveling agent, lubricants, salt solution, caustic soda and softener.

Table 2. Composition of synthetic textile waste water

Chemicals	Quantity
Ramafix (Dye)	100 mg/l
Sorbecol (Leveling agent)	2 ml/l
Nylube C (Lubricant)	4ml/l
Salt	1g/l
20% Caustic soda	2ml/l
Wet soft (softener)	20 ml/l

The quantities of these chemicals were fixed by trial and error procedure. Leveling agent is used to remove dye patches present in the fabric. In finishing process softeners are used to provide required softness to the product. Depending on the requirements of customers various types of softeners are used such as electromeric, maxsoft SKJ, wetsoft, nexil and LM10. The dye concentration was determined from the absorbance characteristics in the UV- Vis range by calibration method. A spectrometer was used. The absorbance at different known concentration of dye is shown below.

Table 3. Absorbance at different known concentration of dye

Concentration in mg/l	Absorbance
1	0.033
5	0.082
10	0.149
20	0.330
30	0.267
40	0.645
50	0.739
60	0.990
70	1.200
80	1.373
90	1.388
100	2.5

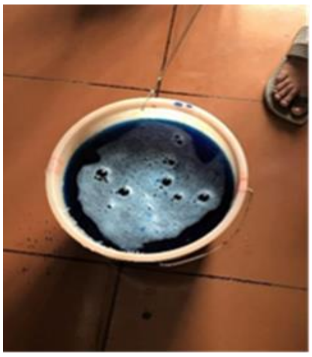

Fig. 3. Synthetic dye water sample

Functions of earthworms in organic and inorganic contents from waste water:

General characteristics: Earth worms are tireless tillers of our soils and their castings are richest and best of all fertilizers. They are very useful in treatment of waste water as well as sludge. They are also useful for treatment of waste water from industries as well as domestic and residential sewage. Earthworms are long, narrow, cylindrical, bilaterally symmetrical, segmented animals having without bones. The body is dark brown, glistening, and covered with delicate cuticle. They weigh over 1400–1500 mg after 8– 10 weeks. Usually the life span of an earthworm is about 3–7 years, depending upon the type of species and the ecological situation. Earthworm's harbors millions of nitrogen fixing and decomposer microbes in their gut. They have chemoreceptors which aid in search of food. Their body contains 65% protein (contains 70–80% high quality lysine rich protein), 14% fats, 14% carbohydrates, and 3% ashes. Earthworms are generally absent or rare in soil with a very coarse texture and high clay content or soil with pH<4. Earthworms are also tolerant to moderate salt salinity in soil, but some species like the tiger worms (Eisenia fetida) has been found to be highly salt tolerant and resistive towards chemicals. Therefore in our project tiger worms are used in vermifilter for treatment of textile wastewater, which is usually comprises huge amount of chemicals in it.

Ecology and biology of earthworms: Earthworms can also tolerate toxic chemicals in the environment. As worms breathe through their skin proper ventilation of air in soil medium is necessary. They can tolerate a temperature range between 50 and 29^0C. A temperature of 20^0–25^0C and moisture of 60–75% are optimum for best worm function. Generally earthworms can also tolerate extensive water loss by dehydration. Earthworms are bisexual animals and multiply very rapidly. After copulation each worm ejects lemon-shaped 'cocoon' where sperms enter to fertilize the eggs. Studies indicate that they double their number at least every 60–70 days. Given the optimal conditions of moisture, temperature, and feeding materials earthworms can multiply by 28, i.e. 256 worms every 6 months from a single individual. The total life cycle of the worms is about 220 days. Red worms take only 4–6 weeks to become sexually mature. They have been reported to bio-accumulate them in their tissues and either biodegrade or bio transform them into harmless products with the aid often enzymes. They have also been reported to host microbes in their gut which can biodegrade chemicals.

Economic significance: Earthworms can physically handle most organic waste water and potentially at a fraction of the cost of conventional methods of wastewater treatment. Vermiculture technology by earthworms is a self-promoted, self-regulated, self-improved, self-driven, self-powered and self-enhanced, very low energy and less chemical requiring zero waste technology, easy to construct, operate and maintain. Any vermiculture technology involves about 100-1000 times higher 'value addition' than other biological technologies. It has less operational cost since it requires energy only for pumping of waste and no skilled labor. Maintenance costs also minimal as it does not involve any mechanical devices.

