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DETERMINATION OF THE AREAS SUITABLE FOR BIOGAS ENERGY PRODUCTION BY USING GEOGRAPHIC INFORMATION SYSTEMS (GIS): EUPHRATES BASIN CASE

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Abstract

One of the agricultural activities in our country is animal breeding. The animal manure from cattle breeding enterprises can be used as an organic material in producing biogas. The energy needs of agricultural enterprises can be met by establishing biogas production facilities. At the same time, environmental pollution can also be prevented. With today's information and technology, it is possible to investigate the areas suitable for biogas energy stations. The aim of this study is to determine the potential areas in the Euphrates Basin which are suitable for biogas plants. The Euphrates Basin covers Adiyaman, Sanliurfa, Gaziantep and Kilis provinces. In this context, the borders of the provinces subjected to the study and the topographic properties of the region were drawn using ARCMAP 10.0 software. Furthermore, cattle numbers were entered into the Geographic Information Systems (GIS) database. The potential biogas areas in each province were determined and these areas were tried to be interpreted in different colours. In the study area, it was determined that the potential biogas energy of 862863.7 MJ or electricity energy of 239684.4 kWh would be obtained from approximately 2061883.4 tonnes of animal waste per year. It was determined that these values were equal to an amount of the annual energy capacity needs of 103 houses. Biogas energy production facilities can be established in the places which have an intensive agricultural activity and this can eliminate environmental pollution problems.

Key words: *biogas, GIS, Euphrates basin, cattle manure*

INTRODUCTION

Rapid population growth and industrialisation in developing countries cause a rapid increase in demand for energy (Onal and Yarbay, 2010; Koc and Senel, 2013).

It is stated by researchers that a situation determination has to be made for energy resources in the world and in our country in order to ensure the planned use of energy resources facing the danger of exhaustion and to regulate the use of renewable energy resources (Koc and Senel, 2013).

Due to both the decrease in costs and the necessity to increase the share of renewable energy worldwide, the use of these energy sources in energy production planning is recently required. Renewable energy sources are non-fossil energy sources such as hydropower, wind, sun, geothermal, biomass, biogas (including garbage gas), wave, discharge energy and tide (Ozcan et al., 2011).

The resulting gas mixture of the biodegradation of organic wastes in an anaerobic environment is called biogas.

Especially in meeting rural energy needs, biogas, with the high production and abundance of raw materials and the high thermal value, can be considered as an energy source (Polat and Olgun, 2004). Biogas energy is a flammable gas resulting from the processing of biological materials. The difference of biogas from other flammable gases is that it is produced only from vegetable and animal origin organic raw materials (Anonymous, 2006).

Bioenergy is a biological, non-fossil organic matter. Biomass, which has sources such as agricultural and forestry products, vegetable wastes, marine plants, industrial and domestic wastes, is an environmentally friendly, renewable and local energy source that can respond to economic needs (Acaroglu, 2007; Ozturk, 2008). The wastes generated during the processing of vegetable products may be shown

as vegetable waste. These wastes are cereals, stem and straw, corn remnants, sugar beet leaves, weeds, etc. (Kocer et al., 2006).
The aim of this study was to identify the potential biogas energy fields in the Euphrates basin and to evaluate the availability of using animal wastes as a biogas energy.

MATERIALS AND METHODS

The study was carried out in the Euphrates basin and it covered four provinces (Adiyaman, Sanliurfa, Gaziantep and Kilis) (Figure 1). The areas suitable for biogas energy production and the obtainable biogas energy amounts in the study area were examined. Furthermore, the number of animals in the region and the amount of animal waste and biogas were determined. The number of cattle in four provinces and their districts was taken from the Veterinary Information System (VETBIS) of the Ministry of Food, Agriculture and Livestock for 2015 and the literature data for the Euphrates Basin (Anonymous, 2015a).

