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AN EMERGING TECHNOLOGY OF LOW COST, DECENTRALIZED WASTEWATER TREATMENT: VERMIFILTER INTEGRATED WITH HYDROPONICS

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Abstract : Wastewater is water which has been adversely affected in physical, chemical and biological characteristics. The wastewater generation and its treatment has become a consequential health issue in the developing countries due to the inadequate treatment facilities. The most important source of contamination of water resources is discharge of untreated wastewater in surface and sub-surface water courses.

Vermifiltration is more dependable than various other wastewater treatment technologies as they need more area, high maintenance cost, high energy consumption. Stagnant wastewater consist organic matter such as polysaccharides, methanol could be degraded by the bacteria, fungus and algae. Some of them, such as acetone and methanol, could cause acute toxicity when existed in wastewater at high concentration. It also causes different waterborne diseases like diarrhea, cholera and some other. The treatment systems that require comparatively low costs, energy and maintenance are better for treatment of rural domestic wastewater. There is no sludge formation in this process which requires more expenditure on landfill disposal. This is an odour free process and resulting vermifiltered water is clean enough to be reused in parks, gardens and for farm irrigation. Earthworms decomposes different biodegradable material from wastewater aerobically and convert it into humus which can use as a fertilizer.

Index Terms - bio-filter, Eisenia fetida, sewage wastewater treatment, vermifiltration, earthworms, enzymes, microfiltration, greywater, decentralization of wastewater, hydroponics, organic matter removal, emerging technology.

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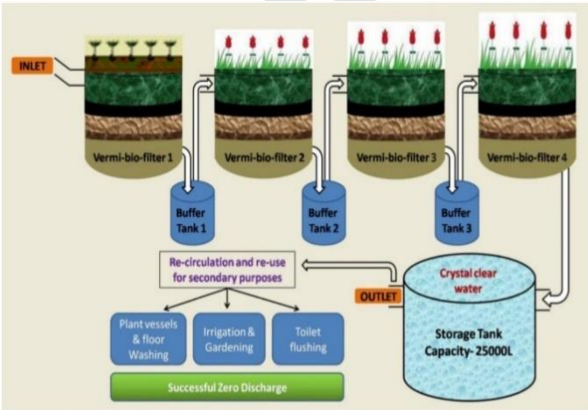
I. INTRODUCTION

In the recent past, developing countries like India have changed their approach towards the treatment of liquid effluents. The research has been intensively directed towards simpler, energy saving, environmentally bio-safe and cost-effective technological solutions. In addition, the environmental regulations by Pollution Control Boards have undergone vast changes. (Kumar et al. 2008). Today, most of the wastewater treatment plants have started looking for biotechnological alternatives in their systems. Apart from the benefits of improved capacity, efficiency and lowered operative costs, microorganisms, enzymes and earthworms also keep the treatment process as natural as possible. (Ghatnekar et al. 2010). There has been considerable achievement on drinking water supply, but the problems of excreta and wastewater disposal have received less attention. The world met the MDG for drinking water by the end of 2011 (WHO, 2012) but the target for the sanitation has not been achieved. Greywater, a major component of the domestic wastewater, is usually generated from dishes, showers, sinks, and laundry. (Amare Tinush Adugna et al. 2016). Vermifiltration technique is a new approach towards wastewater treatment to save cost, energy and eliminate chemical usage. Unlike conventional water treatment amenity, vermifilter uses no chemicals, the system is all natural. We have tried to develop a sustainable and environmentally friendly technology for the treatment of college canteen wastewater at low cost. (Nandini Misal and Mr. Nitish A. Mohite et al. 2017). Earthworms are long, narrow, cylindrical, bilaterally symmetrical, segmented animals without bones. Earthworms' body works as a 'biofilter' and they have been found to remove the 5 days' BOD (BOD5) by over 90%, COD by 80–90%, total dissolved solids (TDS) by 90–92%, and the total suspended solids (TSS) by 90–95% from wastewater by the general mechanism of 'ingestion' and biodegradation of organic wastes, heavy metals, and solids from wastewater and also by their 'absorption' through body walls. (Rajiv K. Sinha, Gokul Bharambe, Uday Chaudhari et al. 2008). When technique integrated with vermifilter sludge produced on surface was reduced by 40%. He also discovered and studied almost 44 species of earthworms. Out of 44, only 13 are suitable when integrated with constructed wetland technique. (Nathasith Chiarawatchai et al. 2010) 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 vermiculture soil and to study the effect of variation in terms of removal of BOD as well as COD by differing the organic loading. (Jothilakshmi, Sivaranjani, Subasri, Thilagavathy and Vishali et al. 2018). So, vermifiltration is more economic process for sewage treatment.