Mechanism of earthworms in waste water treatment: Earthworms are versatile waste eaters and decomposers. It promotes the growth of beneficial decomposer bacteria in waste water and acts as an aerator, grinder and crusher, chemical degrades and a biological stimulator. The two processes-microbial processes and vermin-process simultaneously work in the Vermifiltration system. Earthworms further stimulate and accelerate microbial activity by increasing the population of soil microorganisms and also through improving aeration by burrowing action. Earthworms host millions of decomposer microbes in their gut and excreta called vermicast. The nutrients N and P are further used by the microbes for multiplication and enhanced action. Studies show that the number of bacteria and actinomycetes contained in the ingested material increased up to 1000 fold while passing through the gut. A population of worms numbering about 15000 will in turn fosters a microbial population of billions of millions.

Synergic action of enzymes, microorganisms and earthworms in vermifiltration: The role of different types of enzymes, microorganisms, and earthworms for effluent treatments has been studied. Studies confirmed that enzymes can act on specific recalcitrant pollutants to remove them by precipitation or transformation to other products .They can also change the characteristics of a given effluent to render it more amenable to treatment or aid in converting effluent material to value added products.

Fig.4. Eisenia fetida

Hydraulic Loading Rate: It is expressed as the ratio of flow, in cubic feet per second, divided the surface area of a wet basin or vault in square feet. The commonly accepted formula for calculating particle capture is the Hydraulic Loading Rate (HLR). Hydraulic loading rates or wastewater infiltration define the rate wastewater enters the soil. Correlating design hydraulic loading only to soil texture overlooks several factors such as structure, clay mineralogy, bulk density, effluent quality, soil aeration, and methods of effluent application, which all can greatly affect the hydraulic characteristics of the soils. The hydraulic loading rate is a critical on-site sewage system design parameter, and must integrate system hydraulic and treatment performance as well as service life expectancy to address public health and water quality concerns. Hydraulic loading rates are typically based on soil texture and a crude measure of hydraulic capacity by percolation rate (NSFC, 1996). The percolation test has met with varying success and has been supplemented with soil morphologic descriptions as the basis for establishing loading rates in some states. The volume and amount of wastewater that a given vermifiltration (VF) system (measured in area and depth of the soil medium in the vermifilter bed in which the earthworms live) can reasonably treat in a given time is the hydraulic loading rate of the vermifilter (VF) system. It critically depends upon the number of live adult earthworms functioning per unit area in the vermifilter bed. The size and health of the worms is also critical for determining the HLR. High hydraulic loading rate leads to reduced hydraulic retention time (HRT) in soil and could reduce the treatment efficiency. Hydraulic loading rates will vary from soil to soil. The infiltration rates depend upon the soil characteristics defining pore sizes and pore size distribution, soil morphological characteristics, including texture, structure, bulk density, and clay mineralogy.

IV. EXPERIMENTAL RESULT

Preliminary test result:

Table 4. Textile waste water preliminary test result

Tests Conducted	Results
pH	7.5
BOD	300 mg/l
Colour	Dark blue (absorbance value = 2.5)
TDS	1567 mg/l
TSS	2 mg/l
Alkalinity	620 mg/l
Chloride	320 mg/l
Hardness	160 mg/l

Treated water characteristics of Non vermifilter:

Table 5. Treated water characteristics of non vermifilter

Parameter	Influent concentration	Hydraulic loading rate ($l/m^2/day$)	Effluent concentratio n	% Removal
BOD (mg/l)	300	40	260	13.3
		55	280	6.6
TDS (mg/l)	1567	40	1166	25.6
		55	1300	17
TSS (mg/l)	2	40	0	100
		55	0	100
Alkalinity (mg/l)	620	40	560	9.7
		55	600	3.3
Chloride (mg/l)	320	40	259	19.1
		55	289	9.7
pH	7.5	40	7.3	2.7
		55	7.4	1.3
Color (mg/l)	100	40	75.8	24.2
		55	94.4	5.6

