Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. VIII, 2019
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

INVESTIGATION OF ANIMAL ORIGIN BIOGAS POTENTIAL USING GEOGRAPHICAL INFORMATION SYSTEMS: EAST MEDITERRANEAN REGION CASE

Ozan ARTUN [1], Burak SALTUK[2]

[1]Cukurova University, Vocational School of Karaisali, 01770, Adana, Turkey
[2]Siirt University, Faculty of Agriculture, Biosystem Engineering Department, 56100, Siirt, Turkey

Corresponding author email: oartun@cu.edu.tr

Abstract

Animal breeding is one of the agricultural activities in Turkey. The animal manure can be used as an organic material in producing biogas. The energy needs of agricultural enterprises can be met by establishing biogas production facilities in these enterprises. In this study, it was aimed to determine the potential areas in the East Mediterranean region of Turkey which is suitable for biogas plants. The East Mediterranean covers Adana, Hatay, Kahramanmarasand Osmaniye provinces. In this context, the borders of the provinces (Adana, Hatay, Kahramanmarasand Osmaniye) subjected to the study and the topographic properties of the region were drawn using ARCMAP 10.3 software. In this study, it was aimed to determine the obtainable biogas energy fields and the current situation in the provinces in the East Mediterranean region. Furthermore, the number of cattle in the East Mediterranean region for the years 2013-2017 was benefited from in this framework. The potential biogas areas in each province were determined and these areas are tried to be interpreted. The areas that are suitable, non-suitable or partially suitable for biogas energy production were determined. The finding that a total of 7634583.885 tons of annual wet manure can be obtained in the study area was obtained. It was determined that a total of 3193690103 MJ biogas energy amount can be obtained per year from this wet manure.

Key words*: biogas, cattle manure, East Mediterranean region, GIS.*

INTRODUCTION

One of the most important branches of agricultural production is animal (meat and milk) production. Although the main output of modern production is seen as meat and milk in cattle-breeding facilities, the manure and wastes that animals give to the environment can be accumulated in the storage structures and energy can be obtained, but they are left uncontrolled to the external environment. This situation causes soil and water pollution as well as loss of energy that can be obtained by recycling (biogas) from these wastes. Biogas is one of the most advantageous methods to eliminate and recycle waste from livestock.

The energy in the universe is present and constant since the beginning of time. At the beginning of each transformation of the energy used, the energy that was initially used is consumed so as not to be recovered (Akova, 2008).

Turkey is a country of agriculture and livestock. Studies on biogas began in Turkey in 1957. After 1975, soil, water and biogas production activities carried out under the General Directorate of Rural Services in the 1980s were supported by some international agreements, but in 1987 they were cut for an incomprehensible reason. Turkey's biogas potential of 17.3 million TEP/year is estimated to be level (Öztürk, 2005).

Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Biogas originates from biogenic material and is a type of bio fuel.

The continuing use of fossil fuels and the effect of greenhouse gases (GHGs) on the environment have initiated research efforts into the production of alternative fuels from bio resources. The amount of GHG emissions in the atmosphere is rising, with carbon dioxide (CO_2) being the main contributor. In addition, the global energy demand is increasing rapidly, with approximately 88% of the energy produced at the present time being based on fossil fuels (Anonymous, 2014; 2015).

Anaerobic digestion (AD) is expected to meet with increasing success due to the low cost of available feedstock's and the wide range of uses for biogas (i.e., for heating, electricity, and fuel). Biogas production is growing in the European energy market and offers an economical alternative for bio energy production. A study by Achinas et al. (2017) provides an overview of biogas production from lignocelluloses waste, thus providing information toward crucial issues in the biogas economy.

On a farm that feeds 200 cows, 200 cattle per day × 62 l/day/cow = 12400 l fertilizer/day occurs (Öztürk, 2017).

Gas produced by biogas production is not a pure gas. The content of this gas includes approximately 55-75% CH_4 gas, 25-45% CO_2 gas, 1-10% hydrogen gas (H_2), 0-0.3% nitrogen (N_2) gas and 0-3% hydrogen sulphide gas (H_2S) (Weiland, 2010).

Digester volume for typical livestock operation cubic feet per gallon:

- Swine (500 head): 2500/20000;
- Dairy (75 head): 1950/15000;
- Poultry (15000 birds): 5550/42000;
- Beef (300 head): 4050/30400 (Fulhage et al., 1993).