Layout of vermifiltration

II. MOTIVATION AND RELEVANCE

Now a days many developing countries cannot afford the wastewater treatment processes as they are costly, need more land area and in addition use of chemicals for the treatment. Mostly in rural areas they need options which are low cost, space saving and eco-friendly. During wastewater treatment more quantity of sludge is developed. So, management of derived sludge is also big challenge. Generally different treatment plants dump such wastes in landfill sites which need more space. Due to chemical processes, we cannot use such sludge as fertilizer. Also, during secondary treatment, for aeration purpose more amount of energy is consumed by different devices.

Earthworms decomposes different biodegradable material from soil aerobically and convert it into humus which can use as a fertilizer. Earthworm casting is chemically neutral and odour less. So, if we use vermiculture as a biofilter, expenses over different processes can be minimized. We can cultivate different crops above such beds so they can readily get nutrients from castings.

While issues of water supply in the city remains a topic of debate, a recent report by the Centre for Science and Environment (CSE) has revealed that the city is faced with the problem of excessive water supply and collection of large number of sewage generated.

The report states that around 931.2 MLD (million litres per day) sewage water is generated in the city, which is 23% more the quantity estimated by the Pune Municipal Corporation (PMC). Based on the estimates of the water supplied, it is revealed that 64% of sewage water remains untreated. The report also states that 25% of the population is not covered by the sewerage network.

III. LITERATURE REVIEW

- **Ghatnekar S. D. (2010)** performs analysis to treat liquid effluents produced by Gujrat based juice making industry into bio clean and bio safe water. Treated water can use to clean floors as well as for any secondary purpose except drinking.

Capacity of treatment plant is to treat 12000 litres of effluent every day. That use trickling filters with vermi-biofilter. They found bed efficiency of 6-8 months. Total recurring cost for everyday work is found to be Rs. 50-60 whereas conventional treatment costs approx. Rs.5000-6000. After comparison between two, it is found that capital cost is 6-7 times less than conventional one.

- **Patel Jatin B. (2018)** studied vermiculture and he found that 100% capture of organic materials and there is high value of end product called as vermicompost. He explained that process is eco-friendly and odour free. He concluded that it is good alternative treatment for decentralised onsite treatment during his studies.
- **Amare Tinush Adugna (2016)** explained effectiveness of vermifiltration in sub-Saharan urban poor regions. To resolve problems onsite, he is thinking for decentralised process of treatment which is economically, socially and environmentally accepted. Main aim of his project is to check filtration ability of earthworms in hot climatic area. Most of the time there is clogging problem in pipelines during sludge disposal. That problem is also resolved in this vermifiltration application. He also used different filter media like sand or saw dust along with vermifilter and checked it's suitability. He found hydraulic loading rate should be in between 64 $Lm^{-2}d^{-1}$ to 191 $Lm^{-2}d^{-1}$. Overall, thesis demonstrate that, vermifiltration is alternate option to treat wastewater in hot climatic condition as well. the technologies have problems like clogging, odour and fouling, requiring frequent maintenance and regular cleaning, less or unstable removal efficiencies, demanding large area, expensive to implement and others.
- **Nandini Misal and Mr. Nitish A. Mohite (2017)** concluded overall results of community wastewater treatment project by using vermifiltration. They constructed vermifilter technology to treat wastewater coming from college canteen. They had constructed filter bed with layers of Gravels, aggregates sand, sand boulders, cow dung, clay and layer of earthworm named as *Eisenia fetida*. It has been observed that earthworms remove near about 90% $BOD_{5,}$ COD by 85-90%, TDS by 95% and TSS by 95-98%. They also checked oil and grease removal ability and it is found about 99%by vermifilter.
- **Rajiv K. Sinha, Gokul Bharambe, Uday Chaudhari (2008)** studied vermifilter kit and formation of bed produced by Griffith University, Brisbane. Along with, they explained some factors which can affect vermifiltration and earthworms during processes. In this paper they also explain some earthworm characteristics. Hydraulic retention time is about 1-2 hr so that worms can ingest organic matter from wastewater completely. Vermifiltration is effectively used for removal of EDCs (Endocrine Disruptive Chemicals). Reverse osmosis is one of the methods for purification of EDCs which is cost prohibitive at present and rural areas cannot afford it.
- **Nathasith Chiarawatchai (2010)** studied combine effect of two methods as vermifiltration and constructed wetland technique. He concluded that, earthworms are useful to resolve clogging problem which occur in wetland method. Also, it improves treatment performance. He used raw domestic water from Germany and swine water from Thailand for study purpose. He found that removal capacity in wetland technique is about 90% in wetland. When technique integrated with vermifilter sludge produced on surface was reduced by 40%. He also discovered and studied almost 44 species of earthworms. Out of 44, only 13 are suitable when integrated with constructed wetland technique.
- **Jothilakshmi, Sivaranjani, Subasri, Thilagavathy and Vishali (2018)** performed vermifiltration on domestic wastewater along with different hydroponics like canna and ginger plant to get better results. They also performed experiments on different loading rates to find out efficiency of vermifilter. After studies they found out that canna plant i.e. hydroponics are more efficient in filtration along with vermifilter bed. They made this analysis on the basis of sample testing before and after filtration. They checked different parameters as BOD, COD, suspended solids, temperature, etc.

