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The Biogas Potential That Can Be Obtained From The Animal Wastes Of Tokat Province

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ABSTRACT: The limitations in fossil fuels and environmental pollution problems stemming from production have brought the search and development of new eco-friendly resources on the agenda in recent years. Biogas is one of the new and renewable energy sources that has been investigated. It is an energy type that has advantages over other energy types. Biogas is produced mainly from animal wastes as well as vegetal wastes in rural areas. Producing biogas energy helps both meet the energy needs and make use of wastes. The biogas energy produced from animal wastes will provide great economic benefits to Tokat region as well as a number of positive environmental and social effects.
In this study, the data relating to the number of animals taken from Tokat Food, Agriculture and Livestock Provincial Directorate, the annual amount of cattle manure that can be produced on the basis of the animal weight given by the Ministry of Energy and Natural Resources, General Directorate of Renewable Energy, and the amount of biogas that can be produced based on the type of manure were used as a source for the calculation of the biogas potential of the province.

Keywords : *Biogas, Energy, Animal Wastes*

1. Introduction

Biogas is consists of a colorless and flammable gas mixture containing a small amount of hydrogen sulphur (H_2S), nitrogen (N_2), oxygen (O_2) and carbon monoxide (CO), whose main components are methane (CH_4) and carbon dioxide (CO_2). Generally 40% to 60% of the organic matter turns into biogas. The remaining residue is odorless, solid or liquid product, which is suitable for use as fertilizer. After biogas production, wastes are transformed into organic fertilizer, which is more valuable (Gül, 2006).

1.1. Thermal Value of Biogas

Heat obtained from 1 m^3 biogas is equivalent to 4700-5700 kcal/m^3.

1 m^3 biogas is equal to: 0,62 liter of kerosene
1,46 kg of charcoal
3,47 kg of wood
0,43 kg of butane gas
12,3 kg chip
4,70 kWh electric energy

1 m^3 biogas is equal to: 0,66 liter diesel
0,75 liters of gasoline
0,25 m^3 propane (Anonymous 2012).

1.2. Organic Waste / Residual Raw Material Used in Biogas Production

Animal Waste

Cattle, horse, sheep and poultry manure, wastes from slaughterhouses, and wastes generated during the processing of animal products are mainly used in the biogas plants recommended for rural areas.

Vegetal Residues

They are remains of finely chopped stalks, straw, stubble and corn, sugar beet leaves, and grass remains, which are residues of unprocessed vegetable parts and wastes emerging during the processing of vegetal products.

Urban and Industrial Wastes with Organic Content

Sewage and bottom sludge, paper industry and food industry wastes, and industrial and domestic wastewater with high dissolved organic concentration are used for biogas production. These wastes are mainly used in biogas production centers established using high technology by municipalities and large industrial facilities (Anonymous 2012).
Biogas production environments are given in Figure 1 (Anonymous 2012a).

