CO-DIGESTION OF SWITCHGRASS AND PETROLEUM SLUDGE WITH DIFFERENT SUBSTRATE RATIO

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ABSTRACT: *Petroleum sludge (PS) consists of wastewater, waste oils, chemicals, and minerals. In the petroleum industry, sludge is generated on a large scale because of drilling, refining, production, and processing, resulting in pollution of the environment. Switch Grass (SG) is an energy crop used for bioenergy purposes and leads to generating clean energy. The objective of this research study is to optimize the mixing ratio of substrates through the co-digestion process. The mono-digestion and co-digestion substrates at mixing ratios of 60:40 and 40:60 was performed by a biochemical methane potential test system. The experiment indicated that the highest methane yield was obtained from the substrate ratio of 60:40, as 290 Nml/g-VS. This finding suggests that a combination of switchgrass and petroleum sludge at a ratio of 60:40 promotes favorable conditions for enhanced methane production by batch anaerobic digestion system. Moreover, the co-digestion process at the 60:40 substrate ratio has shown 65.28% biodegradability of substrates. The results and finding of this study recommend that PS and SG would be used as energy sources rather than dumped in an open environment.*

Keywords: Co-digestion, substrate ratio, switchgrass, petroleum sludge, Methane yield, volatile solids reduction

INTRODUCTION

It has been identified that the combustion of fossil fuels is the major contributor to both environmental pollution and greenhouse gas emissions in five major sectors, namely power generation, food and agriculture, transportation, industry and economy, and households [1]. Petroleum sludge (PS) is a mixture of wastewater, waste oils, chemicals, and minerals. The petroleum industry generates sludge on a large scale through various sources such as drilling, refining, production, and processing, which leads to environmental pollution [2]). The anaerobic co-digestion with greenish waste sludge can be a source of energy and reduction of waste equally. Such waste can be the origin of renewable energy in the shape of CH_4 and helps in mitigating waste sludge volume [3, 4]. Organic matter is converted to water, methane, and carbon dioxide by bacteria during aerobic and anaerobic digestion. This is a viable technology for higher water content, in contrast to other biodegradable sludge energy recovery technologies. B. Incineration, pyrolysis, gasification. [5 6, 7].

Proximate analysis was employed to ascertain the relative proportions of ash, volatile matter, and fixed carbon in each sample, expressed as a percentage on a dry basis, following specific heating conditions [7]. Many studies have reported the production of methane from petroleum by co-fermentation with other organic wastes such as crop residues, Egeria densa, CaO-CKD, red mud, grasses containing pig manure, sewage sludge, shredded grass, and crude glycerin. can be increased. "Sewage sludge and sugar beet pulp". "Leaching". It is said that the digestibility of sludge increases by 13.95 times when it is digested at the same time as garbage. Proximate analysis was employed to ascertain the relative proportions of ash, volatile matter, and fixed carbon in each sample, expressed as a percentage on a dry basis, following specific heating conditions [9].

However, some studies have found increased CH_4 production when using grass as co-digestion, and no studies on biogas production by co-digestion of petroleum sludge and switchgrass (Panicum virgatum) are found in the literature. yeah.

The biological treatment of spent petroleum hydrocarbons (PHW) is poorly documented in the literature. One reason for this is the limited knowledge of optimal conditions for the digestion and biodegradation of PHW waste. The purpose of this study is to investigate the anaerobic digestion of PS by SG in a batch reactor under mesophilic conditions containing total solids (TS). The purpose of the study is to measure the production of biogas and methane from PS and SW (Panicum virgatum) with different mixing ratios tested at moderate temperatures.

METHODOLOGY

The Switchgrass was collected from Hyderabad, and the sample of Petroleum sludge was acquired from OGDCL field Tando jam. Both samples for further processing had taken to the Institute of environmental engineering. The net weight of SG and PS was 1 kg and 2kg respectively.

Pre-treatment of Switchgrass (SG) and Petroleum Sludge (PS)

The SG pretreatment was carried through physical pretreatment through size reduction of it. Initially, the switchgrass was cut by scissors and was kept in an oven at 80 C for a period of 24 hr. [11]. The dried SG was further taken for size reduction because the course-grind size of SG doesn't work well it was examined the less methane yield and the energy conversion efficiency and it caused the mixing and digestion problems [8]. The dried switchgrass is collected and it was further ground in a size reduction machine, dried grass was passed from the sieve size of 4.57 mm to get equal particle size [12]. Initially, the pH of SG was 6.54 but the pH of petroleum sludge was 5.03 to stabilize the pH sodium hydroxide was added to balance the sludge. The sludge is acidic and was thermochemically treated with sodium hydroxide (3 g/l) at 100 C and 150 rpm for 1 hour to maintain the required pH range during the anaerobic digestion process and to increase the pH. was properly pretreated.

