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Anaerobic degradation of coconut husk leachate using UASB-reactor

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Abstract: *Retting of coconut husk, the major process in quality coir fibre extraction, causes serious pollution with brackish water lagoons of Kerala. An attempt is made to treat the coconut husk leachate by using a laboratory scale UASB-reactor. The experiment was conducted with loading of leachate from 1 kg of fresh coconut husk. The anaerobic treatment was done continuously. The parameters like VFA, pH, COD and polyphenols were analysed regularly during the evaluation of the reactor performance. The polyphenol, VFA and COD were diminished gradually with time. The pH of the reactor during the study was found to be in the range of 6-8. The biogas production was increased with loading and about 82% of the total COD/kg husk could be converted to biogas. The maximum polyphenol loading in the reactor was reached to about 298.51 mg/l of husk.*

Key words: *UASB-reactor, Anaerobic treatment, Coconut husk, Polyphenol, COD*
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Introduction

Recently backwaters are under pressure either as repositories for the effluent of the industrial processes or as a prime site for reclamation to create land for industry or agriculture. Retting of coconut husk for coir industry is prevalent almost all along the backwater which release organic matter and colloidal substance into water led to turbid, large quantity of dissolved oxygen used up, possibilities of depletion of nitrate and sulphate are reduced together with production of H_2S, methane, CO_2 *etc.* Retting ground have revealed extensive damage to the environment with foul smell, rise in temperature, frothing of liquid and white film formation. Retting ground has also caused extensive damage to the aquatic species of backwaters converting waterbodies into Cesspools of foul smell due to stagnation of waters.

In recent years numerous designs have been developed to increase of anaerobic (Bull, 1984) treatment of wastewater. UASB (Lettinga and Hulshoff, 1986), process is currently the most widely used treatment system among the presently available treatment processes. Good performance of the UASB-reactors depends upon the formation of a bed of well settling and highly active granular sludge, with a low sludge volume index and a high methanogenic activity.

The main objective of the present work is to study the anaerobic treatment of coconut husk leachate in a laboratory scale UASB-reactor.

Materials and Methods

UASB-reactor: A laboratory scale Upflow Anaerobic Sludge Blanket (UASB) reactor was used in this study. It is a cylindrical shaped reactor made of glass. The total volume of the reactor is 13.5 l. The reactor mainly consists of a cylindrical column (9 l), effluents and influent pipes, gas flow meter, feeding tank and gas meter. 1 kg coconut husk is taken in the feeding tank and it is subjected to leaching. The leachate is fed to the reactor through the influent pipe, which leads into the conical shaped bottom of the reactor. The effluent of the reactor is coming out through the effluent tube. The influent is fed to the reactor with a pump of FMI Lab pump model QG 400. The gas produced in the reactor is measured with an INSREF Wet Gas Flow Meter.

Seed sludge: The reactor was seeded with 5.1 l of dairy waste water treatment sludge and canteen waste digester sludge.

Experimental procedure: 1 kg green coconut husk of 11 month were selected and transported to laboratory, ensuring limited exposure to sunlight (dry weight 0.2667 kg). It is immersed in 10 l of nitrogen-sparged water. Nutrient solution of 20 ml and trace elements of 1 ml added to the above water. Composition of nutrient solution and trace elements are shown in Table 1.

The husk is subjected to leaching process and the leachate was used in UASB-reactor at rate of 77.76 l/day and the effluent from the system was completely recycled. The hydraulic retention time of the reactor is 7.776/day. The performance of the reactor is observed by analyzing the influent characteristics of the leachate such as pH, volatile fatty acids, alkalinity, COD, polyphenol concentration and biogas production. The parameters were analysed regularly. The process is stopped when all the parameters noticed to be normal / minimal. The load is stopped after 14 days.

Analytical methods: The standard methods (APHA, 1995) was followed during the analysis.

pH measurements: The pH of Influent and effluent was measured using systronics pH system 362.

