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Biogas Production from Agricultural Wastes

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Abstract: wheat straw, groundnut shells and sugar cane bagasse were selected as agricultural wastes, to study the possibility of producing biogas , by the process of anaerobic fermentation , as well as to study the effect of the addition of poultry droppings, on gas production from wheat straw and sugar cane bagasse .Chemical analysis of these agricultural wastes showed small differences in total solids, volatile solids, organic carbon and cellulose content. While higher differences were observed in lignin and total nitrogen content and consequently in C: N ratio. No significant differences were observed, in biogas volumes produced and methane content, between the physically treated samples and the control. Addition of poultry droppings significantly increased the biogas volumes produced for both wheat straw and sugar cane bagasse. Chemical analysis, of anaerobic sludge, showed reduction in cellulose and increase in lignin content.

Key words: Wheat straw,groundnut shells,sugar cane bagasse, biogas

INTRODUCTION

Agricultural residues, when used as fuel, through direct combustion, only a small percentage of their potential energy is available, due to inefficient burners used. Therefore anaerobic fermentation to produce a combustible, clean, healthy and economic gas is one of the alternative options, for changing the pattern of agricultural residues utilization[1]. The main problem with anaerobic fermentation of crop residues is that, most of agricultural residues are lignocellulosic, with low nitrogen content[2]. To improve the digestibility agricultural. residues, many attempts have been done, by reduction of size[3], electron irradiation[4] and heat treatment[5]. While for optimizing their C: N ratio, mixing of agricultural residues with animal manure is usually recommended[6]. The objectives of this study were to evaluate the potential for producing biogas from what straw, ground peanut shells and sugarcane bagasse and to study the effect of poultry droppings addition on biogas production from wheat straw and sugarcane bagasse.

MATERIALS AND METHODS

Materials: wheat straw, groundnut shells were brought from the Gezira Scheme and sugar cane bagasse was from Alguniad sugar cane factory. Dry healthy samples of normal texture were collected. Parts of these wastes were dried and chopped into small pieces and kept for experimental use, another parts were dried and powdered with an electric grinder and stored for experimental use and chemical analysis. Poultry droppings were collected from small holding laying hens. Digested sludge from a biogas digester, working on cow dung, was used as inoculum.

Analytical methods: Total solids, volatile solids, total nitrogen and ash content of wheat straw, groundnut shells, sugar cane bagasse and poultry droppings before and after anaerobic fermentation process were estimated by the methods described by[8]. Total carbon was determined according to Walkely Black methods as described by Page *et al.*,[9]. Cellulose, hemicellulose and lignin were determined according to the procedures described by Vansiest and Ones[10].

Experimental methods: Hundred grams total solid of chopped and powdered wheat straw, groundnut shells and sugar cane bagasse were fed separately to six digesters (3 Liters). Batch type anaerobic digestion, connected to the brine solution system, was adopted. Inoculum and water were added; digester contents were mixed thoroughly and stirred by hand twice a day for five minutes. In another experiment, what straw and sugar cane bagasse were separately mixed with poultry droppings in 1:1 ratio (dry weight basis). All treatments were replicated with two-batch digester and operated for 42 days. Gas measurement was started only after production of combustible gas and its rates were recorded daily and several samples of gas were analyzed for methane according to the method described by[11].

Statistical analysis: Data was assessed by analysis of variance (ANOVA), and by Duncan's multiple range test[12].

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RESULTS AND DISCUSSION

The initial values of Told Solids (TS) Volatile Solids (VS) Organic Carbon (OC) Total Nitrogen (TN), cellulose, hemicellulose, lignin, as well as C/N ratio, of wheat straw, groundnut shells, sugar cane bagasse and poultry droppings before anaerobic fermentation are shown in (Table 1). The results of total solids, volatile solids, organic carbon and cellulose, showed little variation between different agricultural residues. On the other hand, the values of lignin content of wheat straw, groundnut shells and sugarcane bagasse, which were 7.75, 24.27 and 22.00% respectively, indicated that most of the cellulose of groundnut shells, sugar cane bagasse was not available for bacterial degradation and this provides justification for the differences in their microbial degradation, due to the fact that digestibility of a substrate is a function of its lignin content[13]. The differences in total nitrogen content of the substrates under study were reflected in their C:N ratios, which were beyond the optimum range of C:N ratio for biogas production, which is 25-30, as reported by[14].