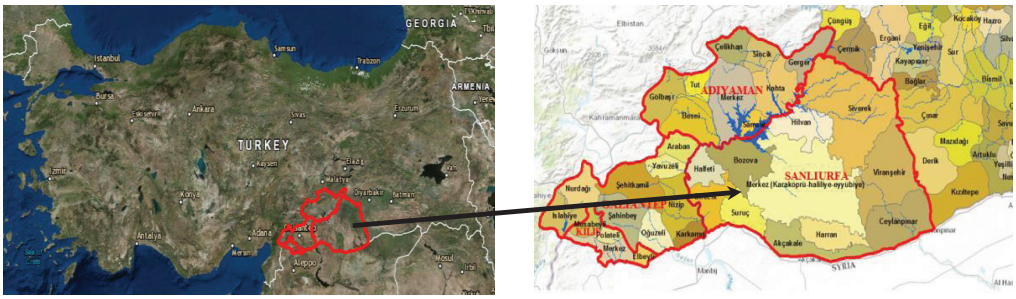

Figure 1. Provinces in the study area

In this study, Geographic Information Systems (GIS) were used to find cattle and animal waste and biogas amounts in the provinces and districts of the Euphrates basin. GIS technologies are applications useful for capturing, storing, manipulating, analysing, managing, and presenting all types of spatial and environmental data that are associated with them (Glass, 2001). For this purpose, all the related places of the basin were digitised in the GIS environment as a polygon first within the limits of the province and then the district boundaries. The UTM map projection and WGS 84 datum are selected as a reference system and all maps and data were transferred to the chosen projection and datum by using ArcMap 10.0 software (ESRI, 2010).
In order to make an examination of each province independently of other provinces, all boundaries were divided on the basis of 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 was prepared for each feature by entering the number of cattle.

For this purpose, these places were digitised in the setting of GIS as polygons based first on province borders and then district borders. ArcMap 10.0 software was used for this purpose. The topographic base map within the said software was used. Since the program works based on layers, any qualification obtained was considered as a layer. First, the borders of the study area were digitalized by making geographical corrections. The whole boundary was divided in to a separate layer on the basis of provinces in order the inquiries for each province to be carried out independently of other provinces.
Similarly, the districts of each province were divided into separate layers based on the borders of the districts. Evaluating the present bedding materials and identifying the water resources of the region, they were digitalized as a separate layer. In this study, the areas suitable for establishing biogas units were determined and shown on the maps created. The animal waste and biogas amount was determined on the basis of the districts by benefiting from the present cattle number for 2015 (Anonymous, 2015a).

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

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 colored in orange (), and the districts with cattle between 1000 and 10000 heads were determined to be potential biogas production areas and colored 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 ().

The prediction map of the suitable biogas production areas of the study area was created in relation to these animal numbers. The number of cattle in 2015 was evaluated within 3 layers and shown on the map of the basin by different colouring (Table 1).

Table 1. Representation of the cattle number on the study area map

Cattle Number in Enterprises	Display Colour on the Map
1-1.000	
1.000-10.000	
10.000-10.000+	

RESULTS AND DISCUSSION

When the provinces in the study area were compared with each other, it was seen that Gaziantep and Sanliurfa 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 be 57521 in Gaziantep province, 53795 in Sanliurfa province, 17078 in Adiyaman province and 2978 in for 2015 (Figure 2.). Upon examining the study area, it was determined that livestock breeding was performed at a lower level in Kilis province. In the study area, it was determined that the number of cattle increased due to population density, but that the number of biogas-producing did not increase at the same rate.

The Pilot Implementation of Increasing Energy Efficiency in the Industry, which is carried out in the region between 2014 and 2018, is aimed to increase the investment of the facilities in the study area with the financial support programs. It is believed that economic reasons and the difficulty of obtaining a qualified labour force in the region are the reasons for not increasing the investment in the animal husbandry and energy-producing industrial enterprises.

Especially in the province of Gaziantep, where industrial investments have a large share, it can be stated that investors tend to orient to textile and machinery producing industrial establishments and put animal husbandry on the second plan.

Other reasons for this are the facts that the number of the villages and the number of cattle in these villages are very low as a result of low population and hard topographic conditions in the province. In contrast, it was also determined that livestock breeding was performed at a significant level in Gaziantep and Sanliurfa provinces. These two provinces are followed by Adiyaman province.

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 according to Hill (1982) and Ekinci et al. (2010) using the number of animals in the study area, 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 Gaziantep province. Gaziantep province was followed by Sanliurfa, Adiyaman and Kilis provinces, respectively.

