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IMPROVEMENT OF AGRICULTURAL WASTE AND RESIDUES USE THROUGH BIOGAS PRODUCTION

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Abstract

Processing residues from agriculture for energy production or exploitation of useful materials allows reconnection of crop production and animal husbandry. It becomes also a prerequisite for achieving sustainable agriculture. One of the most common technologies is the anaerobic digestion of plant and animal residues and wastes (manure, straw). As a result of the process, biogas (methane up to 80 %) is produced. This could be used further as fuel for transportation and heating, and in availability of a generator also for electricity production. The fermentation residues are biomass containing essential elements such as nitrogen, phosphorus and potassium, and could be used further as fertilizer.

Key words: agriculture, energy, fertilization, wastes processing.

Introduction

Processing of residues from agricultural production is a major challenge to farms owners from both environmental and economic point of view. Agricultural residues and waste could produce, through a variety of technologies, energy (briquettes, pellets, methane) that reduce greenhouse gas emissions and replace fossil fuels which in Bulgaria are mostly imported. The actuality of the problem for reutilization of farm residues in EC is the reason for funding of the project INEMAD (2012–2016) under the Seventh Framework Programme. Agricultural University and National Biomass Association are partners in this project from Bulgarian side. The project aims to Improve Nutrients (nitrogen, phosphorus and potassium) and Energy Management through Anaerobic Digestion of agricultural residues.

The first pilot biogas installations in Bulgaria have been created between 1980 and 1988 (Baykov and Petkov 1984) but after 1989 they have been snapped up. The first two biogas working installations in the past have been situated close to Silistra and Pleven, in large poultry farms. Later, a scientific project on biogas from animal manure has been developed in Bulgarian Agricultural Academy. In that facility a biogas installation for small size agricultural farms has been designed by Benev et al. (1994). Recently, a paper describing new pilot-scale biogas plant with a computerised monitoring and control system was developed in the Institute of Microbiology of Bulgarian Academy of Sciences by Simeonov et al. (2012). The last publication on biogas has been an assessment of socioeconomic impact from the implementation of biogas production in Bulgaria in the Master Thesis of Stoyanov (2013). The total potential of biogas production in Bulgaria estimated on the basis of data from Ministry of Agriculture and Food, 2011 gives an energy value of 22.2 PJ.

The total number of biogas installations in Bulgaria in 2011 was 3 (Anonimus 2013), all three having processed sewage sludge.

Materials and Methods

Strong restrictions concerning the deposition of animal manure are accepted in the countries of EU related to the ecological requirements for clean soil, underground water and greenhouse gas (GHG) emissions. Farmers are forced to search for ways of waste processing in utilizable products with commercial value. One of the most popular methods is the anaerobic digestion, that results in biogas production and reduction of CO_2 and CH_4 emissions (Anonimus 2009). The dry residue of digestion represents biomass, containing important nutrients as nitrogen, phosphorus and potassium, which could be used for improving soil fertility.

In the frames of project INEMAD the potential of Bulgarian animal husbandry is investigated in order to reveal the possibilities for production of biogas from animal manure, as well as the possibilities for production of standardized fertilizer from the residues of anaerobic digestion (digestate). The feasibility of the project depends on the product's economical parameters.

Data for the evaluation of the potential of Bulgarian animal husbandry have been taken from the Statistical Yearbook (2013).

The energy (*E*) in MJ, obtained from animal manure having mass (*M*) in *t*, can be calculated according the relation (1):

$$E = 22.6\, M \cdot P_{CH_4} \quad (1),$$

where P_{CH_4} is methane yield in m^3 from 1 ton of manure, and the energy of 1 m^3 methane is 22.6 MJ.

Results and Discussion

According to the official statistical data of FAOSTAT the distribution of animal husbandry in Bulgaria is the following: poultry – 84.39 %; sheep and goats – 9.15 %; cattle – 2.94 %, pig-breeding – 3.25 % (Figure 1).

From Figure 1 it can be seen, that poultry represents the more serious resource for processing of animal manure.

The concept of 'animal unit' is introduced on biogas production. One 'animal unit' per twenty-four-hour period gives waste (excrements), from which about 1.5 m^3 biogas can be produced. That makes equal respectively to: 1 cow; 5 calves; 6 swine; 250 hens.

As it can be seen, despite the big part of poultry-farming, its effectiveness for biogas production is not the best one and should be further evaluated.

The content of nutrient elements sodium, phosphorus and potassium in animal manure is definitive for the role of digestate in soil fertilization.

Chemical composition of fresh manure in g/kg is presented in Table 1, according the data from Yancheva and Manolov (2003).

The total quantity of these elements from poultry excrements is calculated according the data about poultry number in 2011 using the information in Table 1. The results are presented in Table 2.

The total quantity of manure from poultry farming (Table 2) is 663,648 t/year. Potential methane yield from 1 t poultry manure is evaluated to 210 m^3 (Yancheva and Manolov 2003).

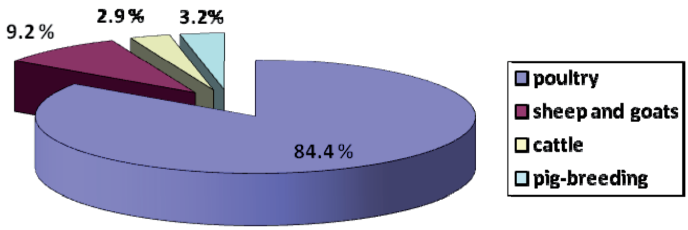

Fig. 1. Distribution of Bulgarian animal breeding by branches.

