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**BIO-TREATMENT OF ORGANIC LEACHATE AND DOMESTIC WASTEWATER,  
USING UPFLOW ANAEROBIC SLUDGE BLANKET REACTOR**

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**ABSTRACT**

Leachate, a semi-solid excruciatingly concentrated waste stream is an unavoidable potential threat which attributes additional burden to the municipal solid waste (MSW) processing and disposal (P&D) facilities. Safe handling, proper treatment, and eco-friendly disposal of leachate poses a challenge due to the elevated concentration of several objectionable parameters. Ancillarilly, sanitary sewerage systems serve only a low percentage of the national population and in non-sewer areas, more than 80% of the black and grey water including human excreta and other fecal matter ends up in septic tanks. Therefore, the present study tried to produce a wholesome remedy jointly to the sanitation and leachate management issues using the biological treatment mechanism. Experimental studies have been carried out to treat the combined effluent of MSW leachate and domestic wastewater in different ratios using up-flow anaerobic sludge blanket reactor. The result revealed that the Chemical Oxygen Demand (COD) removal efficiencies using domestic wastewater and MSW leachate as a substrate were about 84 and 86 %, respectively with Hydraulic Retention Time (HRT) of 12 h. Whereas, the COD removal efficiency of the combined effluent of domestic wastewater and MSW leachate at various proportions (70:30, 60:40, 50:50, 40:60, 30:70) was about 90 %.

**Keywords: Anaerobic treatment, Biochemical oxygen demand, Chemical oxygen demand,  
Domestic wastewater, Leachate**

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## INTRODUCTION

Solid waste landfills may cause severe environmental impacts if liquid (leachate) and gas emissions are not controlled and separately treated. On the other hand, the diverse parts of our nation, coming under Panchayat jurisdiction till date are not equipped with proper sanitation and sewerage system. If we consider the figures alone in the state of Tamilnadu, which comprises six municipal corporations, one hundred two municipalities and six hundred and eleven town Panchayats with a total population over 30 million, unfortunately, only 35% entire population have an access to the scientifically designed sewerage system [1, 2]. Every day this city and towns have to manage 8000 tons of solid waste generated from residential and commercial sources [3, 4]. In Tamilnadu, landfilling, on-site recycling and composting are the common applications in the management of municipal solid waste. There are individual sanitary landfills serving for each town receiving about 100 tons every day. Indian cities/ towns generate, on an average of 300-400 g per capita, per day of solid waste, which translates into approximately 80,000 MT/d or 30 million MT/annum of urban solid wastes, out of this, nearly 8.5 million MT/annum comes from nine major metropolitan centers alone [5, 30, 31, 32, 33]. Out of which approximately 60-80% of these wastes are picked up on a daily

basis and the remainder is gone away to decay on roads, streets, drains. Urban solid waste generally contains up to 20% of recyclable contents, whereas the biodegradable material may constitute around 50-60% and the rest being stoned, dust, etc. [6, 7]. A part of these wastes coming from hospitals and certain industries are of hazardous in nature. According to Bajaj committee, the municipal garbage has a low calorific value (1500 Kcal/kg) and its average density varies between 500-600 kg/m<sup>3</sup> [8, 9]. Municipal solid waste generated in this country may be contributed from the following sources like commercial waste, street-sweeping, industrial / trade waste, debris or construction rejects, waste of animals etc. [10, 11]. Solid waste management in this country involves mainly four steps, namely, collection, conveyance, treatment, disposal. Individually collection may be associated with collection from residents, slum dwellers, market, cattle sheds/ slaughtering place, primary collection of vehicles, etc. [12, 13]. Nowadays manual handling of municipal solid waste is proposed to be totally avoided both primary collection and transportation to compost yards [14, 15]. The vehicle carrying the waste needs to be totally covered so that carriage of waste will not be visible to the public and

exposed to the environment to avoid possible spoilage and scattering on the roads/streets [16, 17]. Resource segregation of municipal solid waste as per Indian scenario concerned is not in practice at all [18, 19]. Leachate generation may be one of the biggest headaches associated with MSW landfill sites [20, 21]. But solid waste has several nutrients and hence can advantageously proceed to produce several value-added co-products and end products viz. Gas, electricity and also organic manure if properly utilized [22].