IV. MATERIALS AND METHODOLOGY USED

- Sampling and data collection

The main concept of this project is to recycle the water from the domestic need and hence the type of wastewater that has been selected is the wastewater 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. In a dairy plant, wastewaters essentially originate from processing, cleaning and sanitary operations such as cleaning-in-place (CIP), cleaning of process equipment, floors, rooms and also trucks. Thus, this term refers to all outgoing waters of the plant, except rainwater (also routinely referred to as storm water). Wastewaters from dairy industries contain both organic and inorganic compounds: milk and by-products residues in the case of the former, while the latter is influenced by the use of sanitizers, alkaline and acidic products. Chemical Oxygen Demand (COD) concentrations are determined by the presence of milk, sugars (e.g. lactose) and added sugars, cream or whey in the wastewater.

- Slow Sand Filter

Slow sand filtration is a low-cost and simple-to-operate technique for removal of chemical contaminants and pathogens. Essentially an SSF is composed of following vertically arranged layers of components. Topmost layer is the supernatant water which is subjected for filtration. Water column provides enough hydrostatic pressure for its percolation through filtration system. Second is a thick layer of actual filtration medium that is of fine sand (effective size 0.15–0.3 mm). It is a low-cost durable medium for filtration. Because of its smaller particle size (0.15–0.3 mm) fine sand provides large surface area for filtration as well as for the formation of biofilm, however its small voids size decreases flow rate (0.1–0.3 m/h) through SSF. Topmost portion of sand is enriched with microbial growth because of better availability of oxygen as compared to lower portion. Most of the decontamination occurs in this active biological layer, also called as schmutzdecke. Microbes form of biofilm on inert sand particles and aid the biofiltration process. Bottom to sand is a layer of gravel which provides free passage to treated water to exit the bed. Gravel supports sand bed and prevents exit hose pipe from clogging. Usually the four layers make up 1 m thick column of the biofilter.

- Biolayer:

Biofiltration has been proved an essential constituent of treatment process for air, wastewater, and raw water. Major sources of potable water in megacities are treated surface water. Raw water is not suitable for human consumption because of unwanted micropollutants, pathogenic microorganisms, organic matter, and other growth-supporting nutrients present in it. Storage raw water may lead to biofouling, adverse taste and odour development, and pathogen growth. In multistep treatment process of centralized wastewater treatment plant, biofiltration constitutes one of the steps primarily for removal pollutant and in part for removal of pathogen. Biofilter is applied as sole process to make raw water potable in remote areas. Trickling filter or granular activated carbon (GAC) or sand filter is a common form of biofilter in wastewater treatment plant; GAC and sand filter are applied for treatment of raw water; rain garden and soil filter are examples of low-impact development filters for management of stormwater; horizontal rock filters are applied to mitigate polluted stream. A biofilter can be defined as any type of filter media with attached microbial community on surface in the form of biofilm performing at least one essential functions of treatment process.

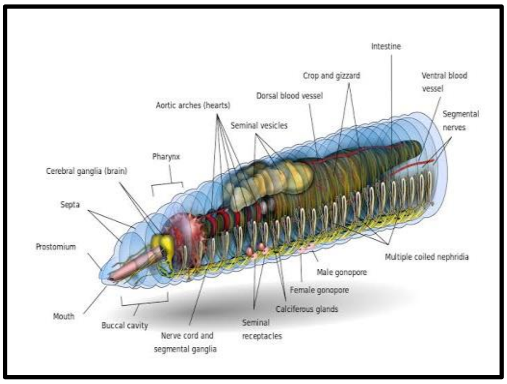
Structural characteristics of Earthworm

Kingdom: - Animalia

Phylum: - Annelida

Class: - Clitellata

Scientific Name: - Eisenia Fetida



Earthworm Species: - Eisenia Fetida

Internal Structure of Earthworm

- Hydroponics

Hydroponics is basically science of gardening in which plants are cultivated in nutrient rich media with or without mechanical support as soil, sand or gravel, etc. Hydroponic plants can easily be cultivated over biolayer of earthworm. Today, hydroponics is becoming a more popular alternative to conventional agriculture in locations with low or inaccessible sources of water or where land available for farming is scarce. For example, islands and desert areas like the American Southwest and the Middle East are prime regions for hydroponics. They used to degrade different organic matter present in sewage. Plants absorb such particles and helps in purification of water. Integration of hydroponics with vermifilter will give better result than only vermifilter. Earthworm digest organic matter present in wastewater and convert it into castings. These castings are nutrient rich with N, P, K content. Hydroponic plants can easily be cultivated over biolayer of earthworm. Plants are typically grown in greenhouses to prevent water loss. Even in temperate areas where fresh water is readily available, hydroponics can be used to grow crops in greenhouses during the winter months.

