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RESEARCH ARTICLE

MANURAL VALUES AND POLLUTION ABATEMENT STUDY OF EFFLUENT AND SLUDGE GENERATED FROM BIOGAS DIGESTER RUN ON VEGETABLE WASTE

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ABSTRACT

Excessive use of chemical fertilizers has led to the environmental pollution by causing soil salinity, heavy metal accumulation, water eutrophication, nitrate accumulation and air pollution. Thus, there is urgent need to use organic fertilizers for sustainable development of agriculture sector. Production of biogas and manure through anaerobic digestion serve as means of recycling of organic matter. Vegetable waste generated in large quantities in markets can be used for production of biogas through anaerobic digestion. The objective of the present study was to study manural value of effluent and sludge generated from biomethanation of vegetable waste. The chemical analysis of effluent and sludge were done using standard methods. The Nitrogen, Phosphorous and Potassium values obtained from the effluent were 0.06 %, 0.010 %, and 0.069 %; from sludge were 0.23 %, 0.019% and 0.090 %. Micronutrients were also present in considerable quantities. The results reveal that the digester effluent and sludge has good manural value and can be effectively used as supplement with other organic fertilizers. The reductions of TS, VS, BOD, COD and MPN of coliforms during biomethanation of vegetable waste were found to be 75.62%, 85.90 %, 93.62%, 92.35 % and 86.25% respectively which helps in reduction of pollution potential of vegetable wastes.

INTRODUCTION

The indiscriminate use of chemical fertilizers has decreased the yield and nutritive value of crops. Its excess use also has resulted into the soil and water pollution (Bakhsh *et al.,* 2007). The use of chemical fertilizers encourages use of chemical pesticides for the control of pests that gradually develops tolerance and requires high doses to control pest. The application of high doses further results in reducing microbial activities in soil and cause hazards to environment and community. Hence there is urgent need to use organic fertilizers for sustainable development of agriculture. Organic fertilizers are cost effective giving higher yield of crops and require less intake of chemical pesticides. Biomethanation serve as a means of recycling of organic matter (Margareta *et al.,* 2006) Biomethanation is the anaerobic digestion of organic matter by putrefactive bacteria in anaerobic conditions. The organic matter being converted into biogas and liquid nutrient enriched effluent. The process also significantly reduces the load of pathogenic organisms (salmonella and clostridium) as well as disease causing indicator organisms including faecal and total coli forms (Issah *et al.,* 2012). The effluent is a valuable organic fertiliser and can be used to replace chemical fertilizers (Lukerhust, *et al.,* 2010).

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The application of liquid effluent has proven to be very successful on several crop fields (Loria *et al.,* 2007; Chantigny *et al.,* 2007; de Boer, 2008). Manure applications to soils have enhanced soil quality and fertility compared to soils receiving synthetic fertilizers (de Boer, 2008; Arthurson, 2009). The effluents from biogas plants are liquid and contain approximately 93-98% water and 2-7% dry matter (Berglund, 2006). The nitrogen, (N), phosphorus (P), and potassium (K) are transformed from organic forms to inorganic forms while the carbon is converted to biogas. The organic forms of nitrogen are converted into ammonium-nitrogen of about 20% (Frost and Gilkinson, 2010) in the effluent compared to the influent. It also provides micro-nutrients that are essential for plants. The effluent coming out of the digester is odor less, repels termites and is found to reduce weed growth. Thus, effluent obtained after anaerobic digestion formed superior quality manure.

In India, about 320 million tonnes of agricultural waste are generated annually (Suthar *et al.,* 2005) of which vegetable waste alone is in major proportion. Vegetable markets produce huge quantities of these wastes per day. They are highly perishable and serve a source of nuisance. The collection, transportation and disposal of vegetable waste from markets is a very serious problem today. Vegetable wastes are responsible for great amount of environmental pollution (Diaz *et al.,* 2007).

Uncontrolled dumping in municipal landfills and spreading on land bears several adverse consequences such as land, water and air pollution (Kumar *et al*. 2009). It also contributes to global warming by emitting methane. It further promotes the breeding of flies, mosquitoes, rats and other disease vectors at the disposal site and cause hazards to human health (Zurbrugg, 2002). In the present study work was undertaken to determine amenability of vegetable waste for biogas production, manural value of generated effluent and reduction in pollution potential of vegetable wastes.

MATERIALS AND METHODS

Materials

- Vegetable waste
- Inoculum from cattle dung based biomethanation plant
- 5 L capacity biogas digesters (KVIC design of floating dome type)
- Combustibility testing assembly
- Gas measurement assembly
- Gas chromatography assembly
- Chemical reagents

Methods

Collection, preparation and storage of sample

The vegetable wastes for the present study were collected from the local vegetable market. The collected wastes were further segregated into individual vegetable waste types. The equal proportions of dominating individual wastes (viz. Potato, Onion, Cabbage, Cauliflower, Tomato and Brinjal wastes) were mixed in the laboratory, shredded and ground in a kitchen blender to make a paste and stored in refrigerator at 4^0C until used.

Preperation of inoculums

Inoculum was obtained from an active mesophilic digester of cattle dung based biomethanation plant located at Degaon village, M.I.D.C., Satara (M.S.), India. One liter of the inoculums was diluted with two liters tap water to make total working volume as 3 liters for 5 L biomethanation studies. The inoculum was passed through 1mm sieve mesh and used to start the experiment.

Physico-chemical analysis of substrate

The physico-chemical analysis of substrate was determined according to APHA (1998), Trivedi and Goel (1984) and AOAC (1990).