The result of total biogas production as shown in (Table 2), indicated that, there was a highly significant difference (p= 0.05) between different three substrates. No statistical difference was observed between the physically treated wheat straw, groundnut shells and sugarcane bagaase compared to the control, except for ground nut shells. These results are in accordance with what was reported by Hashimoto[3], who stated that physical pretreatment of Agricultural waste did not incase its digestibility.

Table 1: Chemical composition of wheat straw, groundnut shells, sugar cane bagasse and poultry droppings before anaerobic fermentation

Item	Wheat straw	Groundnut shell	Sugarcane bagasse	Poultry droppings
Total solids (%)	95.76	95.4	94.67	80.0
Volatile solids (%)$_a$	86.48	88.33	93.77	66.55
Ash content (%)	13.52	11.67	6.23	33.55
Organic carbon (%)	40.93	42.67	44.10	33.2
Total nitrogen (%)	0.516	1.07	0.335	2.74
Cellulose (%)	38.83	34.91	35.4	-
Hemi cellulose (%)	27.67	10.3	18.3	-
Lignin (%)	7.75	24.27	22.0	-
C/N Ratio	79.34	39.85	131.34	12.04

Table 2: Total biogas production from treated wheat straw, groundnut shells and sugarcane bagasse (L / Kg TS.)

Item	Untreated substrates (control)	Physically treated substrates
Wheat straw	46.60 (± 0.61)^a	46.00(± 0.97)^a
Groundnut shells	08.40(± 0.59)^b	18.30(± 096)^c
Sugar cane bagasse	00.02(± 0.001)^d	00.08(± 0.002)^d

Values are means (± Standard deviation SD)

Table 3: Methane content of biogas from treated wheat straw, groundnut shells and sugarcane bagasse (%)

Item	Untreated substrates (control)	Physically treated substrates
Wheat straw	53.90(± 0.81)^b	62.8(± 0.74)^a
Groundnut shells	58.30(± 0.59)^b	58.6(± 0.94)^a
Sugar cane bagasse	ND	ND

Values are means (± Standard deviation SD)

Table 4: Chemical composition of wheat straw, groundnut shells and sugarcane bagaase after anaerobic fermentation.

Item	Wheat straw	Groundnut shell	Sugarcane bagasse
Total solids (%)	18	18.2	8.8
Volatile solids (%)$_a$	85	93.5	86.4
Ash content (%)	38	31.0	42.0
Cellulose (%)	24	33.0	22.6
Hemi cellulose (%)	24	14.0	21.8
Lignin (%)	15	6.5	13.6

Values are expressed as percent of total solids except total solids

Table 5: Means of total biogas production from treated wheat straw, groundnut shells and sugarcane bagasse (L / Kg TS.)

Item	Biogas Volumes
Wheat straw	046.60(+ 0.61)
Sugarcane bagasse	000.02(+ 0.001)
Wheat straw + Poultry droppings	104.6 (+3.38)
Sugarcane bagasse + Poultry droppings	051.52(+ 10.5)

Values are means (± Standard deviation SD)

The methane content of biogas, showed no significant differences between different substrates and between the physically treated substrates and the untreated ones (Table 3), which were lower than that of animal wastes. This may be attributed to the general dominance of carbohydrates material in agricultural residues at the expense of protein and lipids which have been reported to be essential precursors to methane[15].

Table (4) shows the chemical composition of wheat straw, groundnut shells and sugar cane bagaase after anaerobic fermentation. It was observed that cellulose content was reduced by the process of anaerobic fermentation. While lignin content increased due to reduction of cellulose.

Total biogas production values from poultry droppings, poultry droppings mixed with wheat straw and poultry droppings mixed with sugar cane bagasse, were shown in (Table 4). It was observed that the yield from poultry droppings mixed with wheat straw was almost double that of poultry droppings mixed with sugar cane bagasse and poultry droppings alone. .

This results indicated that the processes of biogas generation from a mixture of animal manure with carbonaceous substrate proceeds better than that of animal manure alone and this in agreement with what was reported by[16] who found that the biogas production from swine manure supplemented with maize stalks was enhanced in excess of 50% than non-supplemented manure.

CONCLUSION

From our results, it can be concluded that wheat straw, groundnut shells and sugar cane bagasse can provide an alternative feed stock for biogas production. On the other hand physical treatment does improve neither the quantity nor the quality of biogas. Poultry droppings regulate the process of biogas production from agricultural wastes.

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