- Structural characteristics of Ginger:-

Kingdom:- Plantae

Phylum:- Magnoliophyta

Class:- Liliopsida

Family :-Zingiberaceae

Zingiber officinale

Curcuma longa

V. DECENTRALIZATION FOR WASTEWATER TREATMENT

Decentralized treatment is the practice of placing water or wastewater treatment at the site of supply, demand, or ideally both. It's a flexible, sustainable alternative to large treatment plants that require miles of costly supply and delivery infrastructure.

Often, the hardest-hit areas are smaller, isolated, or poor, making them difficult to serve with modern infrastructure. So, while there is an explosion of need for sustainable water and wastewater treatment facilities, the design, financing, permitting, building, and commissioning of new conventional plants and piping may take years. The combination of new, cost-effective technology with containerized packaging is making decentralization more viable than ever. Fluence Smart Packaged plants are available for water and wastewater treatment, including desalination of surface water or groundwater. Instead, decentralized wastewater management approach can be considered as a sustainable and cost-effective alternative as it treats, discharges or reuses the effluent in the relative vicinity of its source of generation. Like other systems, decentralized systems must be properly designed, maintained, and operated to provide optimum benefits. Decentralized wastewater treatment systems could be a feasible alternative for areas which are not connected to sewer networks as well as ones which are newly developed, so that the construction of their infrastructure is inadequate, not ready or would be executed in the future.

VI. DESIGN AND ESTIMATION OF VERMIFILTER

Average height of profile = 1.50m

Water head = 1.50m

Excess height = 1m

Total depth = 4 m

L = 36 m

B= 18 m

Dimension of 1 tank = 36 x 18 x 4 m

Layer	Depth	Size in mm
Biolayer loamy sand	1.05m	0.2-0.35
Coarse Sand	15cm	3-6
Round Pebbles	15cm	6-20
boulders	15cm	40-75

