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Biomethanation study on some common Agro-industrial Organic wastes

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Abstract

India is in developing stage and requires high amount of energy to meet the increasing demand due to economic and industrial developmental activities. Almost all countries are using currently non-renewable energy sources to satisfy their energy requirement but these sources have numerous limitations and drawbacks. The energy resources which are renewable in nature have several advantages and benefits as far as our social, economic and ecological angles are concerned and to go towards sustainable development of environment, so that future generations will not get compromised. Biomass includes the plant and animal based organic matter and organic wastes of their origin. Biomass is converted into energy by several physical, chemical and methods of biological origin. India is basically agricultural country and organic waste is generated daily in large quantity. The generated wastes are highly perishable due to their high moisture and organic matter content. The management of the wastes from these sectors with inappropriate treatment methods cause the deterioration of health of environmental. Hence, the present study was focussed to study biomethanation of vegetable wastes with other agro-industrial wastes (viz. cattle dung, fruit waste, poultry waste and distillery waste) and the objectives were to treat these wastes to generate energy in the form of biogas energy and to study decrease in pollution potential of environment. The results indicated these agro-industrial wastes can be used as potential substrate for biomethanation to reduce its environmental pollution potential and sufficient energy generation in the form of biogas.

Keywords: Agro-industrial wastes, environmental pollution, co-digestion, energy.

Introduction

The majority of energy of world i.e. 85% is obtained from non-renewable energy resources. India needs high amount of energy to fulfil the energy demand required for growing economic and industrial development. Like other nations, India also is dependent on non-renewable energy resources as its main source of energy. These resources are limited in nature and thus are extensively exploited and hence are under pressure and will get exhausted very soon at the same rate of their usage rate, and there will be question mark for future energy requirement. Thus, India has to focus on the available renewable energy sectors like solar, wind, hydropower, biomass including municipal-industrial wastes and India due to advancement in science and technology sector has a potential to exploit these renewable energy resources to fulfil energy needs.

Biomass is the material from biological organisms especially from plants and animals, remnants resulting from agriculture and forest resources and waste arising from the origin of municipalities and various industries[1].

The use of biomass to generate energy by thermo- chemical based methods and methods based on bio-chemical approaches. Organic waste can be utilized to produce biogas energy by digestion in anaerobic mode. This organic waste resulting from agriculture and forest resources and waste arising from the origin of municipalities and various industries causes the pollution of soil, air and water resources from the environment[2].

India is reported to be the major producer of fruits and vegetables. In India, the quantity of variety of fruits and vegetables India is around 150 million tons. The waste generated from these areas comes to around per year 50 million. These wastes upon its disposal in landfills by several Municipalities causes extensive air, water, soil pollution[3]. Fruit and vegetable wastes are generated due to poor and inadequate transportation, collection and marketing practices. The common disposal methods like landfill and incineration cause serious environmental and health risks[4]. India has the largest population of livestock of over 300 millions which produce about 980 million tonnes of dung. Most of the cattle dung are disposed in landfills or are applied to the land without treatment. These inappropriate disposal methods can cause adverse environmental and health problems such as pathogen contamination, odour, air borne ammonia, greenhouse gases, etc[5]. The distilleries are listed at the top in the “Red Category” industries having a high polluting potential by the Ministry of Environment and Forests, Government of India[6]. The distilleries generate wastewater called spent wash. The disposal of spent wash causes soil and water pollution. Poultry industry waste includes a mixture of faecal and urinary excreta, bedding material or litter, waste feed, dead birds, broken eggs, feathers dropped and removed in poultry sheds and water released after flushing systems[7]. The disposal causes water and air pollution, and hazards to human health[8-10]. The use of organic wastes as an optional source of energy offers several useful advantages including very easily and available at local source, no need for transportation and hence saving transportation expenditure, greenhouse gases will be generated at reduced rate and hence very negligible pollution of environment, and don't have to depend on limited reserves of fossil fuels.

Biomethanation is degradation of organic matter from biological source in anaerobic environment especially using closed vessels that we call as digesters with all other accessories that provides environmental conditions in controlled way to generate biogas and nutrient rich effluent released from the digester can be used as soil conditioner[11]. India being agricultural country and has huge scope to get energy from these ample of wastes. The biomethanation can be a zero pollution technology. Hence, the aim of study was to perform anaerobic co-digestion of mixture of agro-industrial wastes in order to produce energy and reduce the pollution potential of these wastes.

Materials and Methods

Collections and preparations of samples: Vegetable wastes (VW) for the present study was collected from Pratapsingh Maharaj Vegetable Market, Satara, M.S., India. Fruit wastes (FW) were collected from local fruit market. The paste was prepared separately from the equal quantity of individual dominating vegetables and fruits respectively. Cattle dung (CD) was collected from a farmhouse near to Satara. Distillery waste (DW) was collected from Ajinkyatara Distillery Industry, Shendre, Satara, M.S., India. Poultry waste (PW) was collected from Poultry located at Karandi, Satara. They were kept in refrigerator at 4^{o}C until used.