The main objective of this study is to yield a sustainable waste treatment mechanism which would be capable of addressing multidimensional waste from different sources under a single platform associated with revenue generation from waste-derived co-products.

## **MATERIALS AND METHODS**

The experimental work has been carried out in Annamalai University, (Chidambaram, Tamil Nadu which lies approximately at the junction of latitude 11.3908°N and longitude 79.7148°E) premises during 2016 and the expenditure attributed to the study was self-financed. The reactor was operated over a period of 45 days with various changes and alterations performed on the same over the experimental tenure is delineated below.

### **Solid waste and leachate collections**

Solid wastes were collected freshly from Chennai MSW Pvt. Ltd. ( 12°58'41.95"N, 80°15'50.53"E) by means of collection vehicles, while landfill leachate was collected in the form of fresh and legacy leachate from the leachate treatment plant of Hyderabad Integrated MSW Ltd. ( 17°31'5.57"N, 78°35'26.01"E).

### **Seed sludge facilities**

In order to minimize the startup period, the reactor was seeded with the help of active sludge, collected from high rate anaerobic digester, treating distillery effluent located at M/s Sakthi Sugars Ltd. Appakoodal, Bhavani, Erode Dt. and M/s Sriman Narayana Sago Factory, namagripet, Rasipuram Tk, Namakkal Dt.

### **Method of Study**

It involves analysis of physic-chemical properties, operating and monitoring parameters and the experimental setup for bio-treatment of leachate.

### **Operating parameters**

pH, COD, HRT, Temperature, co-substrate was determined for the samples according to the standard method for examination of water and wastewater [23].

### **Optimization of the parameters**

The study emphasized the achievable removal efficiencies against different influent loading conditions. For instance, pH of the sample was measured using pH meter, ELICO makes model LI 120. Likewise COD value was obtained (i.e.

1000 mg/L) using the standard lab procedures. Optimization of hydraulic retention time is another key factor, which was paid utmost attention in order to maintain a balance between the influent rate and removal efficiency. The principal factors which influence the above study of combined leachate and sewage water treatment are the reactor volume and the flow rate.

### Monitoring parameters

pH, COD, TDS, VSS, VFA, and Biogas production have been monitored manually during the experimental period and obsessive changes in the observation values has been noted interpreted to optimize the yield.

### Monitoring methods

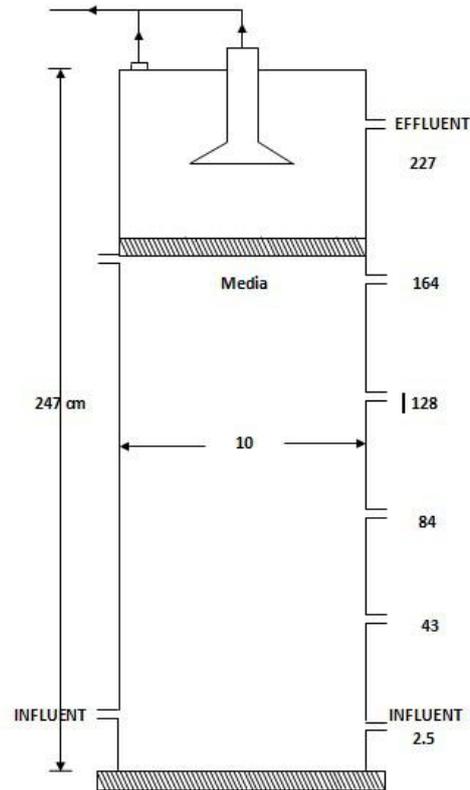
Different parameters were computed based on their lab procedures. For instance, volatile suspended solid (VSS) has been measured using what-man filter paper no. 44. Similarly other significant parameters such as total dissolved solids (TDS), BOD<sub>5</sub> etc. were monitored on intermittent analysis basis and any certain change in value has been thoroughly analysed and interpreted for the most appropriate explanation. Production of volatile fatty acid (VFA) also found to be influential over the reaction kinetics. The standard procedure used to find the VFA value in the reaction medium is as follows. The sample was filtered first and then 100ml of the sample was taken for

