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Degradation of Organic Constituents in a Biphasic Anaerobic Digester for Treating Pharmaceutical Wastewater

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Abstract: ***A laboratory scale of biphasic anaerobic bioreactor was operated in a total working volume of 36.92l with 6.15l of Acidogenic and 30.77l of Methanogenic reactor for treating Pharmaceutical wastewater in a mesophilic conditions. The Organic Loading Rate for this experimental study was varied from 1.448 to 30.80Kg COD/m^3.d for Acidogenic Reactor and 0.364 to 9.435Kg COD/m^3.d for Methanogenic reactor. The maximum COD removal efficiency was attained 87.54% with OLR of 2.750Kg COD/m^3.d in Methanogenic reactor and 27.39% with OLR of 3.578 Kg COD/m^3.d Acidogenic reactors. The overall reactor reached the maximum COD removal efficiency of 83.52% with an influent COD of 2864mg/l of pharmaceutical wastewater.***

Keywords: ***Acidogenesis, Biphasic, COD, Mesophilic, Methanogenesis, Pharmaceutical wastewater.***

I. INTRODUCTION

Pharmaceutical wastewater is normally categorized by extraordinary harmfulness which builds a potential risk to the natural atmosphere and to wastewater treatment plant, if not controlled properly [12]. The manufacturing of pharmaceutical compounds are primarily involves through fermentation, extraction and chemical synthesis. These steps are then followed by preparation and packaging of the final product [20]. The volume of wastewater generated during the manufacturing of drugs is expressively greater than the amount of the end product and it has been conveyed that 200 to 30,000 kg of wastes can normally be generated for every kilogram of active component formed [19]. The COD level of pharmaceutical wastewater was found very high, the difference between diverse manufacturing activities can be still huge, where the COD of influent wastewater was found to be 4,410 to 40,000 mg/l [6], [21]. The various methods was applied to treat pharmaceutical wastewater which include process such as Coagulation, Sedimentation, Adsorption, Advanced Oxidation Processes (AOPs) and Biological treatment [8], [13], [27], [30]. In recent years the discharge and treatment of pharmaceutical wastewater creates health issue with release of antibiotic drugs in the natural environments, due to their microbial activity there was only limited efficiency achieved through common biological treatment[4],[10].

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The pharmaceutical wastewater was treated through both anaerobic as well as aerobic processes defined by many authors [22], [24], [23]. Activated sludge having higher biodegradability as compared to pure municipal primary settled sludge, which broadly reveals about 30-45% in VS reduction through conventional anaerobic digestion [11].The concentrated leachate was mostly treated by anaerobic treatment methods which can reduce operating cost and also create usable biogas product, pathogen free solids production which will be utilized as a cover material [16], [14]. The biogas comprised of primarily methane which comes in primary source of renewable energy arrived from the anaerobic digestion process which is under biochemical process. Nowadays most of the digester are designed and used as one stage digestion slurry systems which are responsible for treating the materials having enormous amount of water content for example liquid manure from sludge. The two stage approaches has been adopted by many authors for possible solution to enhance the overall efficiency by means of biodegradation rate/yields and production of overall energy [1],[25],[15],[26],[18] [31]. Few authors reported that the splitting and optimizing the hydrolysis/acidogenic and methanogenic process could enhance the overall reaction rate, maximize biogas yields, and make the process easier in mesophilic conditions [5],[17].Two-stage anaerobic digestion where the digestion method has been divided into a acidification stage and a methanogenic stage, has been shown to develop biogas production from a mix of primary and waste activated sludge [7] and for Waste activated sludge alone [11]. The core aim of this research article is to degrade the organic constituents in terms of COD removal efficiency with respect to Organic Loading Rate in a biphasic anaerobic digestion for treating pharmaceutical wastewater.

II. MATERIALS AND METHODS

The biphasic digester has been selected to investigate the COD reduction efficiency independently by acidogenic and methanogenic organisms made up of Plexi glass with a working volume of 36.92l for different operating conditions of real time pharmaceutical wastewater. The reactors are kept in series with individual gas collectors. The digesters are two phased and comprised of 6.15l of fermentative acidogenic and 30.77l volume of methanogenic phase. The reactor is accomplished with suspended growth process in Acidogenic reactor (AR) and with attached growth process in Methnogenic reactor (MR). Biphasic reactor was operated with 1:5 ratio diluted pharmaceutical wastewater from the influent tank by means of a peristaltic pump of Model PP-30EX (Miclin's).

The coconut coir was used as a bio carrier in the methanogenic reactor and the specifications of the bio carrier is shown in the Table.1. The photographic view of bio carrier is shown Figure.1. The gas production was continuously measured by means of water displacement method individually. The experimental setup is shown in Figure.2.and the physical features of the experimental set up are shown in Table.2.

