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Study of Operation and Performance Evaluation of Fixed and Suspended Anaerobic Filter Media of Compacted Sewage Treatment Process

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Abstract

Described in this study are experiments conducted to evaluate performance of fixed and suspended filter media in anaerobic reactor of compacted sewage treatment for domestic wastewater. Basically now a day's compacted sewage treatment process is most preferred because of its advantages over septic tank for treating domestic wastewater. The media which used as fixed is graded stone media and for suspended media bioballs are used in two different reactors. The work involved laboratory scale batch reactor which is prime important stage of compacted sewage treatment. Two reactors are simultaneously observed over period of 180 days after development of biofilm over both filter media. The results are observed on the experimental basis with different condition. Suspended Filter media i.e. Bioballs gives 80% reduction efficiency in BOD whereas Fixed filter media gives approx. 70% reduction efficiency in BOD

***Keywords:** Bioballs, Biofilm, Anaerobic Filter Media*

INTRODUCTION

With rapid expansion of cities and domestic water supply, quantity of gray/wastewater is increasing in the same proportion. As per CPHEEO estimates about 70-80% of total water supplied for domestic use gets generated as wastewater. 60% of industrial waste water, mostly large scale industries, is treated. Performance of state owned sewage

treatment plants, for treating municipal waste water, and common effluent treatment plants, for treating effluent from small scale industries, is also not complying with prescribed standards. Thus, effluent from the treatment plants, often, not suitable for household purpose and reuse of the waste water is mostly restricted to agricultural and industrial purposes. There are higher risk associated to human health and the environment on use of wastewater especially in developing countries, where rarely the wastewater is treated and large volumes of untreated wastewater are being used in agriculture. In class-I cities, oxidation pond or Up-flow Anaerobic Sludge Blanket technology is the most commonly employed. The conventional wastewater treatment processes are expensive and require complex operations and maintenance.

The anaerobic treatment technology has rapidly developed in recent decades. Compact Sewage Treatment Process (CSTP) is essentially adopted for the collection, treatment and disposal or reuse of treated wastewater from individual household, isolated communities, Industries and other parts of communities. Centralized wastewater treatment system involves large quantities of wastewater. However, centralized collection and treatment of wastewater requires pumps, piping materials and energy, ultimately increasing the cost of the treatment system. Hence, constructing a centralized treatment system for small communities or urban areas will result in burden for low income countries.

To overcome this problems or lacunae, the Decentralized Wastewater Treatment Systems (DEWATS) are the good alternatives which are more cost effective and efficient way of wastewater treatment to improve environmental health conditions as well as providing opportunities for reuse and resource recovery. The anaerobic treatment process has also recognized as one of the most effective methods for treating organic waste stream, including industrial and domestic wastewater. There are various factors affecting design and performance of anaerobic filters. In general these factors can be divided into three categories; physical factors, performance factors and hydraulic factors.

MATERIAL AND METHODS

A. Fixed Filter Media

For fixed filter media, three layers of graded stones are provided in anaerobic reactor. Lower layer is gravel of 20 mm average size, middle layer is gravel of 5

mm average size and top layer is sand of size 0.5 - 1.0 mm.

Table I Properties of Graded Stone

Sr. No.	Material	Size	Specific Gravity	Bulk Density
1	Sand	0.5 - 1.0 mm	2.65	1560
2	Gravel	3.0 - 8.0 mm	2.65	1600
3	Gravel	15.0 - 30.0 mm	2.65	1600

"Fig.1 Graded Stone Provide In Three Layers"

B. Suspended Filter Media

The filter media designed to provide a greater surface area and which are impossible to clog. These are commonly used in aquarium filtration. The properties of bio ball are listed below in Table2.

Table II Properties of Bio Ball

Sr. No.	Properties	Value
1	Capacity	1.5 cm
2	Diameter	2.5 cm
3	Material	HDPE
4	Density	0.96 gm/cm^3

"Fig.2 BioBall"

C. Reactor set up

The laboratory scale Anaerobic Reactor was fabricated with dimensions arrived based on the literature and standards. Reactor 1 is containing fixed media having volume 10 liters and reactor 2 containing suspended media having volume 20 liters. Both reactors are circular container with tap at bottom for collection of sample effluent.

Table III The Dimensions Of The Reactor 1

Sr. No.	Reactor Dimensions	Value
1	Diameter	22 cm
2	Height	25 cm
3	Thickness	5 mm
4	Working volume	10 litre

Table IV The Dimensions Of The Reactor 2

Sr. No.	Reactor Dimensions	Value
1	Diameter	35 cm
2	Height	40 cm
3	Thickness	5 mm
4	Working volume	20 litre

D. Research Methodology

Research involves study of existing standard sewage treatment processes and their efficiency and to set parameters for further study. To find availability of various suspended and fixed filter media in market. Once filter media is finalized then design and fabrication of model and stabilization of reactor or experimental set up. Analyzing characteristics of effluent collected from each reactor. Collecting results and comparing with standard processes finding out best possible combination of filter media and overall efficiency.