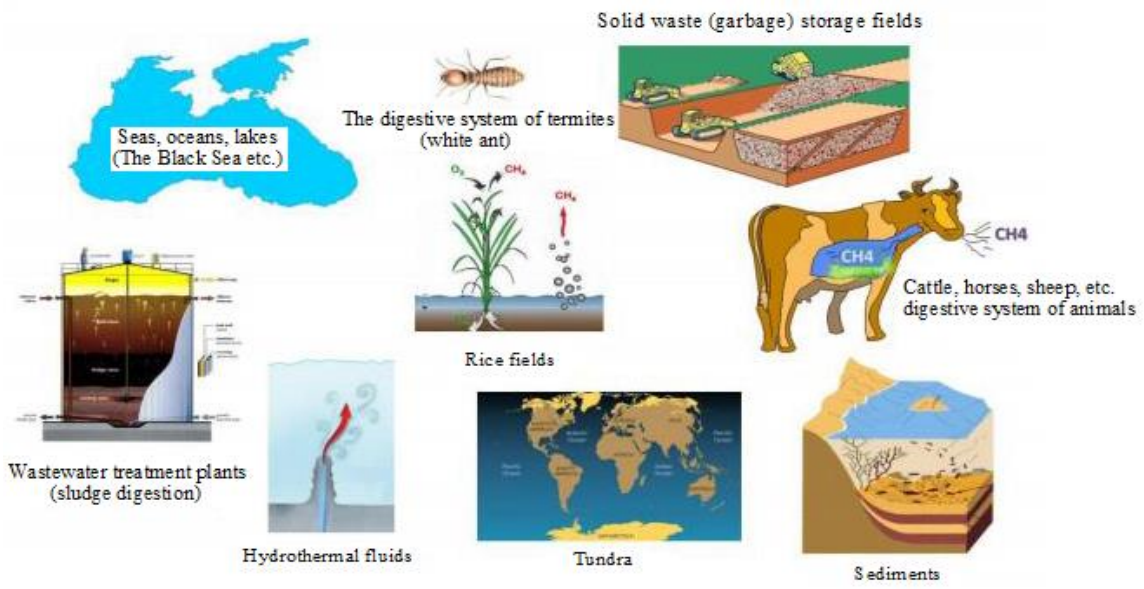

Figure 1. Biogas production environments

1.3. Biogas Formation

The fermentation of organic wastes or organic substances is shown in Figure 2 in three phases. Of these phases, the first is hydrolysis, the second is acid production, and the third is methane production. In the first stage, high molecular organic compounds are hydrolyzed by extracellular enzymes and converted into smaller molecular weight organic compounds. Organic compounds that are converted to low molecular weight at the acid production stage are converted into volatile fatty acids and acetic acid by acid bacteria. In the third phase, decomposition of acetic acid and the synthesis of CO_2 and H_2 bring about methane production (Demir and Öztürk, 1989).

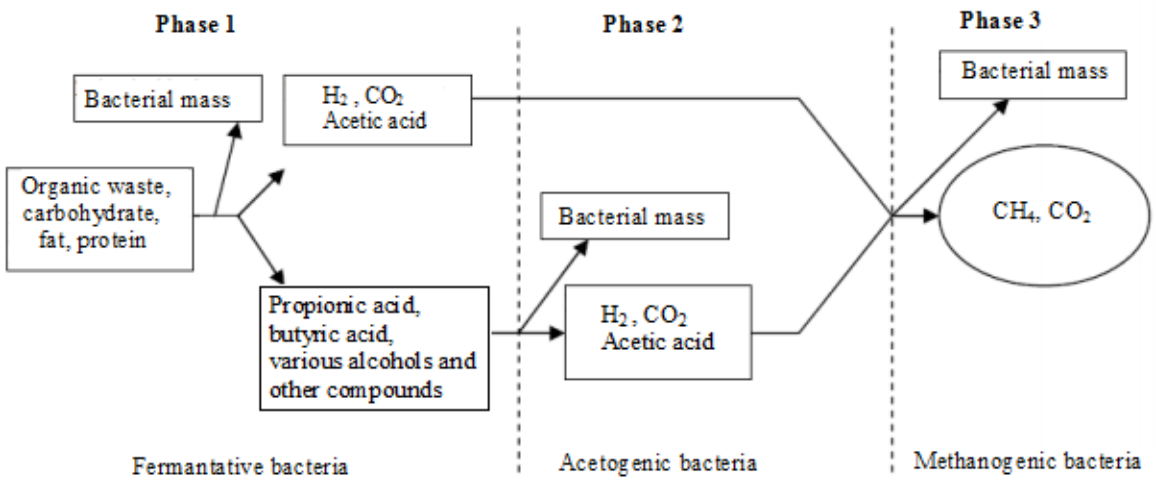

Figure 2. The stages of biogas production

1.4. Uses of Biogas and Its Side Products

Use of Biogas for Heating:

The combustive feature of biogas comes from methane gas found in its composition. When biogas is mixed with air at 1/7 ratio, full combustion occurs. Biogas can be used in gas fired ovens and hobs as well as thermosiphons and water heaters. Biogas can also be easily used in liquefied petroleum gas-operated heaters by making pressure adjustments on the nozzle diameters. When used in biogas stoves, a flue system is required to prevent the hydrogen sulphur gas present in the gas from spreading to the medium. For this reason, central heating systems are preferred for a healthier heating.

Use of Biogas for Energy Purposes:

Biogas can be used for lighting by turning it into direct combustion or electric energy. Liquefied petroleum gas lamps are used for the direct use of biogas for lighting purposes. In this system, asbestos mantle and glass lantern are used to increase the lighting flame. The glass lantern fixes the light as well as it gives back the heat that is coming out so that the flame is stronger.

Use of Biogas on Motors:

Biogas can be directly used in gasoline powered engines without any additives as well as by purifying methane gas in its content. When used in diesel engines, it is necessary to mix it with diesel at certain ratios (18-20%).