analysis. If the pH were higher than 6.5 acid was added until pH reaches 6.5 then titrated with acid (HCL 0.1N) until pH=3 (Consumption 4ml). Then the sample was taken in the digestion flask with fuming stone and connected to the condenser. It was heated until the liquid begins to boil, for 3 min and cooled down for 2 min and afterward titrated with 0.1N NaOH until the pH= 6.5

Ultimately the biogas production was quantified using water displacement method [37, 38]. The water in the gas collector was acidified with sulphuric acid to reduce the solubility of CO<sub>2</sub>, one of the constituents of biogas, for optimum measurement of biogas volume.

### Upflow anaerobic sludge blanket reactor (UASBR)

UASB reactor (the reactor was designed and fabricated with the help of internal resources) was used in this work was drawn up of vertical polyacrylic rectangular shape tanks with an internal working volume of 15L. The elevation of the reactor is 3m in this working height was 2.4m with the width and breadth of 0.18m and 0.061m respectively. Details of reactor are presented in Fig. 1. The inlet of the reactor was at the bottom and the outlet was at the top. This reactor contains four sampling ports for every 60cm. The gases produced in the reactor were collected at the top of the reactor and was measured by using the water displacement method.



All dimensions are in cm

Figure 1: Detailed schematic process experimental setup

## RESULT AND DISCUSSION

Disposal of municipal solid waste (MSW) in the sanitary landfill is usually associated with soil, surface water, and groundwater contamination when the landfill is not properly constructed. An up-flow anaerobic sludge blanket process is a modern anaerobic treatment system that can have high treatment efficiency and a short hydraulic retention time [24].

The wastewater from the septic tank was integrated with the MSW leachate [25] to feed the UASBR as a substrate. Several parameters were examined using Standard Method of Water and Waste water analysis, APHA, 14<sup>th</sup> Ed., 1985 at a preliminary stage for domestic wastewater and as well

as for leachate and the results are tabulated and compared in Table 1.

### Startup scenario

The reactor start-up phase lasted for 45 days. Since the sludge formation activity was initially minute when compared to the anticipated figures a lower feed concentration of 3000 mg/l helped in controlling the excessive VFA formation which guarded against the excessive pH drop. By the day 45 COD reduction was more than 85%, showed in Fig. 2. A similar sort of study carried out by Bhatti et al. [26] consistently reported the similar removal efficiency often ranges between 80 to 98% on the 6th and 32nd day from the reactor startup periode. The gas production also

increases enormously from 12.6 l/day to 27.4 l/day. This indicates that the reactor attained a stability condition. All the results of domestic wastewater treatment are listed in Table 2.

As a second stage, the treatment efficiency of UASB reactor was investigated fed with the leachate for the same optimized HRT of 12 h for the same 15 day period and the values of pH, COD, TDS, VFA, VSS and gas produced were continuously monitored. Here the relationship between the removal of MSW leachate in association with the COD removal has been represented in Fig. 3. Contradictorily Kalka [24] has reported that the wastewater renovated with 10% of leachate didn't satisfy the discharged limits for dilution and unfit for disposal into the water bodies even after biological treatment.