Table - 1: Nutrient solution and trace elements composition (g/l)

Nutrient solution		Trace elements	
Composition	**Quantity**	**Elements**	**Quantity**
NH_4Cl	1.4	$FeCl_3$	2
KH_4PO_4	1.25	$MnCl_2.2H_2O$	0.5
$MgSO_4.7H_2O$	0.5	Mg_2EDTA	0.5
$CaCl_2.2H_2O$	0.05	$NaSeO_3$	0.5
$NaHCO_3$	2	H_3BO_4	0.1
Yeast extract	0.5	$ZnCl_2$	0.05
		$NH_4MoO_{24}.4H_2O$	0.05
		Al_2Cl_2	0.05
		$CoCl_2.6H_2O$	0.05
		$CuCl_2.2H_2O$	0.05

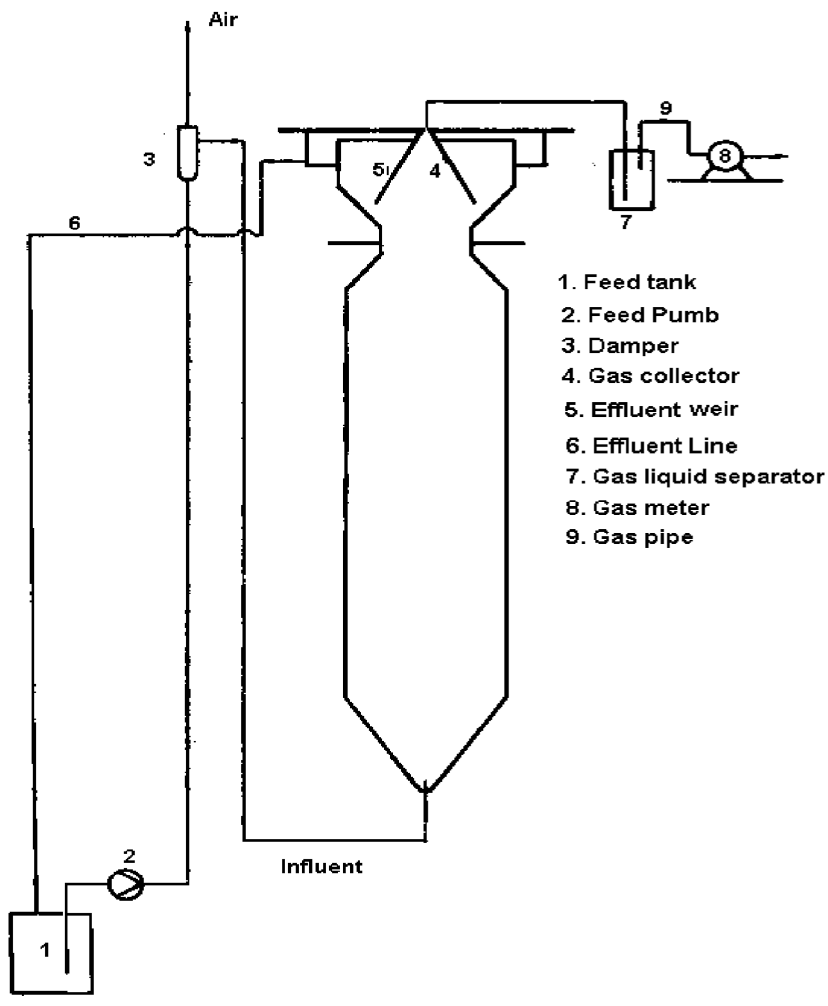

Fig. 1: Schematic diagram of UASB-reactor setup

Volatile fatty acid and alkalinity measurements: Volatile fatty acid analysis was carried out by simple titration method as per 'bicarbonate and total volatile acids concentration in anaerobic digester using simple titration (Anderson and Yang, 1992).

Gas production rate measurement: The gas production was determined by INSREF wet gas flow meter. Total biogas production was recorded daily. The design of the apparatus permitted a daily gas production rate corrected to standard temperature and pressure to be calculated.