Proximate and ultimate analysis:

Proximate analysis was performed using standard methods outlined by the American Public Health Association (APHA). The experiment is carried out on Oven Dry, the sample was put into a dry oven for 24 hr at 105ºC, for a Muffle furnace the sample is kept within MF at a temperature of 550 C for 2 hr. Various variables were analyzed before and after the test. The ultimate analysis of the values of CHONS was acquired from the literature, PS = [8], SG= [1]**Batch Experiments for Methane Production for AMPTS**

An automated methane potential test system "AMPTS" is used to measure the biomethane yield. was used by. The reactor was filled with samples by filling different ratios of PS: SG (R1=100:0).

R2=(00:100), R3 (60:40) R5=(40:60) leaving 100 ml for vapor phase accumulation [4].

Inoculum was added from the CSTR present in the lab. The bottles of 500ml were used in AMPTS then nitrogen gas was purged to expel oxygen gas from the reactor. The substrate ratio is in-cooperated in duplicate ratios. The AMPTS batch carried under a mesophilic temperature of 35.5^o C

Physical and chemical parameters were examined using standard methods for water and wastewater analysis (APHA 2005). Table 1 shows the initial properties of the substrate (Petroleum sludge and switchgrass). Methane is primarily based on the properties of the substrate and its composition of superior quality produced in batch mode.

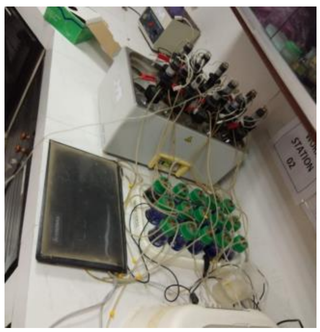

Fig 3 Substrate ratio samples **Fig 4 AMPTS setup**

Volatile acids present in the substrate show a relationship between the pH and alkalinity response of the biogas composition. [12]

THEORETICAL BIOCHEMICAL METHANE POTENTIAL AND METHANE-BASED DEGRADABILITY

Theoretical Biochemical Methane Potential (TBMP) of the PS and SG was obtained by Buswell formula (3.12) Experimental Bio-chemical Methane Potential (EBMP) can be determined by equation (3.14) and Methane Based Degradability (MBD) can be found by dividing EMBP with TMBP (4) (HF et al. 1952, Oran et al., 2011, Zhou et al. 2011, Sahito et al. 2014)

$$TBMP = C_aH_bO_cN_d + \frac{4a-b-2c+3d}{4}H_2O \rightarrow \frac{4a-b-2c-3d}{8}CH_4 + \frac{4a-b+2c+3d}{8}CO_2 + dNH_3$$

$$TBMP = \frac{2790 \text{ x } H + 930 \text{ x } C + 350 \text{ x } O - 600 \text{ x } N - 175 - S}{C+H+O+N+S}$$

$$MBD\,(\%) = \frac{EMBP}{TBMP}\ X\ 100$$

RESULTS AND DISCUSSION.

Characterization of Sample before and after BMP

Table no 1 is illustrating the result of proximate analysis and ultimate analysis of four substrate ratios to investigate the trends of moister content, T.S, AC, volatile matter, and fixed carbon of each reactor on a percentage dry-basis after heating under specified conditions.

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Fig. 5 Mechanically reduced SG **Fig. 6. Sample of PS**

Table 1. Results of proximate analysis and ultimate analysis before AMPTS batch

Reactor	R1 (100: 0)	R2 (0 : 100)	R3 (60 : 40)	R4 (40:60)	R5 INOCULUM
MC	91.97	94.48	92.10	91.81	98.25
Ts	8.03	5.52	7.90	8.20	1.75
Vs (wb)	11.44	3.10	3.93	2.99	0.86
VS (Dd)	56.00	55.95	61.00	63	48.53
AC (wb)	6.58	2.42	3.56	3.17	0.89
AC (Db)	44.00	56.05	39.00	37	51.47
pH	7.9	8.8	8.6	8.5	7.5
TA mg/l	1800.00	1100.00	1900.00	1600	1600.00
VFA mg/l	410.00	580.00	350.00	370	370.00
VFA/TA mg/l	0.23	0.48	0.25	0.23	0.23
C%	47.49	53.63	49.95	-----------	n.d
H%	6.01	6.25	6.25	-----------	n.d
O%	46.27	34.93	41.73	-----------	n.d
S%	0.11 3	3.16	1.3	-----------	n.d
N%	0.11	1.76	0.77	-----------	n.d
C/N	432	30	65	-----------	n.d