As a final phase, the treatment efficiency of UASBR was attempted for various proportions of MSW leachate-domestic waste water mixture. The reactor was operated at the optimized HRT of 12 h for the same period of 15 days. MSW leachate was collected and blended well with domestic wastewater in different proportions of 70:30, 60:40, 50:50, 40:60 and 30:70. The results were achieved and data is tabulated below in Table 3.

In this context its quite evident to mention that the composition of the solid waste which was utilized to collect the bio-

leachate has been portrayed below in figure 4.

It can be explicitly observed that the organic biodegradable waste is the major fraction of the entire composition and reaches more than 80% which signifies the risk of minimal persistent pollution.

Some experimental values for COD removal and quantity of Biogas collected, which were computed during the experimental time period, are shown in the form of graphical representation in Fig. 5 and Fig. 6 respectively. The similar sort of study was carried out by numerous authors [27, 28] and it has been confirmed that though isolated microorganism such as *Burkholderia sp.* And *Pseudomonas sp* often yields better efficiencies against certain pollutants but implementation and maintenance of pure culture is fairly an unfeasible work to carry out [29, 34, 35, 36].

The anaerobic digester yielded approx. 0.20 m<sup>3</sup> of biogas when supplied with roughly 3.7 L of bio-leachate [39, 40]. Ghani and Idris (2009) have reported similar sort of conversion efficiencies, whereas, a slightly depleted efficiency was observed by Hashemi et al. (2015) possibly due to the geographical and local influences over the composition of MSW. Furthermore, the synthesized biogas was effectively converted into Compressed Biogas (CBG). The conversion rate

recorded an efficiency of around 40% (i.e. 1 m<sup>3</sup> of biogas yielded roughly 0.4 kg methane or CBG). Taking all sorts of expenses into the consideration the overall production expenditure was calculated as 5.6 Rs./ m<sup>3</sup> of biogas attributed to a calorific value of 20 MJ/ m<sup>3</sup> or so, which is quite cost-effective as per the present market scenario [41, 42, 43, 44]. Despite the efficient production rates there are some

debates regarding the most pertinent and frugal end use of the final product. Some of the researchers stated that the conversion of CBG into electricity is more profitable when compared to the direct utilization as an alternative to LPG and vice-versa. In this context, a relevant piece of information is the CBG to electricity conversion rates which often ranged 10 Kwh/ m<sup>3</sup> or 1.2-1.5 unit [45, 46].

Table 1: Comparative characteristics of domestic wastewater and MSW leachate

Sl No.	Parameters	Concentration (domestic wastewater)	Concentration (MSW leachate)	Unit
1	pH	7.2	6.9	-
2	EC*	1.482	1.850	milli mho/cm <sup>2</sup>
3	Turbidity	10	16	Nephelo Turbidity Unit
4	COD	890	1004	mg/L
5	TSS**	1000	1300	mg/L
6	TDS***	900	1240	mg/L
7	Chlorides	987	1440	mg/L
8	Sulphates	68	99	

\*Electrical Conductivity \*\*Total Suspended Solids \*\*\*Total Dissolved Solids

