ANAEROBIC TREATMENT OF PEAT AND SAWDUST

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Abstract. Peat should be utilized before utilization of peat next historical substance – brown coal, as the wet peat bogs is source of methane and drained bogs is source of CO_2 emissions. Anaerobic treatment of peat (25%) or sawdust (25%) is performed together with pig manure (50%) and with ferment (25%). In control reactors were used mixture of pig manure 75% and ferment 25%. Percentage of biogas obtained per 1 kg of organic matter varies for peat samples from 36.7 to 60.5% and for sawdust samples from 9% to 84.5% compare to control (pig manure; ferment).

Key words: biogas, peat, sawdust, anaerobic digestion.

Introduction

Humans often are faced with problems how to utilise peat or wood wastes in most environmenttally acceptable way. It is well known, that peat was widely used for burning in furnaces, for increasing of soil organic matter or as growing media in heat plants in last century. Accordingly to legislation in Latvia, energy is considered as renewable, if at least 75% of source material used in power plant is renewable biomass (wood wastes, peat and others).

Accordingly to investigations [1], "the seasonal mean CH_4 emissions from ten natural minerotrophic peatlands in the northern boreal zone of Finland were 8.1–250 mg m^{-2} d^{-1} during a dry summer, and 15–330 mg m^{-2} d^{-1} during a wet summer." Authors estimates, that bogs "in the boreal zone in Fennoscandia, Canada and Russia should be a larger natural source for atmospheric CH_4 than estimated in the global inventories for wetland CH_4 emissions." If the peat areas are drained, methane (CH_4) emissions decreases significantly, but there is increased risk of carbon dioxide (CO_2) emissions as consequence of aerobic degradation of peat and due to accidental fires. For example, it is estimated, that during last 10 years an average of around 2 Bt of CO_2 is released every year from peatlands in Southeast Asia as a result of peatland deforestation, drainage, degradation and fire. This is equivalent to about 30% of global CO_2 emissions from fossil fuels [2]. For this reason, extraction of peat should be done before the mining of next historical stages of peat – i.e. brown coal, what is relatively stable substance, covered by thick ground layer and not polluting atmosphere. Life cycle analysis appears about 10% of the environmental impact of coal, if the peat is produced from former agricultural areas, and roughly more than half of the impact of coal, if peat is produced from fertile areas drained for forestry [3].

In six EU countries (Finland, Ireland, Sweden, Latvia, Lithuania and Estonia) consumption of energy is approximately 120 Mtoe of which about 3.8 Mtoe (3%) is produced by peat. Usage of peat is most significant in Finland, where over 22% of all fuel used by CHP-plants is peat. In Latvia peat resources is around 1.5 billion tons and extracted amount is yearly around 0.6 million tons. Fuel peat is not used at the moment (2004) in Latvia, but there are some plans to increase the share of peat up to 5% of the primary energy, and also to build a reserve supply. The closing of Ignalina nuclear power plant in Lithuania can change the fuel resources of Latvia and Lithuania in the coming years [4]. Low peat usage in Latvia can be explained both by highly developed natural gas network and by environmental considerations, as the combustion of peat causes lot of solid particles and gaseous emissions. Co-firing of peat and wood for energy is better, as can to reduce the SO_2 outlets of peat combustion. Forest area in Latvia covered 2.884 millions ha, total wood amount in 578 millions m^3 with average yield 174 m^3/ha. Amount of wood harvested were 13 millions m^3 in 2003 and yearly additional growth is 16.5 millions m^3. Approximately one third of forest harvested (mainly brushes) is loosed or burned in forest after clear cutting or additionally, around 1 million ha of post-agricultural areas are overgrown with bushes with average yield 40 m^3/ha. Energetical wood covered 28% of summary energy consumption in Latvia in 2003 [5]. Sawdust was produced in Latvia in amount of 91000 and 148640 tons in year 2001 and 2003 respectively. The percentage of sawdust deposited in landfills decreases from 44% (40 000 tons) in year 2001 to 4.7% (7000 tons) in year 2003. Most of sawdust was utilized for production of pellets and briquettes for heat energy production. Approximately 15% of sawdust was exported.