Using by Products:

Biogas production yields fermented organic fertilizer in liquid form as a by product. The obtained fertilizer can be applied to soils in liquid form, granulated, and / or left to dry in concrete-soil ponds. The main advantage of the organic fertilizer obtained as a result of fermentation is that a large part of the pathogenic microorganisms are destroyed as a result of anaerobic fermentation. This makes the organic fertilizer about 10% more efficient (Anonymous 2012).

1.5. Benefits of Biogas Production

Animal and plant organic waste / residues are often either directly burned or spread as fertilizer to agricultural soils. It is more common to use such wastes in the production of heat, especially by burning. In this way, it is not possible to produce desirable heat, nor can it be used as fertilizer after it is burned.

• Biogas technology helps generate energy from organic waste / residues and produce fertilizers for the soil.
• It is a cheap and eco-friendly source of energy and fertilizer.
• It helps recycle waste.
• Foreign weed seeds that can be found in animal manure lose germination skill as a result of biogas production process.
• As a result of biogas production, bad smell of animal manure disappears.
• It eliminates disease agents that threaten human health and groundwater resulting from animal manure.
• After biogas production, the wastes do not disappear but become more valuable organic fertilizers (Anonymous 2012).

When research into the same topic was reviewed, the following studies were found;

Baran et al. conducted a study on biogas production from bovine and poultry manure in Adıyaman province. It was estimated that there were 81.733 bovine, 305.724 ovine, and 231.358 poultry in the province as of 2015. According to the estimations, the amount of manure that could be obtained was 294.238.80 $tonyear^{-1}$ for bovine, 214.006.80 $tonyear^{-1}$ for ovine and 5.089.88 $tonyear^{-1}$ for poultry. Estimations indicated that the amount of biogas production from animal manure was 6.473.253.60 m^3year^{-1} for bovine, 8.274.929.60 m^3year^{-1} for ovine and 264.673.50 m^3year^{-1} for poultry. The equivalent of the total energy to be obtained was 70.560.426.49 $kWhyear^{-1}$ (254.017.53 $GJyear^{-1}$) (Baran et al., 2017).

Şenol et al. carried out a study investigating the potential of biogas and electricity that can be produced from poultry manure in Turkey in 2016. It was found that there was a total of 320,4 million poultry animals in our country in 2016. When biogas production from poultry manure in our country in terms of energy was studied, the total annual energy production was estimated as 13,36 billion MJ. In addition, the value of this energy generated from all poultry manure in Turkey as electrical energy was found to be 7.270 Mwh of electricity daily (Senol et al. 2017).

Ilgar, conducted a study on the determination of the biogas potential of Çanakkale according to the available animal stock. It was estimated that a total of 96.934.753 m^3/ year biogas could be produced according to the data about the number of bovine, ovine and poultry animals taken from Çanakkale Provincial Directorate of Agriculture (Ilgar, 2016).

Ayhan, studied the biogas production potential from animal wastes in Bursa province. As a result, while the biogas production from chicken wastes in 2008 ranked first with 54.612 dam^3, the total biogas potential of 2014 increased by 33% compared to 2008 and reached 129.106 dam^3. If 50% of the theoretical potential was used, the amount of biogas in 2014 was calculated to be 64.553 dam^3 and in the case of 25% consumption, it was estimated to be 32.276 dam^3. According to the 2014 data of Bursa province, 2.788 TJ thermal energy and 271 GWh_e electric energy was calculated (Ayhan, 2015).

Koçer and Kurt, conducted a study investigating livestock production potential and biogas production in Malatya. In the study, the average dry biomass obtained in one year in Malatya province and the average thermal value of this dry biomass obtained were calculated. The results revealed that approximately 87.645 m^3/day biogas could be produced from animal manure using biogas plants in Malatya, (Koçer and Kurt, 2013).

In this study, biogas amount and energy potential which could be obtained from bovine, ovine and poultry wastes in Tokat province was calculated. The number of animals used in the study was taken from Tokat Food, Agriculture and Livestock Provincial Directorate.

2. Material and Method

Tokat is located in the central part of the Black Sea Region between 39° 52'- 40° 55' northern latitudes and 35° 27'- 37° 39' east longitudes. It borders Samsun city in the north, Ordu city in the northeast, Sivas city in the southeast, Yozgat city in the southwest, and Amasya city in the west. The province has an area of 9.982 km² and is the 4th largest in terms of surface area among 18 provinces in the Black Sea Region (Anonymous 2017).