Table.1. Coconut Coir Fiber Specifications:

SI. No	Parameters	Significations
1.	Color	Coir Fiber- Yellow
2.	Moisture	Up to 5 percentage
3.	Impurity	Less than 6 to 9 percentage
4.	Length	4cm to 25cm
5.	Load ability	20 tons in 40 feet HC Container
6.	Bale weight	115kg to 125kg
7.	Packing	Plastic straps

Figure.1.Photographic view of the Bio carrier

Table .2. Physical Features of Two Stages Anaerobic Bioreactor

Description	Measurements
Total working volume of the reactor, l	36.92
Working volume of the A.R reactor, l	6.15
Working volume of the M.R reactor, l	30.77
Diameter of the A.R reactor, cm	14
Diameter of the M.R reactor , cm	30
Diameter of Influent & Effluent pipe, cm	1
Peristaltic pump	PP – 30 (EX)

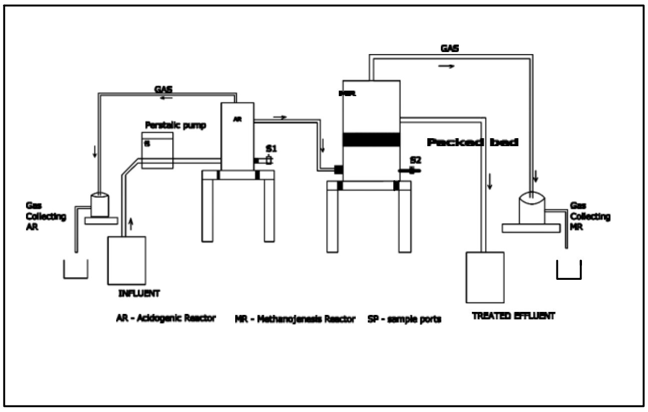

Figure.2. Schematic diagram of the experimental set up

Samples were collected from M/S Life care Formulations, 91/5 Link Road Near, Mettupalayam Industrial Estate, Sonia Gandhi Nagar Extn, Mettupalayam, Puducherry 605009 and characteristics of samples were analyzed as per the procedure given in the Standard method for water and wastewater [2]. The analyzed parameters of pharmaceutical wastewater are present in Table 3.

Table.3. Physico-Chemical Characteristics of pharmaceutical wastewater

Sl.No.	Parameter	Sample-1	Sample-2	Sample-3	Average	IS 10500
1.	pH	4.6	4.22	4.58	4.46	6.5-8.5
2.	Total solids,mg/l	7100	8000	7800	7633	2000
3.	Total suspended solids, mg/l	6,600	7300	7000	6966	100
4.	Total dissolved solids, mg/l	500	700	800mg	666	500-2000
5.	$BOD_5@20^0C$,mg/l	7560	8200	7000	7586	30
6.	COD, mg/l	16800	17200	16000	16667	250
7.	Potassium, mg/l	190.8	188.6	196.4	191.9	50-75
8.	Oil and Grease, mg/l	45	57	73	58	10
9.	Phosphates, mg/l	120	134	150	134	40-200

Inoculum

The digested slurry was collected from the active biomass plant located at M/S Life care Formulations, 91/5 Link Road, Near Mettupalayam Industrial Estate, Sonia Gandhi Nagar Extn, Mettupalayam, Puducherry 605009 to accelerate the start-up process.

Start-up Process

The wastewater was collected from the treatment facility at Chidambaram Municipality for start up of the reactor. The influent and effluent samples from the reactor were collected once in three days and were analyzed immediately. The reactor achieved at steady state conditions during the period of 18th to 21st day with a removal efficiency of COD is 87.54%.

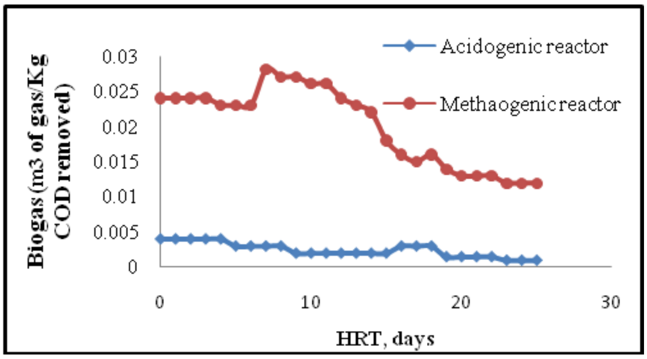

Figure.3. Characteristics Curve of HRT, days versus Biogas production in Acidogenic and Methanogenic reactor during start-up.