However, combustion of wood for energy can also cause significant amount of ashes, especially, if the small diameter wood (for example, branches) or bark is burned [6]. Peat and wood wastes contains significant amount of plant nutrients and bioactive substances, that are able to facilitate the plants growth [7], improve soil quality and save energy for mineral fertilisers production. Usage of peat and wood wastes for production of methane gas and organic fertiliser will be preferred, as the methane combustion is more environmentally acceptable method compare to burning of solid biomass. Idea is an anaerobic treatment of peat and wood wastes (for example, sawdust), for methane production in energy cells. Problem is that high percentage of lignin in peat and wood wastes can potentially slow down fermentation process. Aim of research is investigation of biogas (methane) volume obtainable from peat and sawdust in anaerobic fermentation process. Mixtures of manure-peat or manure-sawdust are created naturally often, as the peat and/or sawdust are utilized traditionally as litter material in livestock farms. Biogas and organic fertiliser obtained can be successfully applied for local needs at rural farm.

Materials and methods

Investigation was performed help by equipment named F-10, consisting 10 laboratory reactors, each in volume of 3.0 l, see Fig.1. All reactors were provided with common temperature regulation system, providing constant temperature in container 54±1.0 ^{o}C. Liquid ferment (bacteria association) in volume of 0.5 liter and pig manure in volume of 1.5 liters were filled into two reactors. These reactors serves as the controls, due to well investigated characteristics of pig manure fermentation process and in consideration of fact, that optimal content of bacteria association should be around 25% of volume of mixture fermented [8]. The peat in volume of 0.5 liters (30 g dry matter) were co-fermented with 0.5 liters liquid ferment (bacteria) and with 1.0 liter pig manure into each of four reactors.

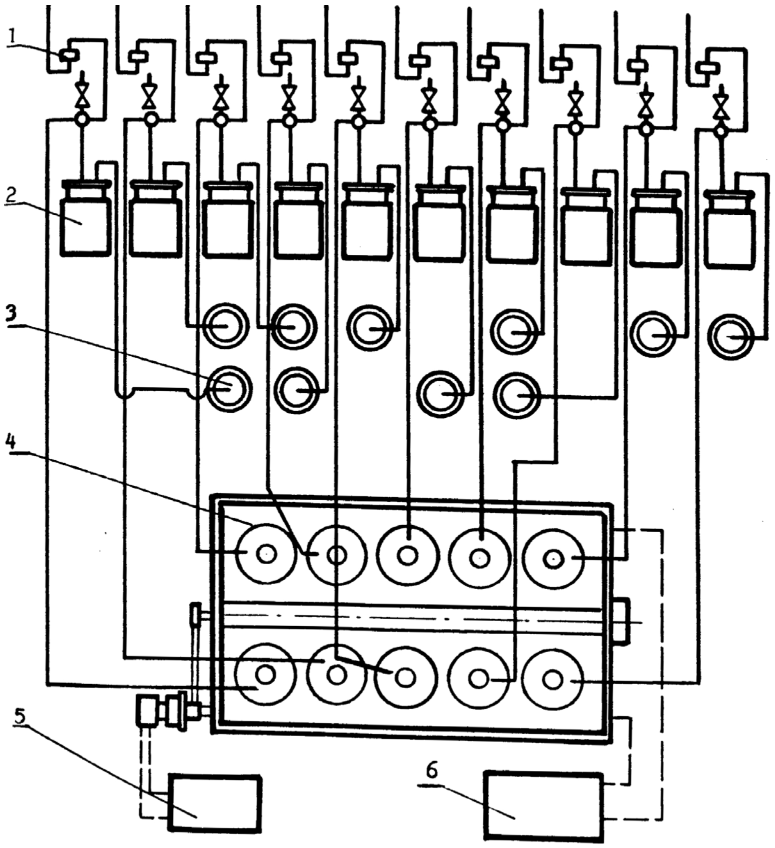

Fig. 1. **Unit for anaerobic fermentation of biomass**: 1 – pressure gauge, 2 – gas cylinder, 3 – receptacle for liquid, 4 – container with bio-reactors, 5 – automatic mixing unit, 6 – automatic temperature maintenance unit

The sawdust in volume of 0.5 liter (67 g dry matter) were co-fermented with 0.5 liter liquid ferment (bacteria) and with 1.0 liter pig manure into next four reactors. Four repetitions were performed for more reliable data obtaining from investigation of relatively small samples, as the peat and sawdust were materials with uneven structure. All reactors were running in thermophilic conditions at temperature 54±1.0 °C during 60-day trial period. Gases released were investigated help by gas-water cylinders 2, initially filled with water (see Fig. 1). Volume of gases released from each reactor was measured as volume of water displaced out of gas-water cylinder during fermentation process. Volume and content of methane (NH_4) and carbon dioxide (CO_2) released were measured help in daily routine. Content of organic mater and pH value were measured both before and after the 60-day fermentation period using standardized methods accepted in Latvia.