Table no 1. S.D = 5 n.d = not determined

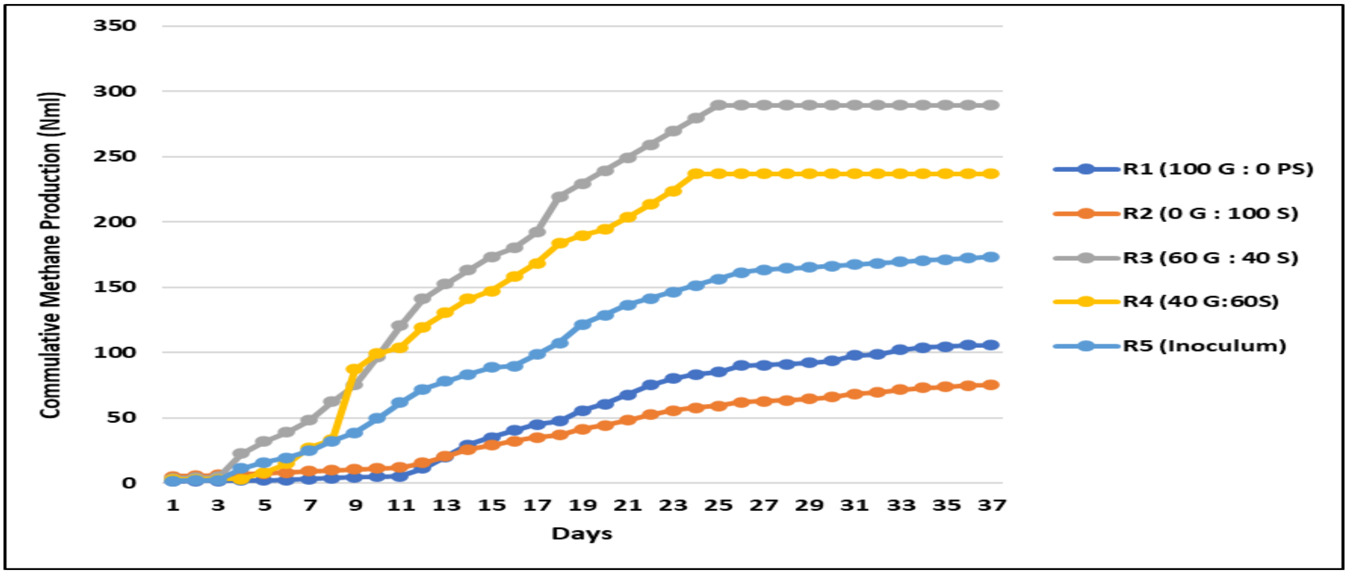

Fig 1 Cumulative Methane Production

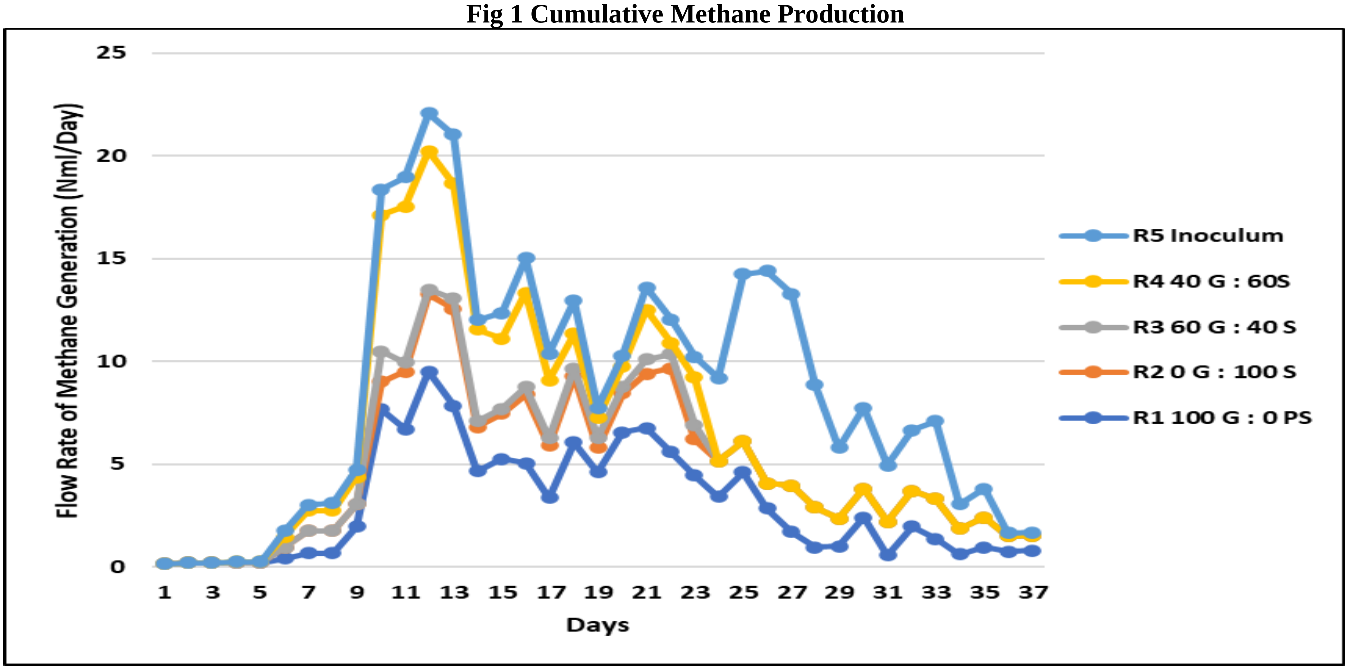

Fig: 2 Flow Rate of Methane Generation

Table 2 Characterization after results after AMPTS.

Reactor	R1 (100: 0)	R2 (0 : 100)	R3 (60 : 40)	R4 (40:60)	R5 INOCULUM
MC	92.98	96.76	85.12	86.33	98.43
Ts	7.93	3.09	14.88	13.7	1.57
Vs (wb)	5.02	1.62	2.38	2.88	0.96
VS (Dd)	64.33	47.6	36.12	32.1	57.88
AC (wb)	2.92	1.48	1.60	1.88	0.61
AC (Db)	35.67	52.53	53.88	67.9	42.12
pH	7.10	6.50	7.90	7.5	7
TA mg/l	1200.00	900.00	1300.00	1250	1800
VFA mg/l	390.00	480.00	250.00	290	480
VFA/TA mg/l	0.32	0.53	0.15	0.25	0.23

THEORETICAL BIOCHEMICAL METHANE POTENTIAL AND METHANE-BASED DEGRADABILITY

Table 3 TBMP at different ratios of substrate

Ratios	Chemical formula with sulfur	Chemical Formula with Nitrogen	TBMP (NmL/gVS)	EBMP (NmL/gVS)	MBD (%)
R1G (100:0)	$C_6H_{100}O_{41}S$	$C43H_{217}O_{124}N_2$	235.52	105.7	44.9
R2 (0:100)	$C_{43}H_{236}O_{10}S_0$	$C_{81}H_{970}O_{41}N_4$	302.3484	84.35	28.70
R3 (60:40)	$C_{12}H_{2082}O_{32}S$	$C_{174}H_{8238}O_{128}N_4$	440.3	289.5	65.78
R4 (40:60)	$C_8H_{54}O_{23}S$	$C_{123}H_{219}O_{93}N_4$	463.12	237	54.34

The correlation of PH, TA, VFA, and MBD.

Various parameters such as VFA, pH, and alkalinity are used as indicators to assess the stability of anaerobic methods [3]. Digestive processes can be adversely affected by low pH, resulting in increased VFAs and inhibition of low methane methanogenesis [22]. The VFA/TA ratio is another important parameter that influences digestion stability [19]. Table 2 shows the measured values of TA, VFA, and pH in wastewater at the end of the Automatic biochemical methane potential test (AMPTS).

Values clearly indicate the MBD in the R3 reactor is 65.78 % has increased the total alkalinity and decreased the VFA of R3, the pH of R3 is 7.9 and it has the lowest VFA among all reactors, and the highest methane yield of 290 Nml/g.VS, however, Reactor 2 has a pH of 6.5, and the lowest methane yield of 85 Nml/g-vs the R1 has a high VFA of 480 mg/l, it shows the R1 reactor is more inclined to acidogenesis which is one of the main reasons for low methane production. Nevertheless, it analyzed low methane generation illustrated in reactor substrate in which PS ratio is high.

CONCLUSION:

Land pollution and it management is one of the rising issues worldwide, this study was conducted to manage toxic waste like petroleum sludge and energy crop switch grass. It can be utilized through an environmentally friendly approach to co-digestion. Co-digestion can help in recovering energy in the form of methane. In this study, the different substrate ratio was analyzed and it was revealed that the highest methane generation was shown in substrate R3 60:40 = 289.5 Nml/g.Vs and has MBD = 65.78 % at mesophilic temperature 35.5^0 C

RECOMMENDATION:

It is recommended to use any reagent to reduce the toxicity of petroleum sludge. Biological as well as chemical pretreatment are recommended to enhance the degradability of switchgrass.

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