The calculation method of Hill (1982) and Ekinci et al. (2010) was also used separately for the districts of all provinces in the basin, and the amounts of wet, manure and potential biogas energy of these districts were calculated. Owing to these calculations, the appropriate places where biogas energy production facilities could be established in the provinces of the basin were tried.

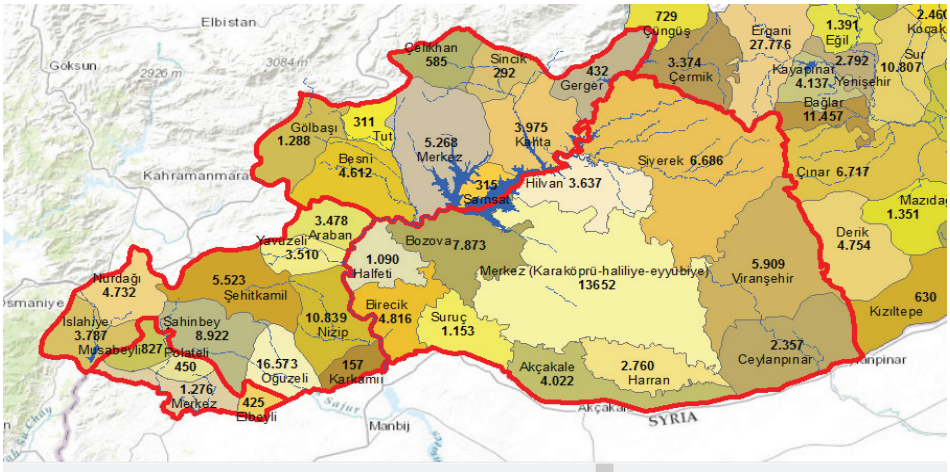

Figure 2. Number of cattle in the Euphrates Basin

Table 2. The amount of potential wet manure and obtainable biogas energy in the Euphrates basin provinces

Province	Total Number of Cattle	Annual Average Amount of Wet Manure (tons)	Annual Amount of Obtainable Biogas Energy (MJ)	Annual Amount of Obtainable Biogas Energy (Kwh)
Gaziantep	57521	902792.1	377803.4	104945.4
Sanliurfa	53795	844312.5	353330.6	98147.4
Adiyaman	17078	268039.1	112169.9	31158.3
Kilis	2978	46739.7	19559.8	5433.3

to be determined and mapped in the GIS environment.

The highest animal population in the study area is in Gaziantep province and it is especially concentrated in Oguzeli and Nizip districts.

According to the VETBIS records for the year of 2015, the cattle amount of Oguzeli and Nizip districts in Gaziantep constitutes 47.65% of the current population of cattle in Gaziantep province. It was determined that the number of cattle in Oguzeli district constitutes about 1/3 of the total number of cattle in Gaziantep province. Thus, biogas production facilities built in the region, such as this district, 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 Gaziantep Municipality in Oguzeli district in 2014. In addition, Nizip district is seen as a potential biogas production area. The number of cattle in Nizip district constitutes approximately 20% of the total number of cattle in Gaziantep province. It was determined that biogas plant investments would also be appropriate in this region.

In the study, upon examining the feasibility of biogas plant areas, it is determined that 21.6% of Gaziantep province are very convenient, 61.7% of them are potential and 16.7% of them are not suitable for biogas production (Figure 3). It is also determined that 104945.4 kW of biogas based electrical energy can be obtained in Gaziantep province. Gokcol et al. (2008) reported the annual electricity consumption value for a house to be 2332 kW. According to this, in Gaziantep province, it is determined that the annual electrical energy needs of 45 houses or one-day energy needs of 16425 houses can be supplied from this source. Bozova, Eyyübiye and Siverek districts constitute 40.6% of the total animal husbandry potential of Sanliurfa province. It is determined that the biogas plants planned to be built should be concentrated in these districts.

The most important characteristic of these three provinces is that they are located close to water resources in the north of the province. Therefore, the biogas plants to be constructed

here can prevent the environmental pollution of water resources and, at the same time, reduce the energy needs of agricultural enterprises and houses.

It was determined that the electricity energy of 98147.4 kW would be obtained in Sanliurfa province depending on the wet manure. This will supply the annual energy requirement for 42 houses (Figure 4).

The annual electrical energy needs of 14 houses or one-day energy needs of 5110 houses can be supplied from this source.