Table 1. Chemical composition of fresh manure by species and categories poultry.

Elements	Laying hens, g/kg	Broiler chickens, g/kg
Nitrogen – total	10–18	14–22
Phosphorus (as P_2O_5)	8–12	10–12
Potassium (as K_2O)	5–7	5–8

The potential of poultry manure for biogas production is evaluated using the relation (1); and result is about 3 PJ. This value does not include other categories of birds.

The evaluation of the potential of pig-breeding and cattle-breeding made in analogical method gives respectively 6.7 PJ and 25 PJ (BiG>East 2007–2010). Biogas potential results to 3.7 PJ for total poultry-farming. The total potential for biogas from animal breeding is evaluated to 35.4 PJ. The necessary primary energy for Bulgaria in the year 2005 was 596 PJ (Aladjadjiyan and Kakanakov 2008). From the comparison of those values occurred that biogas potential can supply about 6 % of primary energy.

Prerequisite for production of biogas through anaerobic digestion is the availability of significant amounts of manure at a relatively limited area, which will reduce to a minimum transport costs to biogas plants. The way of collecting the manure is of particular importance.

Table 2. Total amounts of phosphorus (as P_2O_5) and potassium (as K_2O) from poultry in Bulgaria for 2011.

Category birds	Total amount manure, t/year	Total amount nitrogen, t/year	Total amount phosphorus (as P_2O_5), t/year	Total amount potassium (as K_2O), t/year
Hen	312,758	4441	3221.4	1876.5
Chicken	350,890	6421	3754.5	2717.0
Total	663,648	10862	6975.9	4593.5

Biogas production installation needs a regular supply of sufficient raw material. This is possible if the manure is collected in a concrete platforms for storage of fresh manure (especially pigs) and lagoons. Most of the small farmers collect the manure outdoors in the yard and use it for fertilizer on their own small-sized land. That gives them economic advantages – lower costs for fertilizers; but there are ecological disadvantages – odor, contamination of soil and groundwater, higher emissions of CO_2 and CH_4. This way of manure collection is an obstacle for the production of biogas because the irregular and non-guaranteed supply of raw material.

Larger farms collect livestock manure in concrete platforms (for ruminants) or in open lagoons (for pig breeding). The collected manure is stored most often by drying. Currently it is not used but it is possible in the future to be processed for biogas production through anaerobic digestion and subsequent composting of digestate for fertilizer.

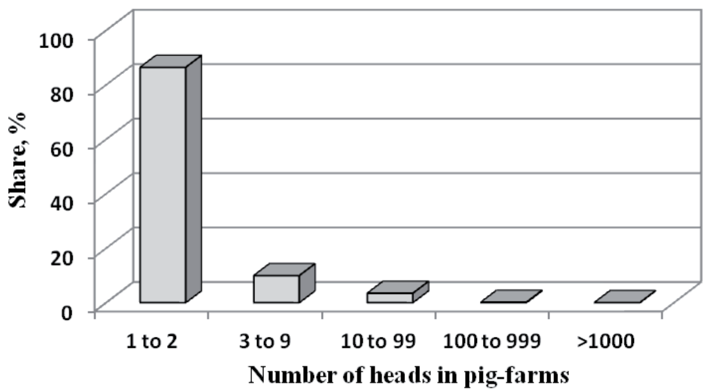

Fig. 2. Distribution according the number of animals in pig farms (BiG>East 2007–2010).

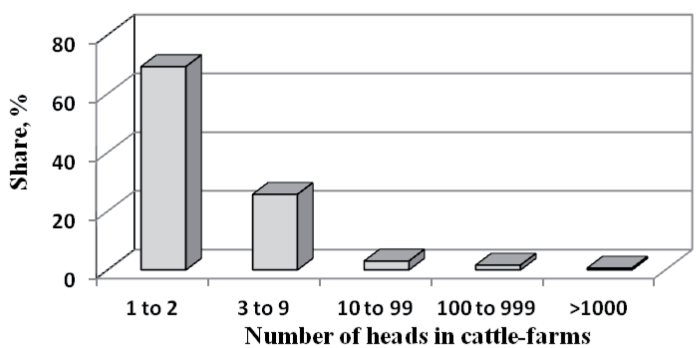

Fig. 3. Distribution according the number of animals in cattle farms (BiG>East 2007–2010).

Pig and cattle breeding farms play a bigger role in biogas production. The following two figures show the distribution of the pig (Figure 2) and cattle farms (Figure 3), according the number of bred livestock units.

As it can be seen from Figures 2 and 3, over 80 % of animals are bred in small farms, with not more than ten heads. The small number of big animal breeding farms is the main obstacle for building of installation for anaerobic digestion. From a technological point of view, small farms are not viable for the production of biogas, as they cannot provide regular inputs to the process of anaerobic digestion. For them it is advisable to create farm cooperatives, but this is a long and complicated process. Obstacles to the introduction of anaerobic digestion are also large distances between farms, lack of state support, etc.

Conclusion

It is necessary to explore the attitudes of owners to operate in regard to agricultural waste processing for production of biogas for energy and compost for soil recultivation, which is the purpose of the project INEMAD.

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