Since the smell of animal fertilizers used in biogas production is lost during the process and many elements threatening human health are eliminated, it will provide a clean and healthy environment for people living in areas where biogas production is carried out (Kumbur et al., 2015).

Since biogas acquisition is mainly based on the decomposition of organic substances, vegetable wastes or animal fertilizers can be used as the main ingredient. Today, biogas production has a wide range of diameters; meets the heating and kitchen expenses of a single house, and is made up of generators with electricity generation (Anonymous, 2018c)

According to the data of 2018 in Turkey, there are 68 business units working with biomass energy (Anonymous, 2018a).

The fact that fertilizers and wastes from animal production are not stored properly and are not used to convert them into energy cause both losses of income and environmental pollution. The pollution that occurs in the environment due to the energy is caused by burning of carbon and its derivatives and the gases formed in this case; mix into the air, water and soil.

Environmental contamination is the result of the deterioration of the ecological balance in nature, and harm to humans and other living things (Karabulut, 2000).

Keeping environmental impacts at a minimum level of damage requires being sensitive to waste management. In addition, it is necessary to bring animal wastes to the economy. Based on this, the amount of manure obtained from animals according to the type of animals is as follows:

• 3.6 tons/year wet manure from 1 cattle;
• 0.7 tons/year wet manure from 1sheep;
• 0.022 tons/year of manure are obtained from 1 poultry.

Based on these values, it consists:

• 33 m^3/year biogas from a ton of cattle manure,
• 58 m^3/year of biogas from a ton of sheep manure,
• 78 m^3/year biogas from a ton of poultry manure (Koçer, 2006).

Waste and biogas are produced as a result of decay of fertilizers and other substances by microorganisms. Biogas consists of a mixture of methane, carbon dioxide and other gases. Biogas and natural gas are similar. Biogas; can be used as fuel in heating or electricity production. The heating requirement depends on the season, not comparable to the production of fertilizers and biogas. Therefore, biogas is frequently used in electricity production. The electricity produced is used on the farm and surplus electricity can be sold (Öztürk, 2017). Biogas production is an excellent way of using organic waste for energy generation, followed by the recycling of the digested substratum (digested) as fertilizer (Comparetti et al., 2013)

Biogas is a cheap, environmentally friendly energy and fertilizer source and provides waste recovery. As a result of biogas production, weed seeds that can be found in animal manure lose their germination. After biogas production, wastes are not destroyed and they are transformed into a more valuable organic fertilizer (Gizlenci & Acar, 2008).

With 1 m^3 biogas it is possible to:

• Keep working a 60-100-watt lamp for 6 hours;
• Cooking 3 meals for a family of 5-6 people;
• Obtain calories equivalent to 0.7 kg of petrol;
• Run a horsepower engine for 2 hours;
• Obtain 1.25 kWh electrical energy (Öztürk, 2017).

Through biogas; natural balance is maintained by preventing soil, water and air pollution. In addition, wastes from biogas production are used as fertilizer in agriculture (Çanka, 2011).

MATERIALS AND METHODS

The study was carried out in the East Mediterranean region of Turkey and it covered four provinces (Adana, Hatay, Kahramanmaras and Osmaniye) (Figure 1). Adana province is located in the northeast of the Mediterranean region and has a surface area of 13844 km^2. Hatay province is located at the eastern end of the Mediterranean region and is the border province of Syria. The surface area of Hatay province is 5867 km^2. The northern part of the province of Kahramanmaras is quite mountainous and has a surface area of 14525 km^2. Osmaniye province is surrounded by Amanos Mountains in the east and southeast and Taurus Mountains from the west to the north. The surface area of Osmaniye province is 3215 km^2.

In this study area, the areas suitable for biogas energy production and the obtainable biogas energy amounts are trying to examine. Furthermore, the number of cattle in the region and the amount of animal waste and biogas were determined. The present number of cattle of 4 provinces (Adana, Hatay, Kahramanmaras and Osmaniye) and their districts taken from the literature data and the Veterinary Information System (VETBIS) of the Ministry of Food, Agriculture and Livestock for the years 2012-2017 (Anonymous, 2018b).

Figure 1. Map of Turkey (a) and the study area (b)

In the study, Geographic Information Systems (GIS) were used to create database for cattle numbers, animal waste and biogas amounts in the provinces and districts of the East Mediterranean region. It is a known fact that GIS technologies are very useful applications for capturing, storing, manipulating, analyzing, managing, and presenting all types of spatial and environmental data (Glass, 2001).