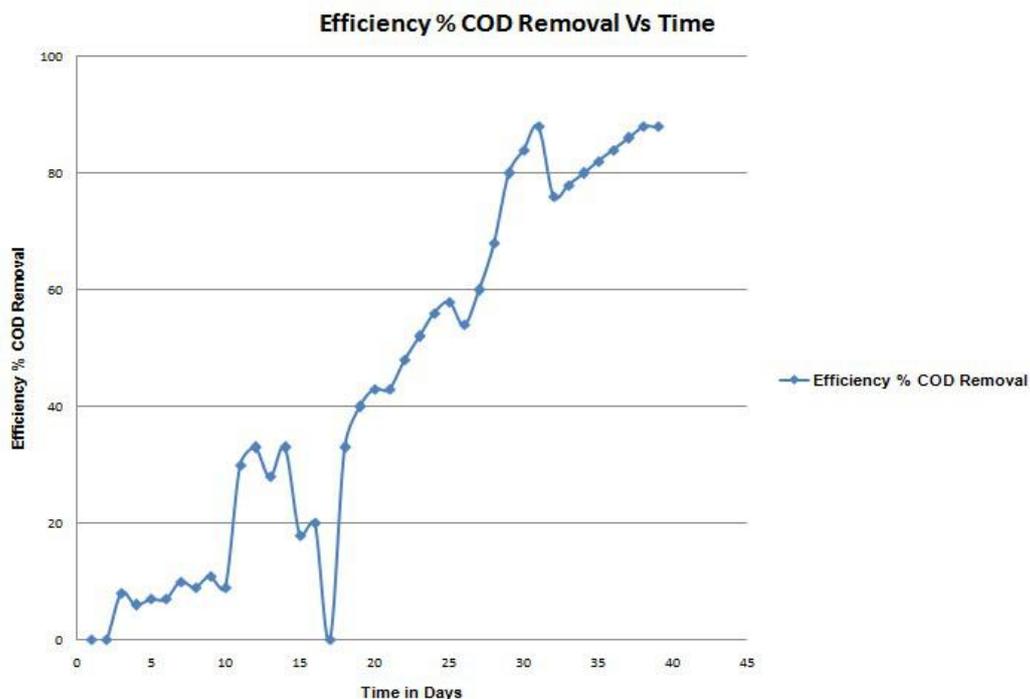


Figure 2: COD removal efficiency obtained during reactor start up period

Table 2: Results of domestic wastewater treatment

Days	pH		COD in mg/l			TDS in ppm		VFA in mg/l		VSS in mg/l	Gas in liters
	Inlet	Outlet	inlet	outlet	%removal	inlet	outlet	Inlet	outlet		
1	7.64	8.68	750	195	74.0	1648	1258	72	18	5300	4
2	7.58	8.34	800	200	75.0	1546	1247	60	16		6
3	7.51	8.16	680	144	78.8	1542	1362	66	12		8
4	7.57	8.23	400	80	80.0	1597	1340	66	12		10
5	7.36	8.11	500	98	80.4	1586	1314	60	9		14
6	6.22	8.12	368	72	80.4	1578	1384	70	9	5400	14
7	5.77	7.79	580	110	81.0	1273	735.1	74	6		16
8	5.77	7.74	600	105	82.5	884.4	587.7	64	6		14
9	5.28	7.67	405	72	82.2	884.4	587.7	64	6		14
10	6.01	7.41	460	84	82.4	730	591.1	71	3	5600	12
11	6.10	7.41	808	140	82.6	868.9	670.9	74	4		12
12	6.10	8.06	876	150	82.3	987	654	78	6		12
13	7.10	8.37	916	155	83.0	1007	880	64	6		14
14	6.96	7.91	890	140	84.0	810	686	71	3		16
15	6.98	7.78	760	120	84.0	800	690	64	5	5800	16