Results and discussion

Biogas production activity was highest in control reactors and in reactors containing the peat in first days of anaerobic fermentation process. Gases obtained from peat became flammable after 2-day fermentation period, as the methane concentration in output gases exceeds 20%.

Production of methane initially rises slowly from reactors containing sawdust, but after one week average volume of methane released was equal to methane produced from peat, and the average methane volume was two times above that from peat mixture at the end of experiment. After bioreactors were opened after 60-days treatment period, dry matter and content of organic matter were investigated as well as degraded organic matter and methane volume per 1 kg degraded organic matter were calculated (Table 1.).

Table 1. **Results of anaerobic treatment of biomass**

No.	Start			Finish				Gas obtained	
	Mixture composition*, %	Organic matter, %	pH	Organic matter, %	pH	Degraded organic matter, %	Degree of decay, %	l CH_4 kg DOM	CH_4, %
1	Control (25_f+75_m)	5.67	6.46	1.73	8.05	3.94	69.50	251.05	71.60
2	Peat (25_p+25_f+50_m)	7.03	6.41	2.74	7.58	4.29	61.02	120.43	59.24
3	Peat (25_p+25_f+50_m)	7.03	6.41	2.40	7.95	4.63	65.86	151.98	71.20
4	Peat (25_p+25_f+50_m)	7.03	6.41	2.99	7.64	4.04	57.47	92.15	52.50
5	Peat (25_p+25_f+50_m)	7.03	6.41	2.62	7.65	4.41	62.73	130.25	70.70
6	Control (25_f+75_m)	5.67	6.46	1.73	8.05	3.94	69.50	251.05	71.60
7	Sawdust (25s+25f+50m)	8.08	6.31	3.37	7.80	4.72	58.42	165.52	69.02
8	Sawdust (25s+25f+50m)	8.08	6.31	4.68	5.91	3.40	42.08	22.51	54.50
9	Sawdust (25s+25f+50m)	8.08	6.31	2.19	7.55	5.84	72.29	213.48	70.44
10	Sawdust (25s+25f+50m)	8.08	6.31	4.04	7.70	4.04	50.00	92.36	67.10

* *f – ferment (bacteria); m - pig manure; p – peat; s – sawdust*

Average methane percentage in gas produced features the quality (e.g. heating value) of gas obtained (see Table 1). Results obtained during investigations are more varying for sawdust mixtures and less for peat mixtures. Percentage of biogas was varying for peat samples from 36.7 to 60.5 and for sawdust samples from 9% to 84.5% compare to biogas volume obtained from control reactors (pig manure 75%; ferment 25%).

Large variations in resulting values for sawdust samples can be caused by uneven distribution of parameters within fermented sawdust samples (different size of solid particles, different content of lignine, different sawdust source, etc.). For example, sample composed by foliage tree sawdust may have higher fermentation activity, compare to sample composed by coniferous tree sawdust, due to specific resins persisting in coniferous tree can to inhibit bacteria activity.

There was more even distribution of results obtained for peat samples, perhaps, due to more uniform structure of peat material.

An average biogas output was practically same (123.5 and 123.7 l/kg OM) for sawdust and for peat. Investigated biogas output was 213.5 l/kg OM for most successful sawdust sample (see Table 1), or by 24.5% higher compare to best yield of peat samples. It will be expected biogas production in range of 100 – 150 l/kg OM (organic matter), that would be obtained from peat or sawdust filled into energy cells or heaps.

Conclusions

1. Anaerobic digestion of peat and sawdust is successful, if the ferment (bacteria association) is added in mixture.
2. Percentage of biogas obtained per 1 kg of organic matter was varying for peat samples from 36.7 to 60.5% and for sawdust samples from 9% to 84.5% compare to control (100% pig manure).
3. Maximal biogas output obtained was 213 l and 152 l/kg OMD (organic matter) for sawdust and peat mixtures (25% peat or sawdust; 25% microbial association; 50% pig manure) respectively.
4. The governing factors affecting biogas production from peat and sawdust is uniformity and quality of source material, usage of appropriate bacteria association, pH value and temperature.
5. It is expected biogas production in range of 100 – 150 l/kg OM, that can be obtained from peat or sawdust filled in energy cells or heaps.

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