Experimental set up: Inoculum constitutes the diluted cattle dung slurry which was collected from active digester previously feed with the slurry of cattle dung. The slurry was filtered to remove coarse sized particles using sieve mesh and till use it was held in refrigerator.

Anaerobic digestion experiments were performed at 1L level. The digesters used had appropriate arrangements to feed the slurry of the substrate, to collect gas and to drain the digester effluent. The digesters used for study were run continuously every day. The digesters were shaken to remove resulted scum. Every experiment before it runs, acclimatization was perfomed using scientific protocol.

The analysis of feed slurry substrate and resulting digester effluent for its physical and chemical properties was done using standard methodology[12].

The vegetable waste and agro-industrial waste (viz. cattle dung, fruit waste, poultry waste and distillery waste) co-digestion experiment were performed in ambient atmospheric conditions. Vegetable waste was mixed with agro-industrial wastes in various proportions as 1:0, 0.75: 0.25, 0.5:0.5, 0.25:0.75 and 0:1. The reactors were operated at HRT of 20 days, substrate pH used was 7. The biogas volumes released every day was measured by method involving water displacement strategy using tray and glass beakers[12]. Biogas volumes from each of digesters were recorded every day. Combustibility was tested by burning the biogas. In order to measure % methane content of biogas from each digester Gas chromatographic analysis was perfomed.

The reduction in pollution potential of vegetable waste and other organic wastes after biomethanation was compared by studying reduction in total solids (TS) and volatile solids (VS) values of initial substrate slurry and outgoing slurry.

Results and Discussion

For co-digestion slurry of vegetable waste used included equal share of potato, Onion, Cabbage, Cauliflower, Tomato and Brinjal vegetables. The slurry of fruit waste included equal quantity of apple, banana, grapes, pomegranate and chiku. Cattle dung, distillery waste and poultry waste was collected in sterile containers and stored in refrigeration conditions before use. The physico-chemical analysis of agro-industrial wastes is represented as per Table-1. The results of physico-chemical analysis revealed that these wastes are highly amenable for biomethanation.

Table-1: Physico-chemical analysis of various agro-industrial wastes

Parameter	Mixed vegetable waste	Mixture of fruit waste, cattle dung, Spent-wash and poultry waste
pH	6.80	6.20
Moisture (%)	89.00	75.19
Total solids (%)	4.43	25.33
Volatile solids (%)	3.83	12.85
Total organic carbon (%)	2.23	7.40
Total nitrogen (%)	0.15	0.46
BOD (mg/L)	97150	54167
COD (mg/L)	174000	117752

The co-digestion of vegetable waste (VW) and agro-industrial wastes was carried out at 20 days HRT, substrate pH 7.0 and under the ambient temperature conditions (30-38^{o}C).

The daily biogas yields in volume (ml) from the co-digestion of VW and mixture of agro-industrial waste (MW) are represented in Figure-1.

Total biogas yield for 0:1,0.25:0.75,0.5:0.5,0.75:0.25 and 1:0 (MW:VW) and equal mixture of VW and agro-industrial wastes combinations in 20 days HRT was found to be 2782ml, 3066ml, 6254ml, 8006ml, 9624ml and 10092ml respectively. The average daily biogas volume for 0:1,0.25:0.75,0.5:0.5,0.75:0.25 and 1:0 (MW:VW) and equal mixture of VW and agro-industrial wastes was found to be 139.1ml, 153.3ml, 312.7ml, 400.3ml, 481.2ml and 504.6 ml respectively. The maximum biogas volume was obtained with the equal mixture of VW and agro-industrial wastes. The highest biogas volume (viz. 618ml) was produced on 9th day of experiment. Figure-2 represents the average biogas yield in terms of L/gm VS degraded during co-digestion of VW and MW in 20 days.

The yield of biogas 0.573 L/gm VS was maximum and was associated with the digester inoculated with the equal mixture of VW and agro-industrial wastes and yield of biogas 0.398 L/gm VS was minimum and was obtained in digester fed with 0.75:0.25 (MW:VW) slurry. Thus during the co-digestion of VW and MW, the highest biogas yield was obtained with the equal mixture of VW and agro-industrial wastes and lowest biogas yield was found with the digester fed with 0.75:0.25 (MW: VW) slurry. The methane content in biogas collected from digester fed with the equal mixture of VW and agro-industrial wastes was 62.18%. Total solids (TS) and volatile solids (VS) percent reduction in digesters operated with the equal mixture of VW and agro-industrial wastes were observed as 69.90% and 79.63% respectively.

These results of digestion of VW and other organic agro-industrial waste in anaerobic way showed higher biogas yield as compared to biomethanation potential of individual waste types[6, 13-21].

Conclusion

This small scale anaerobic digestion study of vegetable waste with other most common type wastes from agricultural and industrial sector shows good potential as far biogas yield is concerned and decrease in pollution potential of these waste is concerned.