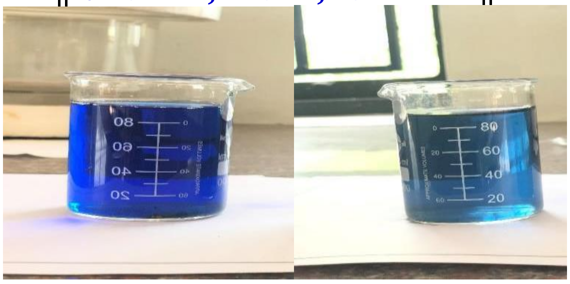

Fig.5. Synthetic dye water before and after non vermifiltration

Treated water characteristics of vermifilter:

Table 6. Treated water characteristics of vermifilter

Parameter	Influent concentration	Hydraulic loading rate (l/m2/day)	Effluent concentration	% Removal
BOD (mg/l)	300	40	180	40
		55	240	20
TDS (mg/l)	1567	40	776.7	50.4
		55	800	48.9
TSS (mg/l)	2	40	0	100
		55	0	100
Alkalinity (mg/l)	620	40	480	22.5
		55	580	6.5
Chloride (mg/l)	320	40	70	78.1
		55	129	59.7
pH	7.5	40	7.2	4
		55	7.3	2.7
Colour (mg/l)	100	40	33.8	66.2
		55	70	30

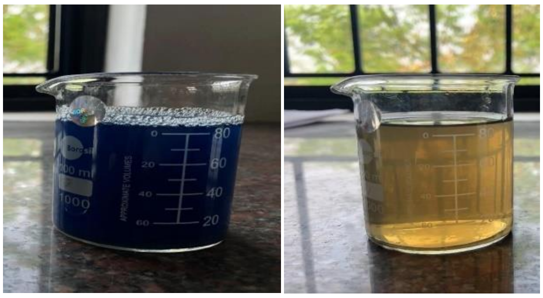

Fig.6. Synthetic dye water before and after vermifiltration

V. CONCLUSIONS

As a part of our project, detailed literature review was conducted on the topic “Textile waste water treatment using vermifilter and non vermifilter”. As a preliminary step a dye water sample containing Ramafix Dye was collected from Sri superior textile industry, Tirpur and its chemical characteristics are analyzed. Then the Vermifilter and non-vermifilter apparatus was made with glass material. The materials like aggregates, sand, garden soil are collected and placed in layers in the apparatus. Using the standard dye water composition given from the industry synthetic water sample is prepared and it is poured to the non-vermifilter apparatus from top.

The treated water after one day was collected from the bottom and its characteristics were analyzed. The treated filtered dye water corresponding to hydraulic loading rates of 40 l/m^2/day and 55 l/m^2/day was collected and its characteristics were found. For the vermifiltration process the apparatus consisting with earthworm is set up and the synthetic dye water is poured and The treated filtered dye water corresponding to hydraulic loading rates of 40 l/m^2/day and 55 l/m^2/day was collected and its characteristics were found as same as non-vermifilter and the results are compared and studied.

Vermifiltration of waste water using waste eater earthworm is a newly conceived technology. From the data obtained it was found that vermifilter is efficient for the removal of BOD, color, TDS, reducing pH, chloride content and alkalinity etc. of textile waste water. About 40% of BOD was removed by vermifilter whereas these values are 13% and 6%respectively for non vermifilter. The TDS content and pH of waste water decreased accordingly. The TDS content was reduced by 50% and pH and value by 7.2 in vermifilter and 25%and 7.4 in non vermifilter respectively. The chloride content is reduced by 78% in vermifilter and 19% in non vermifilter. These characteristics also have a negative correlation with hydraulic loading rate.

The earthworm production growth breed and survive in the moist environment is very well was observed during process of experiment. The advantages of this plant are simple and easy operation, low operating cost and maintenance cost, low energy input, no sludge formation i.e, treated water is nutrient rich and natural way of fertigation for better agricultural production and cost saving fertilizers. This process is aerobic and hygienic hence no odor. Results of vermifilter technology are most cost effective, odor free for treatment with efficiency, economy and potential decentralization.