In addition to the central county, Tokat city has a total of 12 districts including Almus, Artova, Basciftlik, Erbaa, Niksar, Pazar, Reşadiye, Sulusaray, Turhal, Yesilyurt and Zile (Anonymous 2017).

The numbers of bovine, ovine and poultry animals of Tokat province by districts are shown in Table 1.

Table 1. Number of bovine, ovine and poultry animals of Tokat province by districts

Central County and Counties	Number of Bovine	Number of Ovine	Number of Poultry
General Total	236.834	284.054	166.278

To determine the potential of biogas, the annual amounts of fresh manure that can be produced on the basis of animal weight and the amount of biogas to be obtained according to the type of manure are given below (Anonymous 2012).

Annual fresh manure quantities that can be produced on animal weight basis:

➢ 3.6 tons/year from bovine animals
➢ 0.7 tons/year from ovine animals
➢ 0.022 tons/year from poultry animals

According to the above data, annual fresh manure production from each cattle was 3600 kg, 700 kg from each sheep or goat, and 22 kg from each poultry animal.

Biogas quantities to be obtained by fertilizer type:

➢ 33 m^3 biogas from 1 ton bovine animal manure
➢ 58 m^3 biogas from 1 ton ovine animal manure
➢ 78 m^3 biogas from 1 ton poultry animal manure

1 m^3 biogas is equivalent to 4.7 kWh electric energy. This corresponds to a figure more than 1 TL.

3. Findings and Discussion

When animal manure and biogas amounts were calculated based on the total number of animals in our province, the following results were found:

From bovine animals:
(236.834) * (3.6) = 852.602.40 tons/year manure

From ovine animals:
(284.054) * (0.7) = 198.837.80 tons/year manure

From poultry:
(166.278) * (0.022) = 3.658.12 tons/year manure

The amounts of animal manure that can be obtained according to the animal species are presented in Table 2. The amount of biogas that can be produced and the equivalent electric energy values are given in Table 3.

The animal manure and biogas production estimations when considering that about 1/3 of animal manure is lost in the meadows,

Table 2. Amounts of manure that can be obtained from animal stock

Animal Species	Total Number of Animals	Manure (ton/year)	Net Manure
Bovine	236.834	852.602.40	568.401.60
Ovine	284.054	198.837.80	132.558.53
Poultry	166.278	3.658.12	2.438.75

From bovine animals:
(568.401.60) * (33) = 18.757.252.80 m^3/year biogas
= 88.159.088.16 kWh/year = 317.372.717.38 MJ/year

From ovine animals:
(132.558.53) * (58) = 7.688.394.74 m^3/year biogas
= 36.135.455.28 kWh/year = 130.087.639.01 MJ/year

From poultry:
(2.438.75) * (78) = 190.222.50 m^3/year biogas
= 894.045.75 kWh/year = 3.218.564.70 MJ/year

Table 3. Potential of biogas and electrical energy that can be obtained in Tokat province

Animal species	Amount of biogas that can be obtained (m^3/year)	Equivalent electrical energy (kWh/year)	MJ/year
Bovine	18.757.252.80	88.159.088.16	317.372.717.38
Ovine	7.688.394.74	36.135.455.28	130.087.639.01
Poultry	190.222.50	894.045.75	3.218.564.70
Total	26.635.870.04	125.188.589.19	450.678.921.1

4. Conclusion

In this study, biogas potential that can be obtained from animal wastes of Tokat province and the electrical energy values that can be generated from this potential was determined. The results indicated that Tokat has a significant amount of biogas production potential. Total biogas potential, which can be obtained from bovine, ovine, and poultry, was determined as 26.635.870.04 m^3/year annually. Of course, it is not realistic to say that animal manure can only be used in biogas. In addition, it is not possible to obtain biogas with full efficiency (100%) via existing procedures. However, if suitable infrastructures and policies are developed, current studies have shown that even 1% of the amount in question can be used to produce biogas equivalent to the annual amount of biogas produced in 2017 in Tokat province wastewater treatment plant (254.400 m^3).
Tokat province ranks top positions in Turkey in terms of livestock. Therefore, it has been revealed by this study that future plans in Tokat province can contribute to the country's economy through biogas in terms of energy production.
With biogas production, the wastes will be controlled and the negative effects on the environment will be eliminated; meanwhile, this will provide energy generation. Given the positive results of the use of fermented fertilizer from biogas plants in agriculture, the significance of biogas production from wastes is evident. The transformation of biogas obtained from animal wastes of the province to energy will contribute greatly to the energy demand and economy of the province.

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