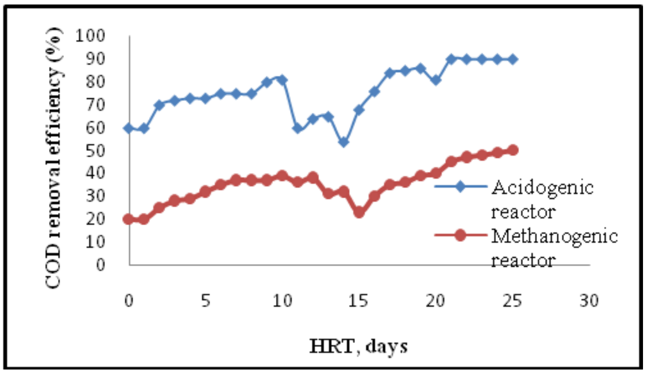

Figure.4. Characteristics Curve of HRT, days versus COD removal efficiency in Acidogenic and Methanogenic reactor during start-up.

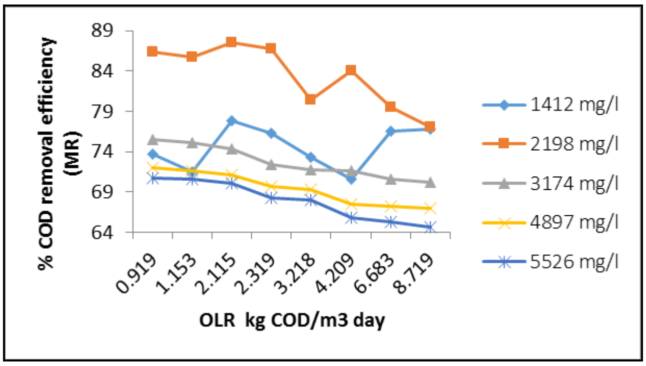

Figure.6. Effect on Organic loading rate kg COD/m^{3}day on the percentage of COD removal efficiency in Methanogenic reactor

III. RESULT AND DISCUSSIONS

After achieved a steady state the reactor was allowed to treat real time diluted pharmaceutical wastewater under varying operational conditions. Five different average influent COD of 1858, 2864, 4051, 6180, 6786 mg/l was fed in the acidogenic reactor. The supernatant form the acidogenic reactor was used as an influent in the methanogenic with an average COD of 1412, 2198, 3174, 4897, 5526 mg/l. The influent flow rate for the entire experimental study was 2.59, 3.456, 4.32, 6.048, 7.776, 11.23, 15.12, 19.44 l/day. The reactor was operated at a mesophilic [28], [29] temperature varied from 25ºC – 37ºC during the study. The room temperature was recorded on daily basis. The performances in terms of COD removal efficiency with respect to the Organic Loading Rate for acidogenic and methnogenic reactor for treating pharmaceutical wastewater are shown in Figure.5 and Figure.6. It identified that the COD reduction rate was affected by the fluctuations in OLR. In the earlier study [3] achieved 77.42% COD removal efficiency in methanogenesis and 26.19% in acidogenesis reactor in diphasic for treating distillery wastewater. The minimum COD removal efficiency was attained at 15.78% for acidogenesis at an OLR of 10.570 kg COD/m3 day and 64.68% for methanogenesis at an OLR of 2.969 kg COD/m^3 day. The maximum COD removal efficiency was achieved in the acidogenic reactor was 27.39% at an OLR of 3.578 kg COD/m3.day and 87.54% with an OLR of 2.750 kg COD/m3.day of methanogenic reactor.

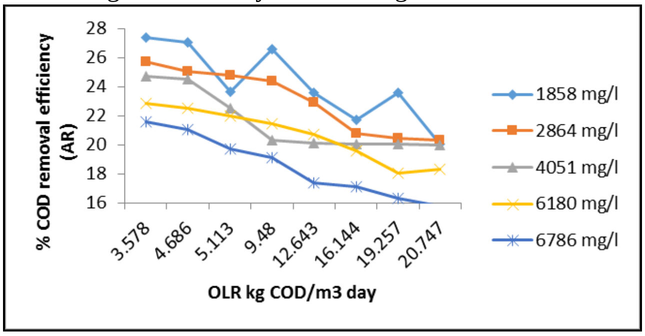

Figure.5. Effect on Organic loading rate kg COD/m^{3}day on the percentage of COD removal efficiency in Acidogenic reactor

IV. CONCLUSION

The biphasic digester provide that it has the potential to reduce the organic pollutant in terms of COD by incorporating suspended growth process in acidogenic reactor as well as attached growth process**.** The maximum COD removal efficiency was achieved in the acidogenic reactor was 27.39% at an OLR of 3.578 kg COD/m3.day and 87.54% with an OLR of 2.750 kg COD/m3.day of methanogenic reactor. In the first reactor the acidogenic population was predominant and the second reactor was established with the methanogenic population.

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