Comparitive study: BOD is an important indicator of organic load of waste water. The BOD load in effluents from both vermifilter and non vermifilter was significantly lower than initial level but vermi-biofiltration should more removal efficiency than non-vermifilter unit. Results show that the earthworms can remove BOD loads by over 40%. BOD removal in non-vermifilter unit (where only the soil, sand and microbial system works) is just around13%. It also indicates that the organic content in textile waste water has the expected degradation. In case of a normal bio-filter the solids. Which were removed accumulates overtime as sludge and chokes the system which then ceases to work properly. However in vermifilter bed these bio-solids were constantly ingested by earthworm and expelled as vermicomposting. This explains why there is no chocking and interrupted functioning of the vermifilter bed. It was found that the total alkalinity of textile waste water sample decreased by 9.7% in non vermifilter and 22.5% in vermifilter.

Total dissolved solids (TDS) showed drastic reduction during vermifiltration as well as are non vermifiltration process. The total reduction in TDS content about 50.4% in vermifiltration unit and that was significantly higher than total removal in non-vermifilter unit i.e., 25.6%. Results that clearly suggested the capability of earthworm to remove solid fraction of waste water during vermi-biofiltration processes. The difference in removal of TDS content between both could be due to difference in biological components and working capabilities of both units. Total suspended solids is completely removed in both vermifilter and non vemifilter, it is due to the adsorption process of soil.

There was a significant negative correlation between color removal and hydraulic loads in both filters. However the color is significantly reduced in vermifilter i.e, about 66%, while in non vermifilter the color removal is only 24%. Results indicated that the pH value of raw waste water is almost neutralized by the earthworms in the vermifilter unit. An average pH of 7.2 was obtained in vermifilter unit while the average value of treated water from non vermifilter was 7.4. The chloride content is also reduced by 78% in vermifilter while in non vermifilter it is only 19%. These characteristics also have a negative correlation with hydraulic loading rate.

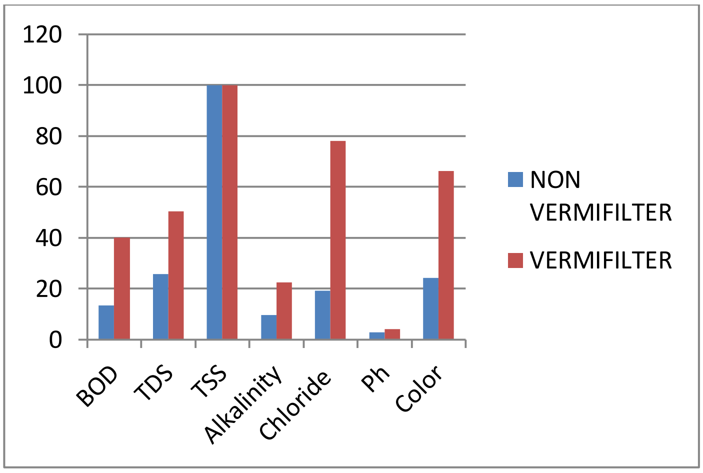

Fig.7. Graph showing comparison of filters at hydraulic loading rate of 40 $l/m^2/day$

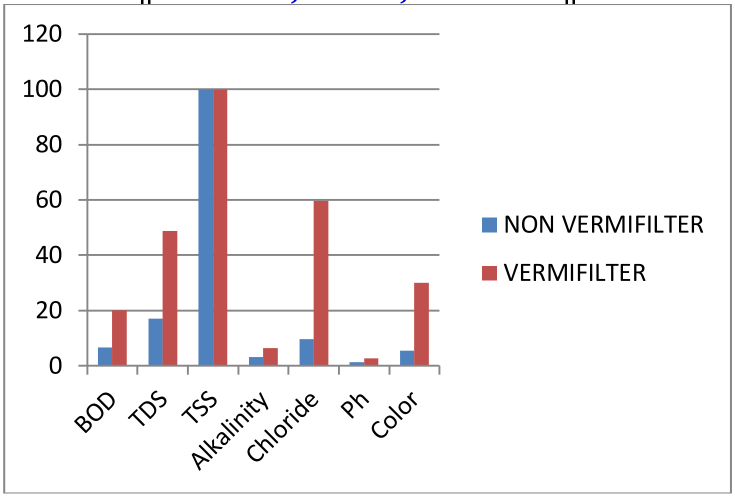

Fig.8. Graph showing comparison of filters at hydraulic loading rate of 55 l/m^2/day

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