Table - 2: Coconut husk leachate characteristics

Days	pH	VFA* (meq/l)	Alkalinity* (meq/l)	COD* (mg/l)	Polyphenol* (mg/l)	Gas production l/day*	Total gas production* (l)
1	6.42	5.29	3.58	1091.20	298.51	2.64	2.64
2	6.54	6.20	4.63	992	261.19	1.66	4.30
3	6.80	6.70	4.67	793.60	238.97	1.35	5.65
4	6.81	6.12	4.89	694.40	238.97	1.45	7.10
5	6.74	5.72	3.90	545.60	147.06	1.35	8.45
6	6.86	4.89	5.18	532.40	119.40	1.43	9.88
7	7.14	3.90	6.86	504	74.63	1.12	11
8	7.86	3.90	5.89	443.52	82.09	1.15	12.15
9	7.17	2.24	7.68	262.08	59.70	0.62	12.77
10	8.07	1.53	11.32	282.24	52.24	0.55	13.32
11	7.15	1.24	10.32	223.52	44.78	0.48	13.80
12	7.22	1.24	10.43	284.48	29.85	0.35	14.15
13	7.33	1.52	10.47	223.52	33.33	0.30	14.45
14	7.13	1.63	10.39	264.16	26.67	0.42	14.87
Mean	**7.09**	**3.74**	**7.16**	**509.77**	**121.96**	**1.06**	**10.32**
SD	**0.46**	**2.08**	**2.86**	**288.17**	**97.08**	**0.66**	**4.06**

* = average of 5 replicate

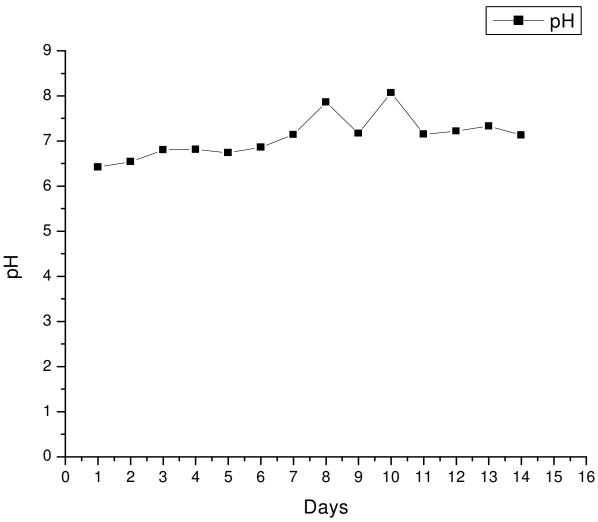

Fig. 2: Variation of pH with time

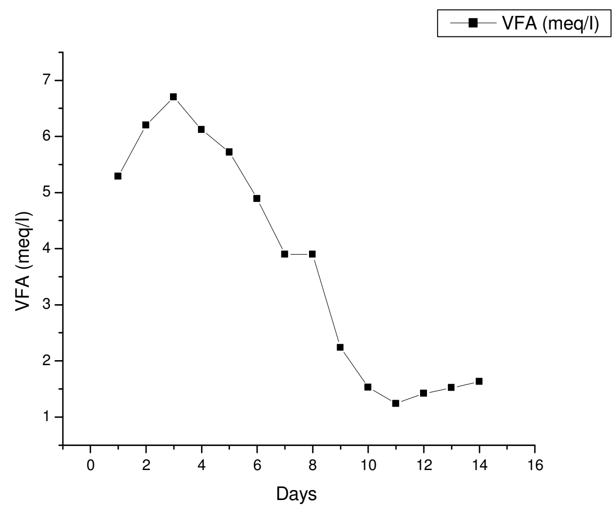

Fig. 3: Variation of VFA with time

Polyphenol degradation: Polyphenolic compounds contain aromatic hydroxyl group that react with Folin phenol reagent to form a blue colour suitable for estimation of concentration upto 9 mg/l. It was measured spectrophotometrically.

COD analysis: The COD tests were carried out according to the open reflux method described in standard method (APHA, 1995).