In the study, the UTM map projection and WGS 84 datum are selected as the reference system and all maps and data were transferred to the chosen projection and datum using ArcMap 10.3 software (ESRI, 2010). In the study, it was aimed to assess the presence of cattle, and animal waste and biogas amounts in the provinces in question, on the basis of districts, in the Geographical Information System environment. For this purpose, the places in question were digitized in the GIS environment as a polygon first within the limits of the province and then the district boundaries. In order to make an examination of each province independently of other provinces, all boundaries were divided on the basis of the provinces as a separate layer. Similarly, the districts of each province were divided in the form of district boundaries as a

separate layer. The database (attribute data) was created by entering the numbers of cattle supplied from the VETBIS system to all these layers prepared.

In this study, the places that are suitable for establishing biogas units were shown on the maps created on the basin by determining the animal waste and biogas amounts on the basis of districts by means of benefiting from the present cattle number for 2015 obtained from the VETBIS system and the related literature (Anonymous, 2018b).

Hill (1982) and Ekinci et al. (2010) are reported that, it is very important to determine the capacity before projecting biogas facilities. In the study area, the calculation of biogas production quantities was performed taking into account the use of whole manure produced. An average amount of 43 $kg \cdot day^{-1}$ of manure obtained from mature cattle can be taken as a basis, for the calculation of the amount of manure.

While producing the prediction map of the study area, the districts with cattle between 0 and 1000 heads were determined to be the areas not potential for biogas and coloured in orange (), and the districts with cattle between 1000 and 10000 heads were determined to be potential biogas production areas and coloured in yellow ().Again, the districts with more than 10000 heads of cattle were determined to be high-potential biogas production areas and coloured in green ().

RESULTS AND DISCUSSION

When the provinces in the study area were compared with each other, it was seen that Adana and Kahramanmaras provinces take an important place both in terms of land area and animal numbers. In the study area, the total number of cattle was determined to be173945 in Adana province, 147898 in Kahramanmaras province, 107272 in Hatay province and 57128 in Osmaniye province for year 2017 (Table 1). Upon examining the study area, it was determined that livestock breeding was performed at a lower level in Osmaniye province. In the study area, it was determined that the number of cattle slightly decreased due to population density; however, biogas production has not changed.

The number of animals in the study area has increased arithmetically in the last 5 years. In particular, the province of Kahramanmaras which in the inner parts of the region and the Feke, Saimbeyli districts of Adana province and Tufanbeyli district on the border with Kayseri province have a potential in terms of obtaining biogas from livestock enterprises. As the livelihoods of these districts are fruit growing and livestock breeding, biogas planting in these areas can meet the needs of the region and can prevent especially the pollution caused by livestock. Due to the existence of usable river sources at the borders of the three districts and especially the winter precipitation is too much in these areas, it is very important to protect the water resources in the region. Seyhan River is used for irrigation of Cukurova delta and it is the most important water source of the region therefore the pollution control of the river is very important. In this context, one or several biogas plants to be established will generate electricity and heat and provide economic benefits to the region. As a result of biogas production, the smell of animal manure disappears unimaginable and the resulting product is transformed into a more valuable organic fertilizer. Methane gas, one of the worst greenhouse gases produced in biogas plants, is converted to CO_2 by burning. In addition, it helps to reduce the effectiveness of the disease factors that threaten human health, provides a significant loss of effectiveness of the diseases that threaten groundwater and creates healthier, hygienic living spaces.

Table 1. Number of cattle in the East Mediterranean Region provinces between the years 2013-2017

Province	Total Number of Cattle				
	2013	2014	2015	2016	2017
Adana	190955	152687	172641	174209	173945
Hatay	102262	97469	93761	89765	107272
Kahramanmaras	102080	127093	129860	134854	147898
Osmaniye	66209	51335	53006	50793	57128

There are various ways to calculate the amount of wet manure and obtainable biogas energy in the literature. In the study area, the amount of wet manure and obtainable biogas energy were calculated for the year 2017, according to Hill (1982) and Ekinci et al. (2010) using the number of cattle, and the results are given in Table 2.

In the calculation made according to Hill (1982) and Ekinci et al. (2010), it was determined that the highest amount of wet manure and obtainable biogas energy was in Adana province. Adana province was followed by Kahramanmaras, Hatay and Osmaniye provinces, respectively (Table 2).