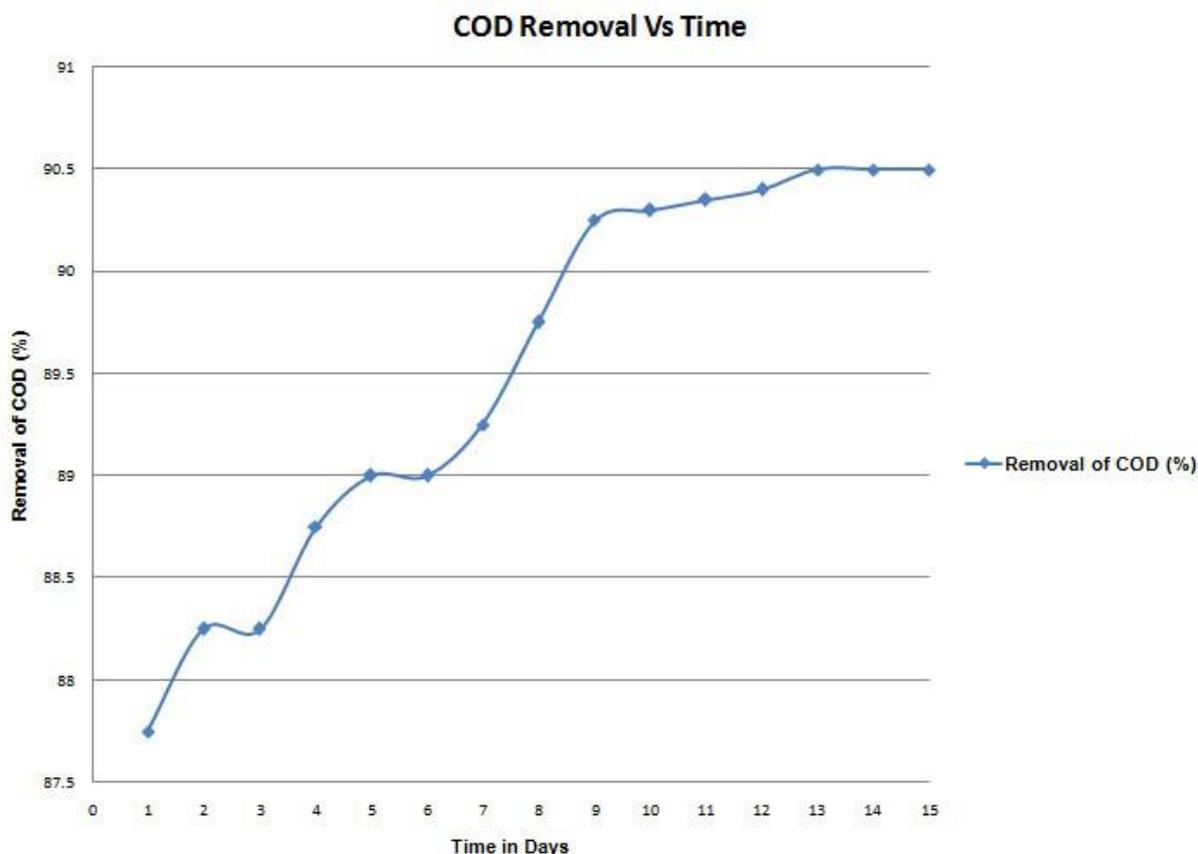


Figure 3: Percentage removal of MSW leachate

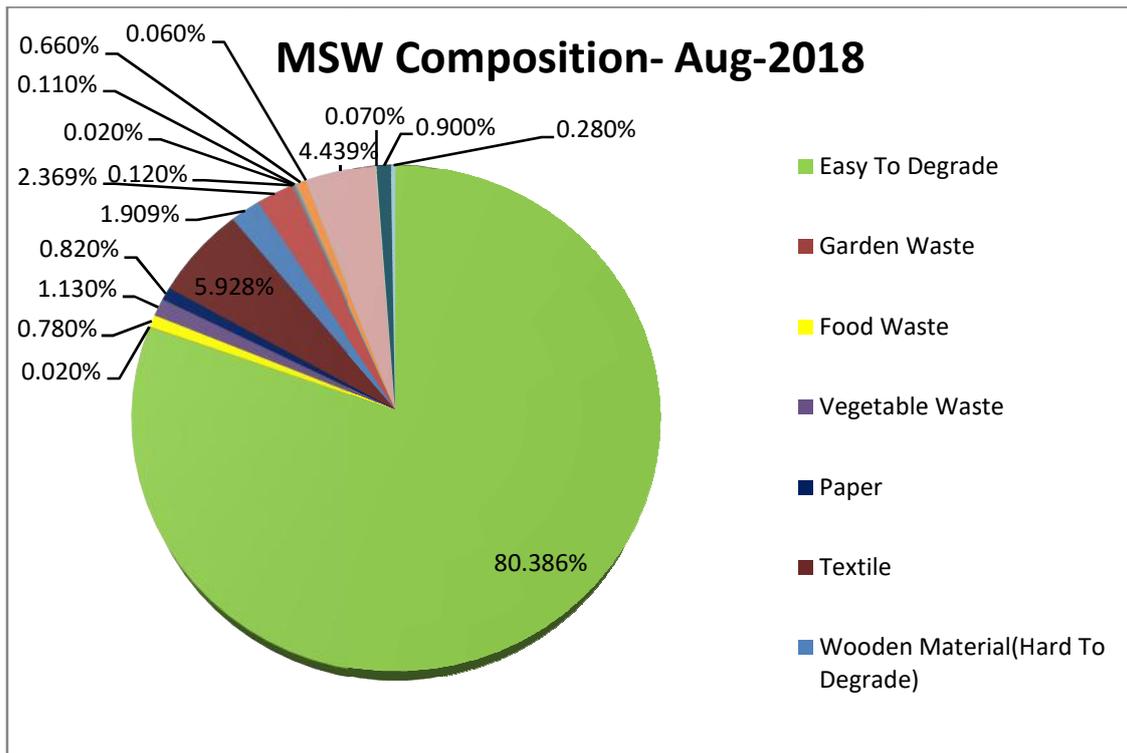


Figure 4: MSW Composition

Table 3: Various achievements after successful completion of the biological treatment process

Sl.No.	Accomplishments
1	Neutralization of pH (i.e. From 8.2)
2	Maximum COD removal of 90%