For biolayer

Hydraulic loading rate = Q /A

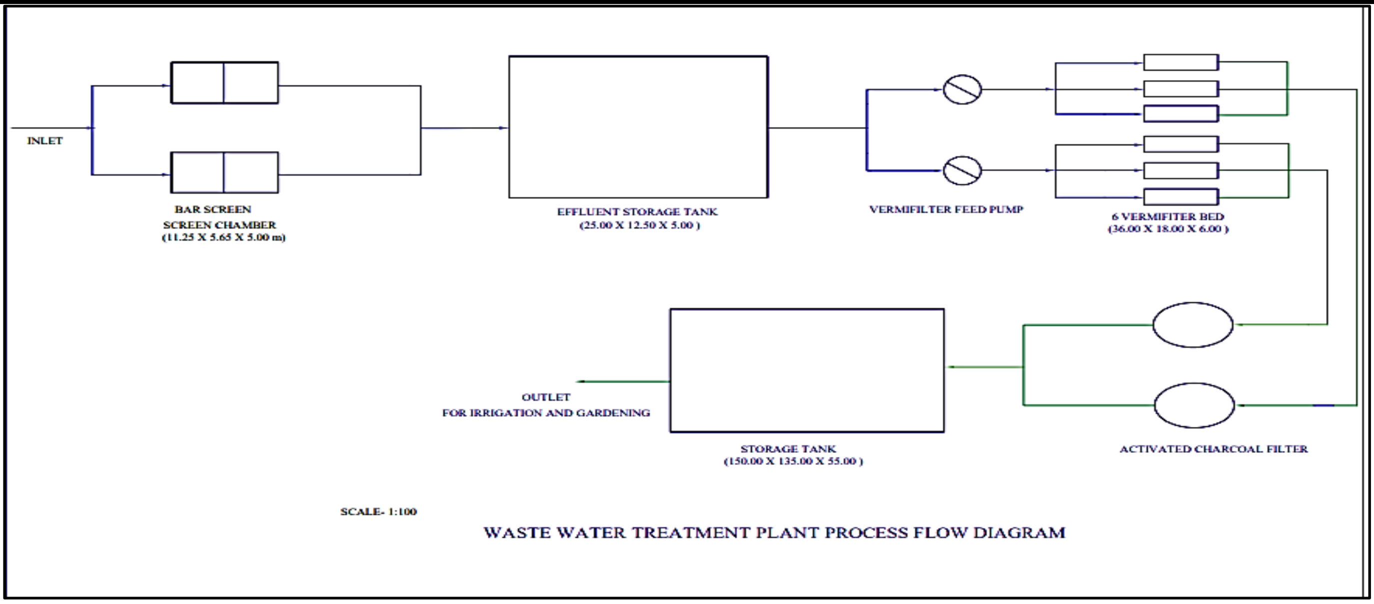
$= 13.5 \text{ x}10^6 / 3.125 \ \ 10^3$

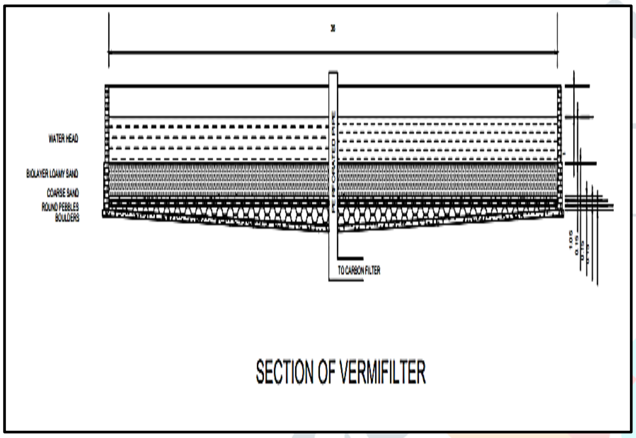
$= 4320 \ l / m^2 / \text{day}$

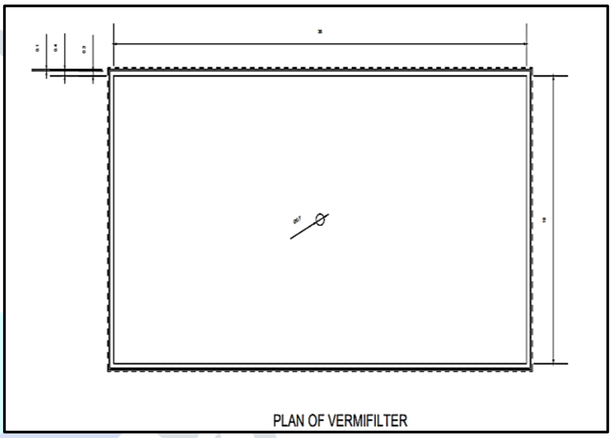
Hydraulic retention time = (porosity x volume of filter bed) / flow rate

$=(0.4 \text{ x } 18 \text{ x } 36 \text{ x } 1 \text{ x } 24) / (13.5 \text{ x } 10^6)$

= 0.4608 hr







ITEM NO.	ITEM	QUANTITY	RATE (Rs.)	TOTAL COST (Rs.)
1.	Excavation	3079.14 m^3 (Min. 4 days work by JCB)	30000 /day	120000
2.	Material			
I)	Cement	1796 bags	400 /bag	718400
II)	Sand	97.84 m^3	1100 /m^3	107624
III)	Brick	73605 No.s	10 /unit	736050
IV)	Aggregate	123.46 m^3	1200 /m^3	148152
V)	Filter Media (Boulders, Round Pebbles, Coarse Sand	291.6 m^3	750 /m^3	218700
VI)	Loamy Soil	680.4 m^3	20 /m^3	13608
VII)	Earthworm	680.4 kg	500 /kg	340200
VIII)	Miscellaneous (Contractor, Water expenses)			221057
3.	Labour			
I)	Meson	130	550 /no.s	71500
II)	Mazdoor	234	400 /no.s	93600
III)	Bhisti	26	350 /no.s	9100
IV)	Mixing mortar	261.22 m^3	50 /m^3	13061

		Total Estimated Cost for 1 Tank	2691053
		Total Estimated Cost for 6 Tank	**16146318 /-**

VII. TESTING AND RESULTS

Laboratory tests carried out:-

- pH
- COD
- 5 DAYS BOD
- TSS
- Ammoniacal Nitrogen
- Phenolic Compounds

Sampling Location: - Outlet of vermifilter bed from which KITCHEN WASTEWATER of building, varun colony, warje. pune is passed (Domestic wastewater)

Date: - 01 / 07 / 2022

Time: - 9.30 am

Weather: - Sunny

PARAMETER	MPCB PARAMETER	ACTUAL	VF
ODOUR	ODOURLESS	UNPLEASENT ODOUR	ODOURLESS
TEMPERATURE	-	26^0C	25^0C
pH	5.5-8.5	8.22	7.20
COD	>250 mg / L	288 mg / L	243.55 mg / L
BOD_5	>30 mg / L	219.45 mg / L	27.05 mg / L
TSS	>100 mg / L	125 mg/ L	90.23 mg / L
NH_4	>50 mg / L	60 mg / L	28.03 mg / L
Phenolic compound	>5.0 mg / L	8.0 mg / L	2.0 mg / L

Sampling Location: - Primary treatment (Equalization tank), Katraj Dairy Industries, Katraj, Pune.