The potential biogas production sites of Kilis province are very limited. The Central and Musabeyli Districts account for 42.8% of the total province potential.

Kilis province does not have areas very suitable for biogas production.

It was determined that 48.7% of Kilis province are suitable for biogas production and 51.3% are not suitable for biogas production. Figure 5 demonstrates the most suitable biogas energy production areas in Kilis province.

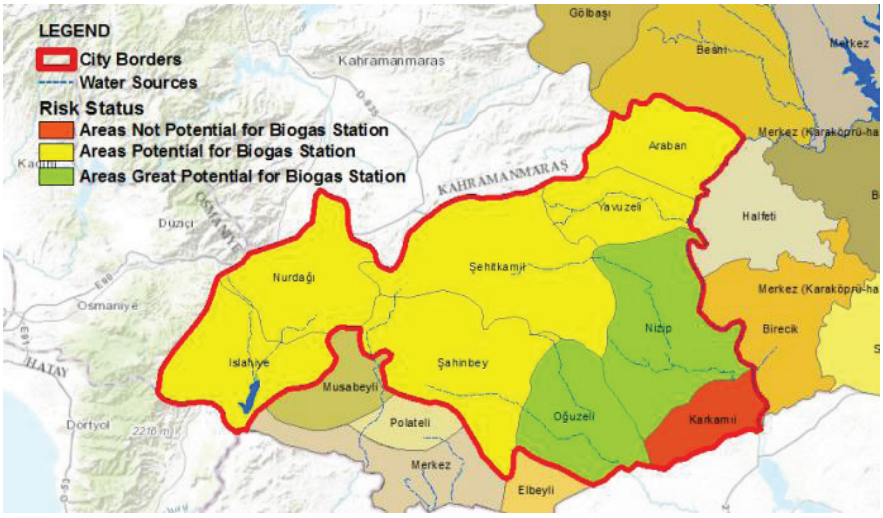

Figure 3. Potential Biogas Energy Fields in Gaziantep province

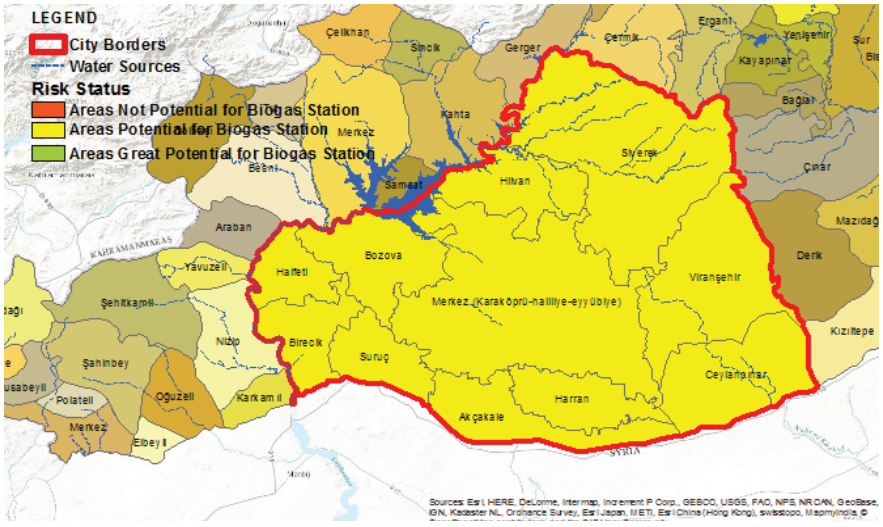

Figure 4. Potential Biogas Energy Fields in Sanliurfa province

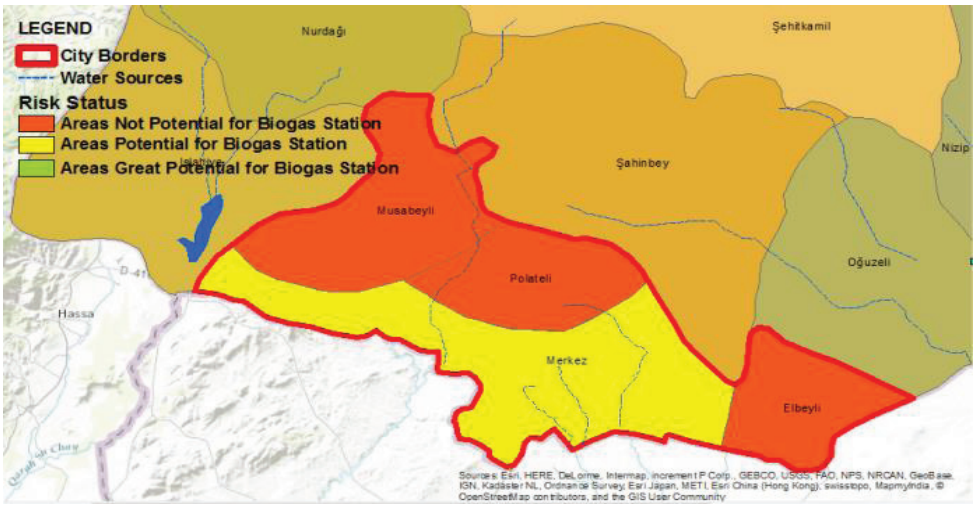

Figure 5. Potential Biogas Energy Fields in Kilis province

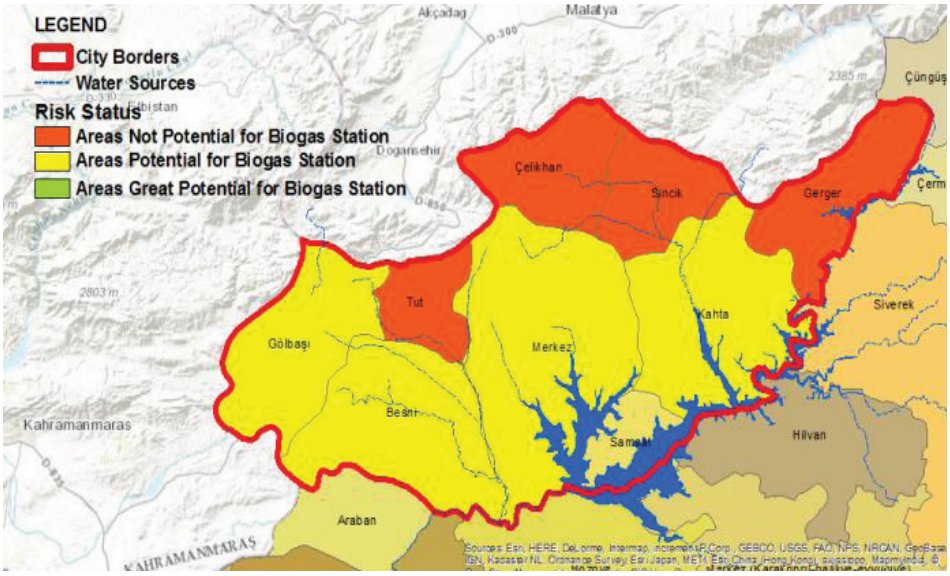

Figure 6. Potential Biogas Energy Fields in Adiyaman province

In Adiyaman province, 81.4% of all provincial cattle are located in the Central district and the districts of Besni and Kahta, and it is determined that livestock enterprises are gathered in the areas close to the water resources as in Sanliurfa province. It was concluded that biogas production facilities in Central, Besni and Kahta districts would be suitable both in terms of water resources and in terms of environmental pollution.

It was determined that 71.3% of Adiyaman province are suitable for biogas production and 28.7% are not suitable for biogas production. 31158.3 kW of biogas based electrical energy can be obtained annually from the biogas facilities that can be installed in Adiyaman province (Figure 6).

In the study area, it was determined that the total potential biogas energy of 862863.7 MJ or electricity energy of 239684.4 kWh would be

obtained from approximately 2061883.4 tonnes of animal manure. This amount will supply the electricity energy needs of 103 houses (Gokcol et al., 2008). If this manure is not used for recycling purposes, it is burned or left on the agricultural lands or in the environment and thus it creates visual pollution and can cause a significant environmental pollution (Aybek et al., 2015; Atilgan et al., 2016). Biogas energy production facilities can be established in the places which have an intensive agricultural activity and this can eliminate these problems.