3	Highest removal of TDS from 970 mg/l to 697 mg/l (50:50 ratio)
4	Optimum removal of VFA from 600 mg/l to 10mg/l (50:50 ratio)
5	VSS content increased by 52000 mg/l to 58000 mg/l within 15 days (50:50 ratio)

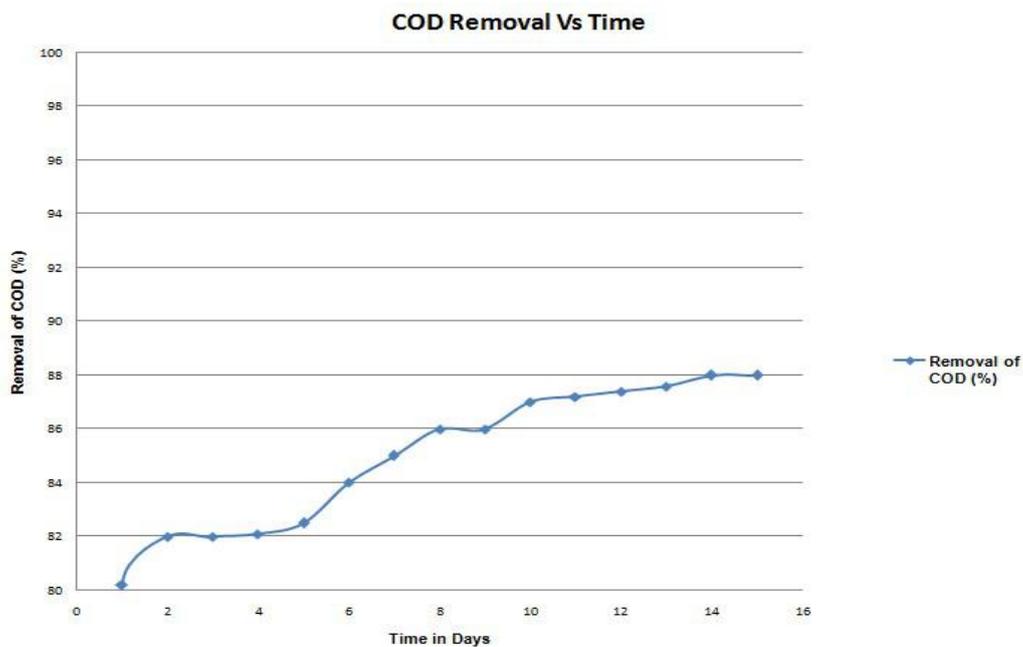


Figure 5: Removal of COD for MSW leachate and domestic wastewater mixture (50:50)