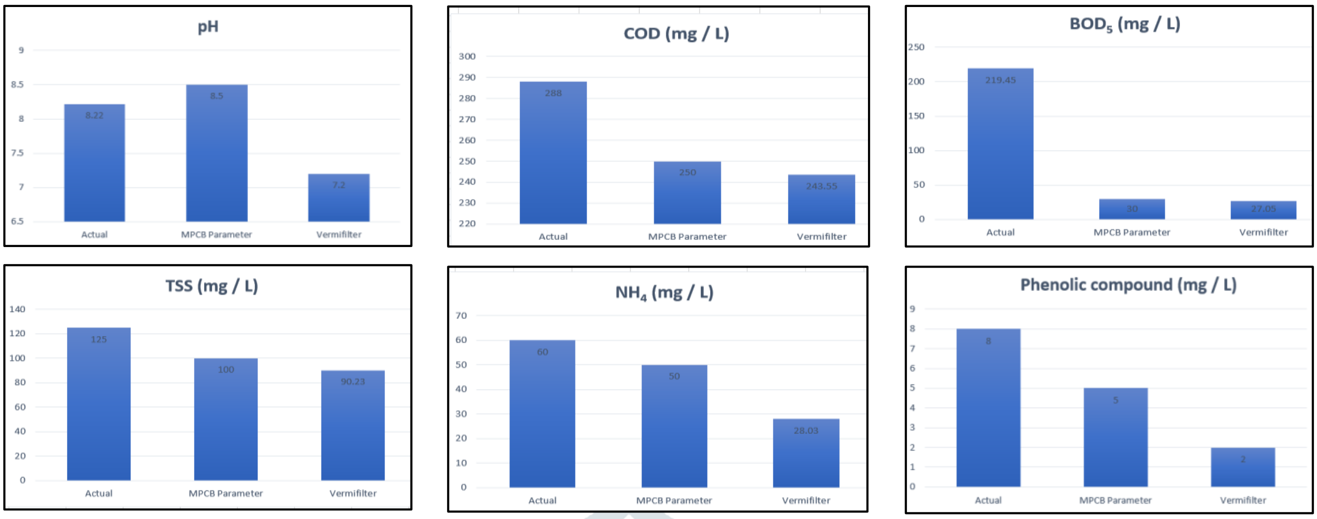
Date: - 01 / 07 / 2022

Time: - 10.30 am

Weather: - Sunny

PARAMETER	MPCB PARAMETER	ACTUAL	VF
ODOUR	ODOURLESS	STRONG ODOUR OF FATS	ODOURLESS
TEMPERATURE	-	28^0C	25^0C
pH	5.5-8.5	8.93	6.76
COD	>250 mg / L	1500 mg / L	230.94 mg / L
BOD_5	>30 mg / L	1000 mg / L	27.33 mg / L
TSS	>100 mg / L	500 mg/ L	50.22 mg / L
NH_4	>50 mg / L	70 mg / L	25.07 mg / L
Phenolic compound	>5.0 mg / L	10.2 mg / L	3.0 mg / L

VIII. INTERPRETATION OF SOME RESULTS BY GRAPHICAL METHOD AND ANALYSIS



Graphical analysis of kitchen wastewater testing results after treating with vermifilter

Analysis:-

As per above data and graphs we can made conclusion as follows:-

- Odour:-

  There is strong odour of different decayed matter which are present in kitchen waste. Decomposition of different organic wastes like, vegetable wastes, oils, fats, proteins, rotten eggs, over fermented material cause bad odour to such liquid. After passing through vermifilter bed bad unpleasant odour of water completely get romoved.

- pH-

  Different soaps which are used for washing activities will make water more alkaline. It can decrease fertility of soil by leaching action with different types of bases. Kitchen wastewater is generally within permissible range of guidelines published by MPCB. But still it can be fatal and shows adverse effects on soil. Different useful microorganism can died because of leaching action. pH of kitchen waste before treating with vermifilter is about 8.22 which is a basic nature. After treatment with vermifilter it decreased up to 7.20 which nearly neutral.

- COD:-

  Chemical oxygen demand is demand of different chemical to ger oxidised and convert into simpler forms. Permissible limit of COD in kitchen wastewater by MPCB parameters is less than 250 mg / L.. but kitchen wastewater contains more than limit as about 288 mg / L. So, amount of COD is more than parameters designed by MPCB. After treatment with vermifilter COD decreased up to 243.55 mg /L.

- BOD:-

  A 5 days BOD is demand of oxygen to different biological factors which are present in wastewater. It also used to express biological or micro organisms count which present in wastewater. More the BOD express more microbial content in Wastewater. Also, organic matter content increases which is present in wastewater. Permissible limit of BOD in kitchen wastewater by MPCB parameters is less than 30 mg / L but kitchen wastewater contains more than limit as about 219.45 mg / L. So, amount of BOD is much more than parameters designed by MPCB. After treatment with vermifilter BOD decreased up to 27.05 mg /L.