Table 2. The amount of potential wet manure and obtainable biogas energy in the Eastern Mediterranean Region provinces

Province	Total Number of Cattle (2017)	Average Amount of Wet Manure (kg/year)	Amount of Obtainable Biogas Energy Mj/year
Adana	173945	2730066775	1142487244
Hatay	107272	1683634040	704572661.7
Kahramanmaras	147898	2321259110	971408079.7
Osmaniye	57128	896623960	375222117.8

The calculation method of Hill (1982) and Ekinci et al. (2010) was also used separately for the districts of all provinces in the study area, and the amounts of wet manure and potential biogas energy of these districts were calculated.

With these calculations, the appropriateplaces where biogas energy production facilities could be established inthe provincesof the East Mediterranean regionare trying to be determined. Also the suitability mapsare evaluated in the GIS environment.

The highest animal population in the study area is in Adana province and it is especially concentrated in Saricam and Yuregir districts.

According to the VETBIS records for the year 2017, the cattle amount of Saricam and Yuregir districts in Adana constitutes 29.76% of the current population of cattle in Adana province.

Thus, biogas production facilities built in the region, such as these districts, can reduce the amount of input in the operator's energy costs and will increase the productivity. Due to the fact that animal breeding is concentrated in this region, there is a 1 MW biogas production facility established by Adana Municipality in Kozandistrict in 2017.

In addition, Seyhan, Kozan, Ceyhan and Tufanbeyli districts are also seen as a potential biogas production area. The number of cattle in these six districts constitutes approximately 70.26% of the total number of cattle in Adana province. In the study it was determined that biogas plant investments would also be appropriate in these regions.

In the study, a slight decrease was observed in the number of cattle in the province of Adana between years 2013-2017. This is due to increased input costs and reduced pastures.

When 2017 data are analysed, it is determined that 43.60% of Adana province are very convenient and 56.40% of them are potential for biogas production (Figure 2).

It is also determined that 1142487244 Mj/year of biogas based electrical energy can be obtained in Adana province.

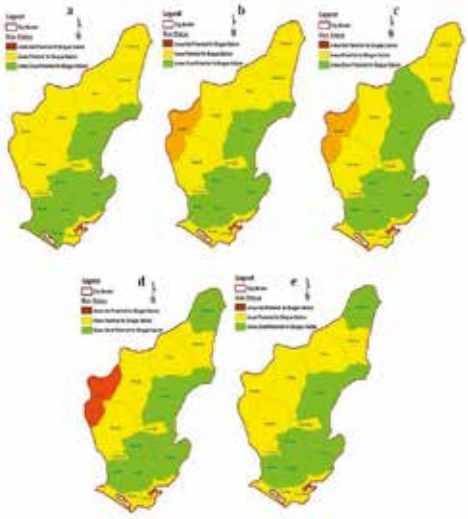

Figure 2. Potential Biogas Energy Fields in Adana province (a. 2013; b. 2014; c. 2015; d. 2016; e. 2017)

Central, Samandag and Kirikhan districts constitute 41.66% of the total animal husbandry potential of Hatay province. It is determined that the planned biogas plants should be built in these districts (Figure 3). It was determined that the electrical energy of 704572661.7 Mj/year would be obtained in Hatay province, depending on the wet manure supplied from this source.

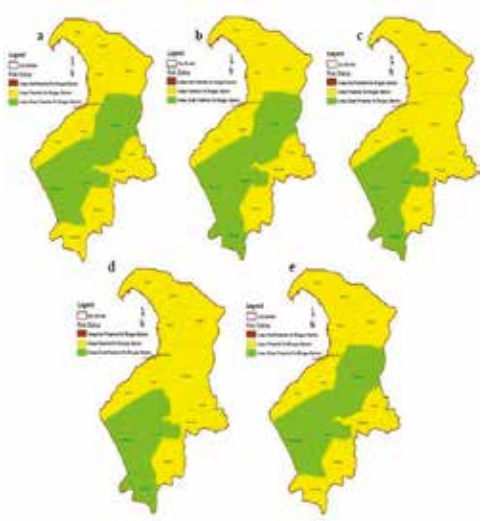

Figure 3. Potential Biogas Energy Fields in Hatay province (a. 2013; b. 2014; c. 2015; d. 2016; e. 2017)

Because of the low total number of cattle, the potential biogas production sites of Osmaniye province are limited. Kadirli, Central and Duzici districts account for 74.58% of the total animal husbandry potential of Osmaniye province (Figure 4).