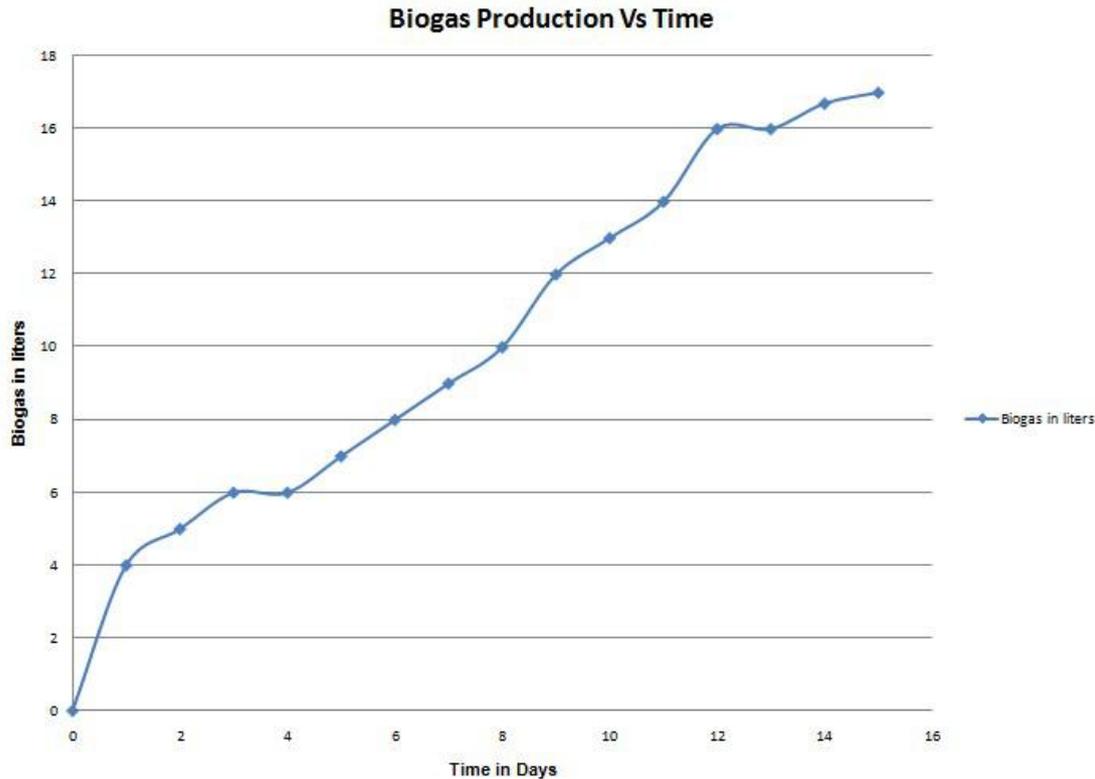


Figure 6: Biogas collected during MSW leachate and domestic wastewater mixture (50:50) treatment

## CONCLUSION

The analysis report of domestic wastewater and MSW leachate revealed that both have almost similar characteristics despite some minor variabilities. The tenure of the start-up period of the reactor was minimized up to 45 days by seeding the reactor with starch-based sludge. The experimental results also demonstrate that the COD removal by variable HRT is almost up to 90% for various mixed proportions of domestic wastewater and MSW leachate (70:30, 60:40, 50:50, 40:60, 30:70), simultaneously the other parameters such as VFA, VSS, TDS etc. also decreased drastically. On the ground of knowledge received during this study, it could be urged that different reactors can be utilized to achieve optimal treatment efficiency.

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