- TSS:-

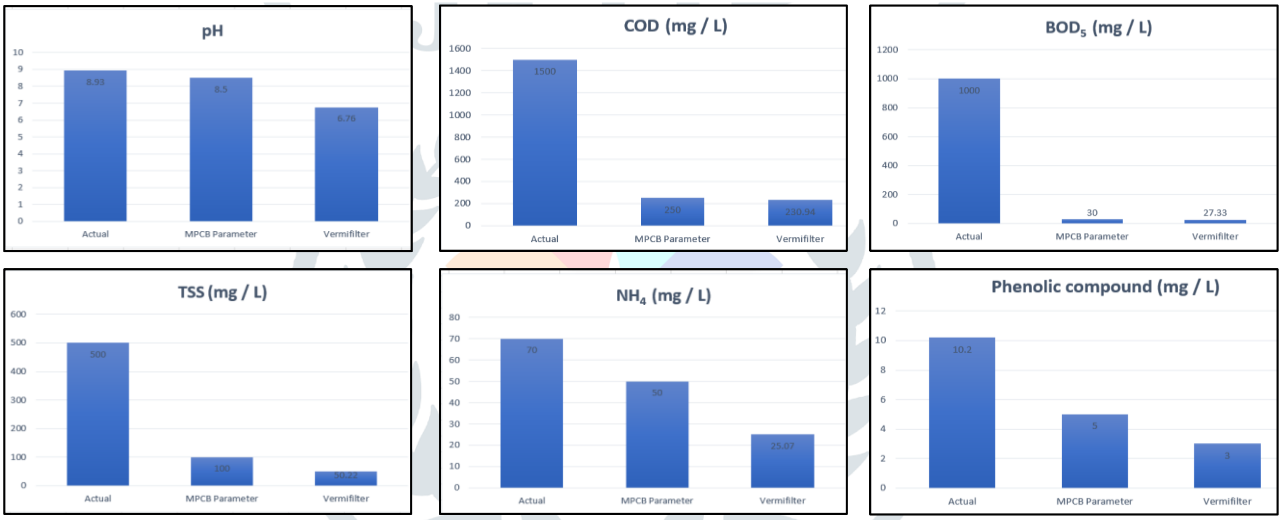
  Total suspended solids (TSS) are present in wastewater because of waste particles which are washed off from different plant parts, washing activities , etc. Oils and fats are also get accumulate over water surface which will use in different food stuffs. Permissible limit of TSS in kitchen wastewater by MPCB parameters is less than 100 mg / L but kitchen wastewater contains more than limit as about 125 mg / L. So, amount of BOD is more than parameters designed by MPCB. After treatment with vermifilter TSS decreased up to 90.23 mg /L.

- NH_4

  Ammoniacal nitrogen0 is present in kitchen wastewater because of decomposition or over fermentation of different substances. Comparatively with toilet and washrooms sewage, kitchen wastewater contain less amount of ammoniacal content in it. But still it exceeds permissible amount by governed rules. Permissible limit of NH_4 in kitchen wastewater by MPCB parameters is less than 50 mg / L but kitchen wastewater contains more than limit as about 60 mg / L. After treatment with vermifilter nitrogen compounds decreased up to 28.03 mg /L.

- Phenolic compounds: -

  Phenolic compound contains different type of aromatic and non-aromatic hydrocarbons such as phenol, ethanol, etc. these chemicals are present due fermentation action of different substances. When microbes consume different type of sugars, they convert it into different alcohol and CO_2. These ethanoic compounds react with some other compounds present in wastewater so as to form different derivatives of hydrocarbon. Permissible limit of phenols in kitchen wastewater by MPCB parameters is less than 5 mg / L but kitchen wastewater contains more than limit as about 8 mg / L. So, amount of phenolic content is slightly more than parameters designed by MPCB. After treatment with vermifilter phenolic compounds decreased up to 2.0mg /L.



Graphical analysis of dairy effluent testing results before treating with vermifilter

Analysis:-

As per above data and graphs we can made conclusion as follows:-

- Odour:-

  There is strong odour of different decayed matter which are present in dairy waste. Decomposition of different organic wastes like milk, fats, microbial content, whey proteins, leftover fermented material cause bad fatty odour to such liquid. After passing through vermifilter bed bad fatty rancid odour of water completely get romoved.

- pH-

  Caustic soda which is used for washing activities will make water more alkaline. It can decrease fertility of soil by leaching action with different types of bases. Dairy wastewater is not within permissible range of guidelines published by MPCB. It can be fatal and shows adverse effects on soil. Different useful microorganism can died because of leaching action. pH of dairy waste before treating with vermifilter is about 8.93 which is a basic nature. After treatment with vermifilter it decreased up to 6.76 which nearly neutral.