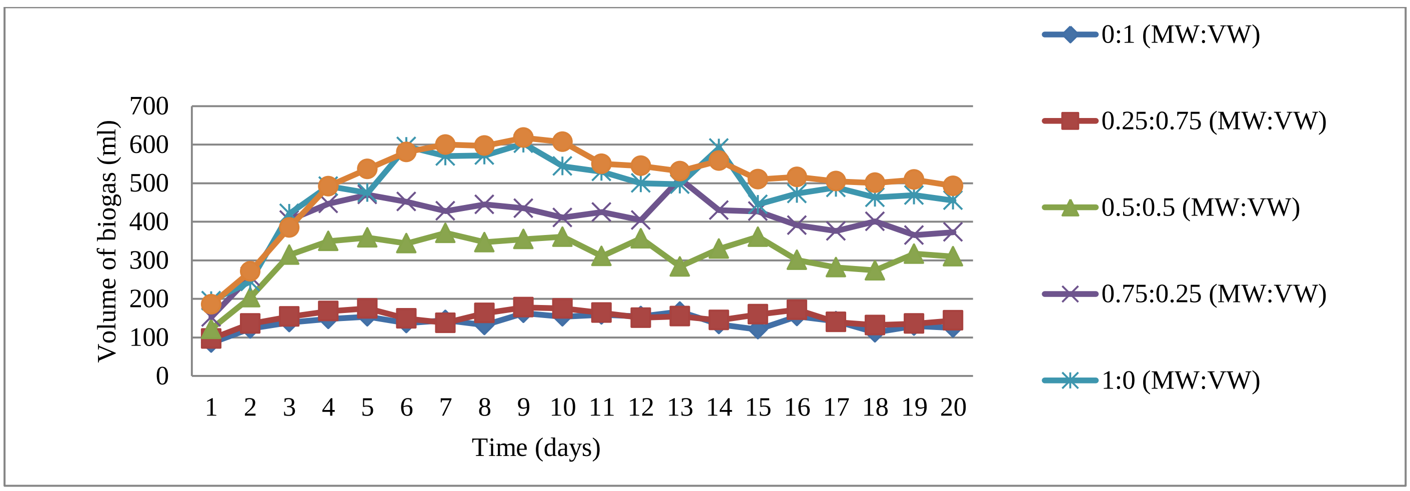

Figure-1: Daily biogas yield from co-digestion of VW with mixed agro-industrial wastes (MW).

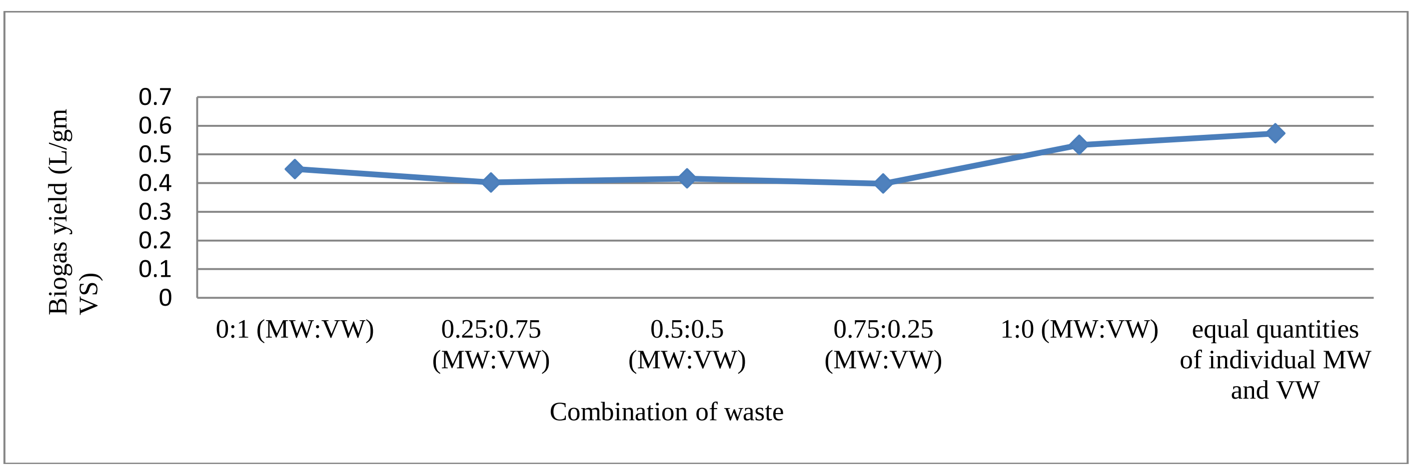

Figure-2: Average biogas yield from co-digestion of VW with mixed agro-industrial wastes (MW).

We recommend that scale up studies based on these wastes can help to set up and these organic wastes can be very effectively used as potential resource for the generation of energy meeting energy thrust of the country and pollution of the environment will not be there as these wastes will not be disposed of in nature.

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