E. Acclimatization process

Before start up, acclimatization was done by feeding both reactor with 5L of fresh wastewater collected from inlet of soak pit and calculated amount of cow dung, urea and DAP. The both reactor was filled with media and the contents were allowed to stabilize at the required temperature. The cow dung, urea & DAP as a nutrients were added in calculated amounts regularly. The sludge was replaced by raw domestic wastewater in calculated quantity to bring in the required MLSS concentration to start the treatment process. MLSS was regularly tested at an interval of week. The concentration of active biomass in the graded stone reactor reaches 3200 mg/L and bioball reactor it is 4250 mg/L for domestic wastewater.

F. Sampling

A monitoring was done for about 180 days to identify feasibility of the reactor with two media installed separately. Wastewater samples were collected before discharging to reactor and from the outlet of respective reactor of the packaged system, which were analyzed for various physio-chemical parameters. Namely pH, chemical oxygen demand (COD), biochemical oxygen demand (BOD), total suspended solid (TSS), volatile suspended solids (VSS). All the analyses were performed according to the Standard Methods.

RESULT & ANALYSIS

A. Performance of Graded Stone Reactor

The rector was started up in Dec., 2017 and operated for a period of 180 days. For the first 4 weeks of operation, the reactor was considered to be in start-up stage due to lower pollutant removal efficiency (35%, 39% and 66% for COD, BOD and TSS respectively). Grades stone takes long period to develop biofilm therefore it took more time compare to bioballs. The system was consider to be acclimatized or matured after the next 30 days of operation when significant removal efficiency (up to

80%) was observed for TSS. The average performance characteristics of the system during the study-period are summarized in Table V.

Table V Average Performance of Reactor 1

Sr. No.	Parameter	Unit	Influent	effluent
1	pH	-	8.56 ± 0.29	7.34 ± 0.13
2	BOD	mg/L	891 ± 150	267 ± 29
3	COD	mg/L	678 ± 121	231 ± 37
4	TSS	mg/L	842 ± 50	151 ± 43
5	VFA	mg/L	210 ± 64	137 ± 48

The average effluent pH was observed as 7.34, within the recommended range of 6.5–7.5 for anaerobic digestion suggesting no excessive accumulation of organic acids within the treatment unit. The average effluent quality was consistent with the removal efficiency for TSS as 82% which will ultimately reduce BOD but it might take increase in HRT for reactor. B. Performance of Bioballs Reactor This reactor also started up in Dec., 2017 and operated for a period of 180 days. For the first 3 weeks of operation, the reactor was considered to be in start-up stage due to lower pollutant removal efficiency (44%, 46% and 68% for COD, BOD and TSS respectively), which might be due to settling and interception of organic matter in the sludge developing at the surface of filter media. The reactor was consider to be acclimatized or matured after the next 21 days of operation when significant removal efficiency (up to 84%) was observed for BOD. The average performance characteristics of the system during the study-period are summarized in Table VI.

Table VI Average Performance of Reactor 2

Sr. No.	Parameter	Unit	Influent	effluent
1	pH	-	8.56 ± 0.29	7.64 ± 0.23
2	BOD	mg/L	891 ± 150	172 ± 28
3	COD	mg/L	678 ± 121	198 ± 42
4	TSS	mg/L	842 ± 50	126 ± 31
5	VFA	mg/L	210 ± 64	158 ± 43

The average effluent pH was observed as 7.64, within the recommended range of 6.5–7.5 for anaerobic digestion suggesting no excessive accumulation of organic acids within the treatment unit. The average effluent quality was consistent with the removal efficiency for COD as 72% and BOD as 84%. Hence, the dissolved fraction partly consisted of soluble microbial products, which are generally resistant to biodegradation. The increased level of COD in the effluent might be due to increase in the effluent VFA concentration.

C. Comparative study of Performance

After studying both reactor on various parameters it is found that both having

advantages and disadvantages in some extent. Bioballs are comparatively gives more efficiency over graded stone. Rate of development of sludge in case of graded stone is slow but temperature variation might not affect. In case of bioballs media, sludge development is

CONCLUSION

Based on the results of the comparative analysis between the performances of the Fixed media and Suspended media in anaerobic compact process carried out during the present study, the bioballs can be a potential alternative over graded sand for treating wastewater in anaerobic reactor of CST. Although, the bioballs could not fulfill the Indian Disposal Standards on its own, indicating the need for further post treatment. It achieved considerably high removal efficiency for pH, BOD, COD (74%) and TSS (82%) without requiring frequent desludging.

Due to its appreciably treatment efficiency for primary domestic waste water treatment and economic operational features, it can be a feasible alternative of media in CST for application in the rural and peri-urban areas of the developing countries like India, where centralized treatment facilities are not available.

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