It is stated that the biogas potential in Turkey is at an advanced level. There are various biogas plants where urban waste is mainly used as a solid fuel. The uncontrolled disposal or storage of organic and animal origin wastes cause odour formation as well as the contamination of underground and surface waters (Anonymous, 2015b). The researchers state that the biogas plants are located in the western part of our country and belong to industrial enterprises and municipalities (Anonymous, 2011; Atilgan et al., 2016). The one biogas plant in the study area confirms this fact.

Therefore, increasing the number of studies on establishing biogas plants in the study area can reduce the energy requirements of enterprises as well as reduce environmental pollution.

CONCLUSIONS

In the study area, the appropriate biogas production sites were tried to be determined using the ARCMAP 10 software according to the given number of cattle and their wet manure production values. To this end, the regions, where the number of animals is high, are identified as the areas suitable or unsuitable for potential biogas production. In addition, the amount of biogas energy per year is calculated from the existing cattle numbers in the Euphrates basin. In the study area, it was determined that the potential biogas energy of 862863.7 MJ or electricity energy of 239684.4 kWh would be obtained from approximately 2061883.4 tonnes of animal waste per year. It was determined that these values were equal to an amount of the annual energy capacity needs of 103 houses**.** These and similar organic wastes are incinerated if not used for recycling, and they are left in the agricultural areas or the environment. Therefore, this creates visual pollution along with causing a significant environmental pollution. Biogas energy production facilities can be established where these and similar agricultural productions are intensively performed, and these problems can be removed.

REFERENCES

Acaroglu, M., (2007). Alternative Energy Sources (In Turkish). Nobel Press No: 1253, 609s.

Anonymous, (2006). Renewable Energy Sources of Turkey (In Turkish). Turkish Environmental Association Press No: 175, 368s.

Anonymous, (2011). Assessment of current conditions and the potential for biogas Investment in Turkey, Turk-German Biogas project, Turkish Government, The Ministry of Environment and Urbanization Available at:http://www.megep.meb.gov.tr/mte_program_modul/moduller_pdf/G%C3%BCbrelikler%20Ve%20Biyogaz%20%C3%9Cniteleri.pdf

Anonymous, (2015a). Republic of Turkey Ministry of Food, Agriculture And Livestock Veterinary Information System Records.

Anonymous, (2015b). Republic of Turkey Nilufer Municipality, Biogas Production Facility Organic Waste Trial Report (In Turkish).

Atilgan, A., Tezcan, A., Cetin, H. (2016). Using of waste plants in production of biogases energy: Kumluca case, 13. Kulturteknik Congress, 12-15 April 2016, p: 435-438, Antalya.

Aybek, A., Ucok, S., Ispir, M.I., Bilgili, M.E., (2015). Digital Mapping and Determination of Biogas Energy Potential of Usable Animal Manure and Cereal Straw Wastes in Turkey, Journal of Tekirdag Agricultural Faculty, 12 (3): 109-120.

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.

ESRI, (2010). Spatial Analyst Tutorial. Printed in the USA.

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

Gokcol, C., Sunan, E., Dursun, B., 2008. Compensation of the Electricity Need for a House in Gebze by Using Wind Energy. Eleco International Conference on Electrical and Electronics Eng. 26-30 November 2008 Bursa.

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

Koc, E., Senel, M. C. (2013). Energy Situation in the World and Turkey - General Evaluation (In Turkish), Engineer and Machine, 54, No: 639, pp. 32-44.

Kocer, N.N. R., Oner, C., Sugozu, I., (2006). Livestock Production in Turkey and Biogas Potential (In Turkish). Eastern Anatolia Region Researches: 17–20.

Polat, H.E. and Olgun M. 2004. Design of Biogas Plants and Usage in Our Country (In Turkish) II. National Egean Energy Symposium, Dumlupınar University ,26-28 May 2004, p. 505-512, Kutahya.

Onal, E, Yarbay, R. Potential and Future of Renewable Energy Sources in Turkey (In Turkish) Istanbul Trade University Journal of Science 9 (2010): 77-60.

Ozcan M., Ozturk S., Yıldırım M. (2011) Determination of Biogas Potentials of Turkey According to Different Source Types (In Turkish). Available at 23.01.2017 http://www.emo.org.tr/ekler/592515d4bc1ad62_ek.pdf

Ozturk, H. H., (2008). Renewable Energy Sources and their usage (In Turkish). Technic Press, 367p.