Results and Discussion

Experimental laboratory model reactor UASB set is filled with anaerobic sludge and was gradually adapted step by step, feeding of coconut husk leachate along with sodium acetate. The performance of the reactor was constantly observed and shown in Table 2. The results showed that the leaching of coconut husk is a slow process and depended on the condition of the ambient characterization of husk leachate consists of higher level of COD, polyphenols and results in release of VFA by hydrolysis. UASB process is a combination of physical and bilogical processes. The main feature of physical process is separation of solids and gases from the liquid and that of biological process is degradation of decomposable organic matter under anaerobic conditions (Bal and Dhagat, 2001).

Effect of pH: It has been noticed that pH of the influent and effluent was in the range of 6.5-7.5 (Table 2 and Fig. 2). The pH of the leachate bring between 6.7-7.5, which provide an ideal condition for anaerobic treatment. Similar observations were also made by Mahadevaswamy *et al.* (2004). Anaerobic digestion requires a stable pH with a range of 6.5-7.5,which is maintained

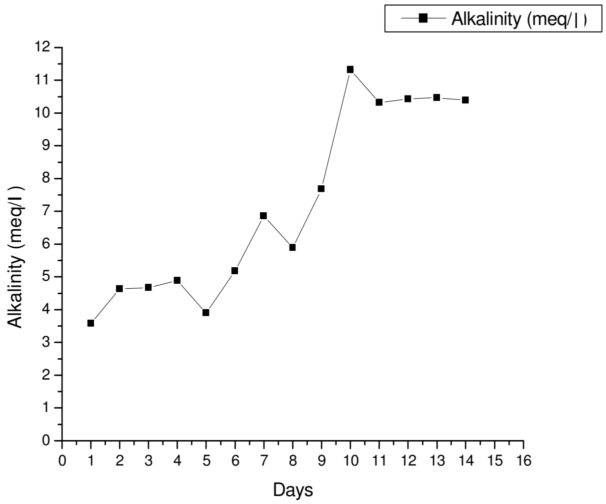

Fig. 4: Variation of alkalinity with time

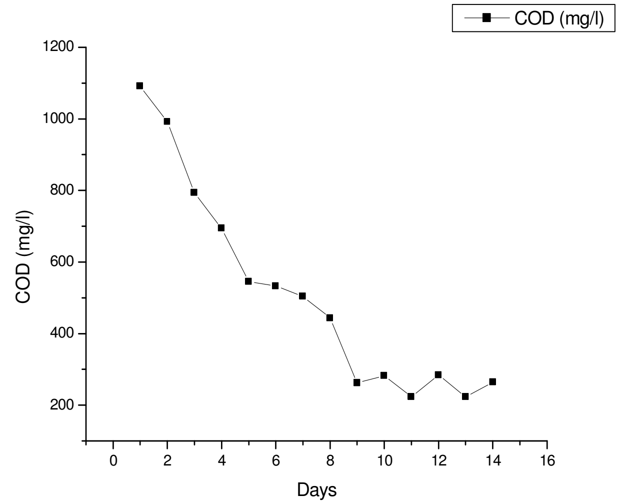

Fig. 5: Variation of COD with time

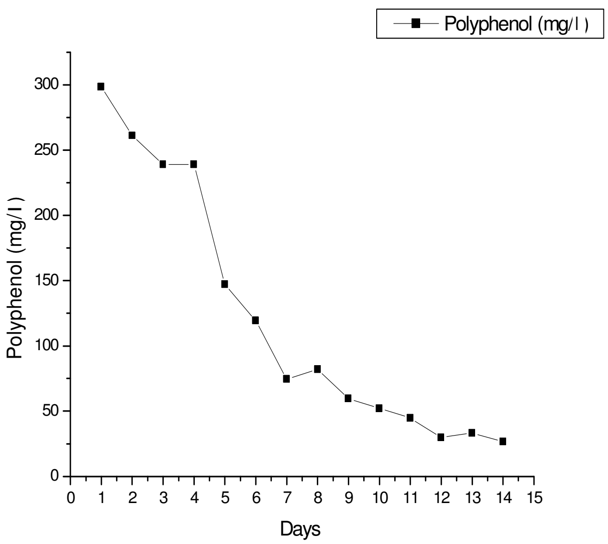

Fig. 6: Variation of polyphenol with time

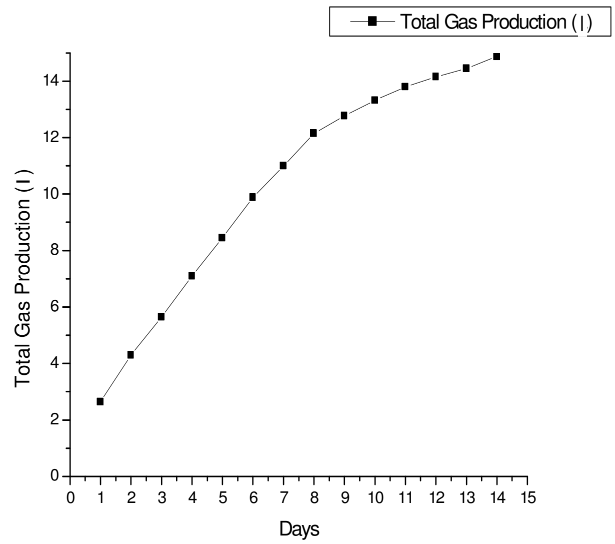

Fig. 7: Variation of total gas production with time

in anaerobic reactors adjusted by carbonic acid or bicarbonate system (McCarty, 1964).

COD removal: COD was found to be decreased from 1091.2-264.16 with the progress of time with a slight increase at 10th, 12th and 14th day of incubation (Table 2).

Recycling the effluent stream tends to reduce the removal efficiency because the reactor approaches a completely mixed system, and therefore the mass transfer driving force for substrate decreases despite a small increase in the loading rate (Barber and Stackey, 1999).

VFA: The variation of VFA with time is plotted from the plots. It is observed that the VFA was initially high but gradually it was declined. The VFA increased slightly in some days; however this increase diminished gradually with time. Sometimes the VFA accumulated in the reactor. With the gradual increase of methanogenic activity, consumption of acetate for methanogenesis also increased (Grasius *et al.*,1997).