Biomethanation of vegetable waste at 5 L level

Biomethanation studies were carried out in a floating dome design type of 5 liter capacity locally fabricated digesters. The effective volume of each of the reactor was maintained at 3L. The 5 L reactor was operated with daily feeding of the substrate at OLR 0.320 g VS/l.d, HRT of 20 days and pH 7.0 of substrate under ambient temperature conditions with two cycles of 20 days retention time. The volumes of biogas were recorded daily. Combustibility testing and % methane contents were also determined.

Determination of manural values of effluent and sludge

The effluent and sludge generated from 5L biogas digester was subjected to their macroelements (N,P,K) and microelements determinations as per methods described earlier.

Pollution abatement study

The reduction in pollution potential of vegetable waste after biomethanation was studied with reference to % reduction of organic content in terms of total solids (TS), volatile solids (VS), biological oxygen demand (BOD) and chemical oxygen demand (COD). The pathogen reduction efficiency of biomethanation process was also studied by determining most probable number (MPN) of coliforms of both influent and effluent.

RESULTS AND DISCUSSION

Physico-chemical analysis of vegetable waste

The waste was yellowish with foul odour. Chemical characteristics of vegetable waste showed that it was acidic with pH 3.7, which was unsuitable for biomethanation as for biomethanation neutral pH is required. The moisture content of the waste was found to be 89.50%. The COD and BOD contents were 174000 mg/kg and 97150 mg/kg respectively. Starch, cellulose, hemicelluloses, lignin, fat and proteins were present in 9900mg/kg, 8700 mg/kg, 2400mg/kg, 2200 mg/kg, 4000mg/kg and 9081mg/kg respectively. The high moisture and carbohydrate content indicated its suitability for biomethanation. The C:N and BOD:N:P ratio were 15.38 and 962:14:1respectively which indicates slight nitrogen deficiency(Bouallagui *et al.,* 2009; Weiland, 2006). The potassium was also present in significant quantity (538mg/kg).Total solids content 44300 mg/kg and total volatile solids content 38300 mg/kg further showed its suitability for biomethanation.

Biomethanation at 5 L level

Biomethanation of vegetable waste at 5 L level was carried out using 20 days HRT, 0.320 L/g. VS/d OLR, 7.0 pH of influent and at ambient temperature conditions (30-40^{o}C). Range of biogas produced was 510-1340mL/d, total amount of biogas produced in 40 days experiment was found to be 40515mL and average amount of biogas was 0.633L/g VS.day.

Manural values of effluent and sludge

The results of manural values of effluent and sludge are represented in Table 1. Chemical analysis of effluent and sludge from 5 L biogas digester showed good manural potential. The sludge is alkaline as compared to supernatant but overall the effluent is neutral. The N, P and K values obtained from sludge and effluent were 0.23 %, 0.019%, 0.090 % and 0.06 %, 0.010 % and 0.069 % respectively. The values of Total ash, Total solids, and total volatile solids, N, P and K from sludge are higher as compared to the effluent. The micronutrients like Iron, Manganese, Zinc and Copper were present in considerable quantities in both effluent and sludge. The results showed that the sludge and remaining effluent has good manural value to be used as a supplement to fertilizers in agriculture.

Table 1. Manural values of effluent and sludge generated at 5 L VW biomethanation digester in mesophilic conditions

Sr. No.	Parameter	Unit	Effluent	Sludge
1.	pH	-	5.89	8.18
2.	Total moisture	%	98.92	90.58
3.	Total ash	%	0.54	2.46
4.	Total solids	%	1.08	9.42
5.	Total volatile solids	%	0.54	6.96
6.	Nitrogen	%	0.06	0.23
7.	Phosphorous	%	0.010	0.019
8.	Potassium	%	0.069	0.090
9.	Iron	-	35.78 mg/l	162.64 mg/kg
10.	Manganese	-	6.64 mg/l	9.24 mg/kg
11.	Zinc	-	0.15 mg/l	0.28 mg/kg
12.	Copper	-	0.07 mg/l	1.89 mg/kg

Pollution abatement study

Performance of 5L VW biomethanation digester in terms of reduction of environmental pollution is represented in Table-2.

Table 2. Pollution abatement study of vegetable waste

S.No.	Parameter	Influent	Effluent	Reduction (%)
1.	BOD 5 days at 20^0C (mg/L)	97150	6200	93.62
2.	COD(mg/L)	1,74,000	13314	92.35
3.	Total solids (mg/L)	44300	10800	75.62
4.	Total volatile solids (mg/L)	38300	5400	85.90
5.	MPN of coliforms	240	33	86.25

The reductions of TS, VS, BOD and COD at 5 L vegetable waste biomethanation were found to be 75.62%, 85.90 %, 93.62% and 92.35 % respectively. The reduction efficiency of most probable number of coliforms was found to be 86.25%. The results indicated that the biomethanation process significantly removes the load of organic matter and pathogens from the vegetable wastes.

Conclusion

- The determination of manural value and pollution abatement study of effluent and sludge generated from biomethanation of vegetable waste has been carried out in a 5 L capacity floating dome design type of reactor.
- The physico-chemical analysis of vegetable waste reveals that it is highly amenable for biomethanation since it contains high percentage of moisture and carbohydrates.
- Chemical analysis of effluent and sludge from 5 L biogas digester showed good manural potential. The NPK values obtained from sludge and effluent were 0.23 %, 0.019%, 0.090 % and 0.06 %, 0.010 % and 0.069 % respectively.
- Biomethanation reduces the pollution potential of vegetable wastes. The reductions of TS, VS, BOD and COD at 5 L VW biomethanation were found to be 75.62%, 85.90 %, 93.62% and 92.35 % respectively. The biomethanation process also reduces the load of pathogens to a great level.
- Thus, biomethanation, a microbiological treatment option appears to be effective for recycling of vegetable waste with good quality organic fertilizer and reduction of pollution load which helps in sustainable development of the agriculture.

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