According to 2017 data it was determined that 96.03% of Osmaniye province is suitable for biogas production and 3.97% are not suitable for biogas production.

In Kahramanmaras province, 48.26% of all provincial cattle are located in the Afsin, Elbistanand Dulkadiroglu districts.

It was determined that 90.65% of Kahramanmaras province are suitable for biogas production and 9.35% are not suitable for biogas production. 971408079.7 Mj/year of biogas based electrical energy can be obtained annually from the biogas facilities that can be installed in Kahramanmaras province (Figure 5).

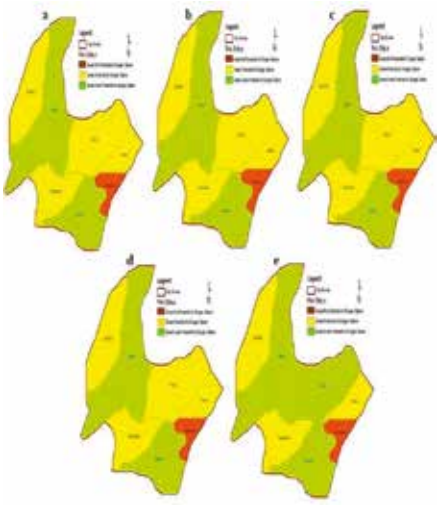

Figure 4. Potential Biogas Energy Fields in Osmaniye province (a. 2013; b. 2014; c. 2015; d. 2016; e. 2017)

According to the information in "Final Renewable Energy Sources" list of Turkey in 2018, there are 62 facilities that obtain biomass energy and these are diversified as landfill gas, biogas, vegetable and animal wastes. In the study area there are two facilities in Adana and Kahramanmaras that have a power capacity of 1840 MWm/Mwp and 1232 MWm/Mwp respectively. When the number of cattle in the study area is evaluated, it is seen that this number is below the potential.

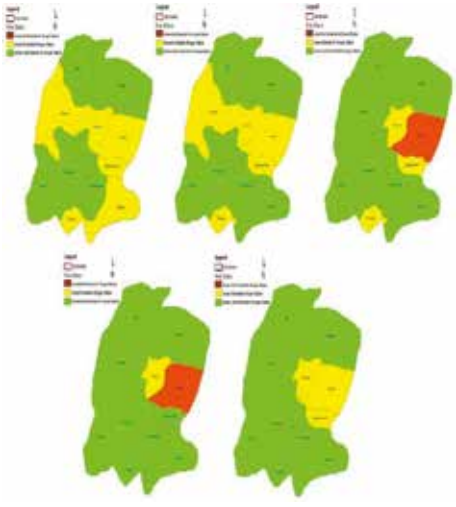

Figure 5. Potential Biogas Energy Fields in Kahramanmaras province (a. 2013; b. 2014; c. 2015; d. 2016; e. 2017)

In the study area, it was determined that the total potential biogas energy of 21654515836 MJ/year would be obtained from approximately 7631583.9 tons of animal manure.

CONCLUSION

The appropriate biogas production sites were trying to be determined in the study area for the years 2013-2017, using the ARCMAP 10.3 software. In this context the given number of cattle and their wet manure production values are used. As a result, the regions, where the number of cattle is high, are identified as the areas suitable for potential biogas production. In addition, the amounts of biogas energy per year 2013-2017 are calculated from the existing cattle numbers in these years, in the East Mediterranean Region. Upon examining the animal capacities of the provinces in the study area, Adana (35.77%) and Kahramanmaras (30.42%) provinces are those with the highest number of animals in the basin. Thus, biogas energy production studies can be prioritized in these two provinces starting from Adana province. Upon examining the districts in the study area, the districts with the highest number of animals in Adana province are Sarıcam Yuregir, Seyhan and Kozan districts. In the year 2017, there are 95.374 heads of cattle for the biogas energy production areas to be established in this region. Considering that cattle manure can be collected from these animals, the number of animals needed for biogas energy production areas can be easily fulfilled from this region. Thus, the information that Adana province is the most suitable area for biogas energy production was obtained. Furthermore, Elbistan and Afsin districts of Kahramanmaras province were also determined as one of the most suitable regions for biogas energy production with a total number of cattle of 50220. It was concluded that biogas energy production facilities to be established in this area will prevent the random collection of animal manure, as well as provide input for the enterprises in an economic sense.