Polyphenol degradation: Sometimes the polyphenol concentration of both influent and effluent were observed to be same due to some accumulation of polyphenols in the sludge bed and deabsorption. It was reported that phenol concentrations upto a range of 500-750 mg/l is generally not inhibitory to the UASB process (Veeresh *et al.*, 2004).It has been reported that retting can be improved by the removal of polyphenol and pectin content of the husk (Bhatt and Nambudiri, 1971).

Biogas production: The total biogas production was 14.87 and it was observed that the production of biogas is increasing with time.

The methane percentage in the biogas is about 75%. It can be seen that in the case of lower-strength waste water, the amount of dissolved methane becomes so significant that the intrinsic property of anaerobic process increased and energy can be recovered as biogas (Agarwal *et al.*, 2001).

The overall performance of the UASB-reactor: It can be seen that about 25 g COD/kg of husk is leached out and about 81.9% of COD can be converted to biogas. The methane content of the biogas is fond to be about 75%. The maximum amount of polyphenol leached out is about 3 g/kg. This polyphenol can be degraded by the reactor to a lower level.

The present study arrives at the following conclusions. The initial soaking of coconut husk in water results in the release of high organic leachate which causes more pollution in the environment including water, land and air. Anaerobic treatment of ret liquor can solve the environmental problem economically. The results of this studies enlight the scope of anaerobic treatment of coconut husk leachate and generation of methane. Degradability of polyphenols in the coconut husk leachate was not limited in the anaerobic treatment contains about 75% of methane, that showed the potential as fuel. About 82% of the total COD was converted to biogas in the UASB system. The system was found suitable to study in the field. Detailed studies required in the direction of phenolic toxicity to anaerobic organisms.

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