- COD:-

  Chemical oxygen demand is demand of different chemical to ger oxidised and convert into simpler forms. Permissible limit of COD in dairy wastewater by MPCB parameters is less than 250 mg / L.. but dairy wastewater contains more than limit as about 1500 mg / L. So, amount of COD is highly more than parameters designed by MPCB. After treatment with vermifilter COD decreased up to 230.94 mg /L.
- BOD:-

  A 5 days BOD is demand of oxygen to different biological factors which are present in wastewater. It also used to express biological or microorganisms count which present in wastewater. More the BOD expresses more microbial content in Wastewater. Also, organic matter content increases which is present in wastewater. Permissible limit of BOD in dairy wastewater by MPCB parameters is less than 30 mg / L but dairy wastewater contains more than limit as about 1000 mg / L. So, amount of BOD is highly more than parameters designed by MPCB. After treatment with vermifilter BOD decreased up to 27.33 mg /L.
- TSS:-

  Total suspended solids (TSS) are present in wastewater because of waste particles which are washed off from different containers. Oils and fats are also get accumulate over water surface. Permissible limit of TSS in dairy wastewater by MPCB parameters is less than 100 mg / L but dairy wastewater contains more than limit as about 500 mg / L. So, amount of BOD is more than parameters designed by MPCB. After treatment with vermifilter TSS decreased up to 50.22mg /L.
- NH_4

  Ammoniacal nitrogen is present in dairy wastewater because of decomposition or over fermentation of different substances. Comparatively with toilet and washrooms sewage, dairy wastewater contain very less amount of ammoniacal content in it. But still it exceeds permissible amount by governed rules. Permissible limit of NH_4 in dairy wastewater by MPCB parameters is less than 50 mg / L but dairy wastewater contains more than limit as about 70 mg / L. After treatment with vermifilter nitrogen compounds decreased up to 25.07 mg /L.
- Phenolic compounds: -

  Phenolic compound contains different type of aromatic and non-aromatic hydrocarbons such as phenol, ethanol, etc. These chemicals are present due fermentation action of different substances. When microbes consume different type of sugars, they convert it into different alcohol and CO_2. These ethanoic compounds react with some other compounds present in wastewater so as to form different derivatives of hydrocarbon. Permissible limit of phenols in dairy wastewater by MPCB parameters is less than 5 mg / L but dairy wastewater contains more than limit as about 10.2 mg / L. So, amount of phenolic content is more than parameters designed by MPCB. After treatment with vermifilter phenolic compounds decreased up 3.0 mg /L.

CONCLUSION

Vermifiltration of wastewater using earthworms is a newly conceived technology. It is effective process which help for proper and easy management of sewage. Due to use of vermifiltration technology excess expenditure required for sewer line construction and for purification of wastewater decreases effectively. As like decentralization of solid waste, liquid waste also decentralized with this technique. Even basic functional unit of this filter i.e. Earthworm is easily available, economic and can survive in huge climatic diversity if moisture is present. So, this is one of better emerging technology for rural and urban sanitation facility development. This report describes the basic mechanism of vermifilter and vermifilter was found to be suitable technique for highly efficient treatment technology for wastewater. This is also a good alternative treatment for decentralized onsite treatment. Earthworms are protective and productive organisms and they play a significant role in breaking pollutants and aerating filter bed. Vermifiltration process driven by the earthworms likely to become more vigorous and efficient with time as the army of worms grows. It further keeps the system thoroughly aerated with plenty of oxygen available for aerobic decomposer microbes. The treated effluent had higher value of nitrate and phosphate concentration which is best suited for sewage farming or horticulture. No sludge was produced and the organic matter and solids present in the wastewater were consumed by earthworms transforming these into valuable vermicompost. This vermicompost can be used as manure as it is having good content of nitrogen and phosphate. Still there are some limitation of vermifilter like vermifilter cleaning process, heavy metals removal, wastewater feeding mode, and saline water treatment. Hence in order to make vermifilter efficient and sustainable more research related to optimum wastewater feeding mode, cleaning mechanism, integration with other technologies and other more efficient earthworm species is required.

The filter medium layer composition had little effect on the vermifilters performance. However, the vermifilters performed better and their life span was longer than the control unit. Therefore, the sawdust can substitute sand as a filter medium, but adding a little layer of sand to the bottom is helpful. However, the vermifilters did no longer support the earthworms' growth after several months of operation due to high moisture content caused by the accumulation of inorganic and slowly degrading organic solids that reduced the porosity. The vermifilters had odour free potential organic matter and earthworms that could be harvested every 6-8 months.

FUTURE SCOPE

- The sawdust vermifilter was performing better than cow dung vermifilter. However, if there are no sawdust and cow dung in the area, different filter bed materials need to be examined individually or in mixture at different composition.
- The identification of individual microbial communities working with earthworms should be studied further detail.
- Additional characteristics of the concentrated greywater should be studied, for instance, heavy metals, salt, surfactants, oil, fat and grease which may have impact on the vermifiltration process.
- The experiments of this study were conducted with three and four times supply during the day time. Effect of different resting periods with different HLR should be studied further.
- The potential of the degraded bedding material for agricultural purpose should be experimentally examined.

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