When the fertilizer produced as a result of livestock activities is converted into production, energy production causes pollution and economic losses. This is also the case if fertilizer is used in plant feeding, not stored and left in indiscriminate environment. As a matter of fact, any pollution (such as litter material, slaughtering wastes, discharge to rivers, etc.) used in agriculture and livestock activities and resulting from activities reaches the levels that threaten the world. In particular, both environment ministries in the European Union candidate countries such as Turkey and in the world are making very strict controls in this regard.

As a result, in this study where the livestock potential is taken as the main material and the potential effects are investigated, it is very important to provide fertilizer storage, especially in areas close to or near the water resources in the basin, to promote the establishment of biogas facilities by making cooperatives in the potential areas.

REFERENCES

Achinas, S., Achinas, V., Euverink, G. J. V. (2017). A Technological Overview of Biogas Production from Biowastehttps://doi.org/10.1016/J.ENG.2017.03.002

Akova, İ. (2008). *Renewable energy sources* (In Turkish). Nobel Press, Ankara.

Anonymous (2014). United Nations Environment Programme. The emissions gap report 2014: A UNEP synthesis report Final report, UNEP, Nairobi

Anonymous (2015). International Energy Agency World energy outlook special report 2015: Energy and climate change Final report, OECD/IEA, Paris

Anonymous, (2018a). Final List of Renewable Energy Resources (In Turkish) (Accessed date) 26.02.2018. https://www.epdk.org.tr/Detay/DownloadDocument?id=vCeOhQftrjs=

Anonymous (2018b). Turkish Statistical Institute data (Accessed date) 26.02.2018 https://biruni.tuik.gov.tr/medas/?kn=101&locale=tr

Anonymous (2018c). Biogas Investments Development Association (In Turkish) (Accessed date) 26.02.2018. http://www.biyogazder.org/

Comparetti, A., Febo, P., Greco, C., and Orlando, S. (2013) Current state and future of biogas and digestate production. *Bulgarian Journal of Agricultural Science*, *19*(1), 1–14, Agricultural Academy.

Çanka Kılıç, F., (2011). Biogas, It's Impoortance, General Condition and Place in Turkey (In Turkish). *Engineer and Machine*, *52*(617), 94–106.

Esri (2010). The mapping and analytics platform data (Accessed date) 26.02.2018 https://www.esri.com/en-us/arcgis/

Ekinci, K., Kulcu, R., Kaya, D., Yaldiz, O., Ertekin, C., Ozturk, H. (2010). The Prospective of Potential Biogas Plants that can utilize Animal Manure in

Turkey. *Energy Exploration & Exploitation*, *28*(3), 187–206.

Fulhage, C. D., Sievers, D., Fischer, J. R. (1993). Generating Methane Gas from Manure. *Agricultural Publication G01881*, Department of Agricultural Engineering, University of Missouri-Columbia.

Glass, G. E. (2001)**.** *Geographic Information Systems in Infectious Disease Epidemiology* (pp. 231–253). Aspen Publishers.

Gizlenci, Ş., Acar, M. (2008). Energy Crops and Biofuels (Biodiesel, Bioethanol, Biomass). *Sectoral Report on Energy Plants and Biofuels* (In Turkish). Karadeniz Directorate of Agricultural Research Institute, Samsun.

Hill, D. T. (1982). A comprehensive dynamic model for animal waste methanogenesis. *Transaction of the ASAE*, *25*(5), 1374–1380.

Karabulut, Y. (2000). *Energy Resources of Turkey*. Ankara University Press, Ankara.

Koçer, N., Öner, C., and Sugözü, İ. (2006). Livestock Potential in Turkey and Biogas Production (In Turkish). Fırat University, Eastern Anatolia Research Center, Eastern Anatolia Studies, 17-20, Elazıg.

Kumbur, H., Özer, Z., Özsoy, H. D., Avcı, E. D. (2015). Comparing the Potential Environmental Effects of Conventional and Renewable Energy Sources in Turkey (In Turkish) III. *Renewable Energy Symposium*, 19-21 October, Mersin, Turkey.

Öztürk, M. (2005). Biogas Production from Animal Fertilizer (In Turkish). Ministry of Environment and Urbanization, Ankara

Öztürk, M. (2017). Production of compost from animal manure and waste (In Turkish). Ministry of Environment and Urbanization, Ankara

Weiland, P. (2010). Biogas Production: Current State and Perspectives. *Applied Microbiology and Biotechnology*, *85*, 849–860