Determination of the Potential Biogas Energy Value of Animal Wastes: Case of Antalya

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(First received December 2020 and in final form January 2021)

(DOI: 10.31590/ejosat.844631)

ATIF/REFERENCE: Atılıgan, A., Saltuk, B., Ertop, H., Aksoy, E., (2021). Determination of the Potential Biogas Energy Value of Animal Wastes: Case of Antalya. European Journal of Science and Technology, (22), 263-272.

Abstract

Increasing the world population will increase the demand for new energy sources in the future. Waste generated as a result of agricultural activities can be considered as a sustainable energy source. Animal manure that occurs from livestock activities can be shown as an energy source if managed properly. Antalya province and its region, where agriculture and tourism are intense, have been chosen as the study area. In the study, taking into account the data of Turkey Statistical Institute in 2019, for cattle animal breeding the numbers of dairy and beef cattle; for ovine animal breeding the numbers of sheep and goats; for poultry, the numbers of laying hen, turkeys, geese and duck were evaluated. Manure amounts and potential biogas energy values were calculated considering the animal numbers of Antalya province in 2019. The amount of electricity and natural gas energy that can be obtained in this potential biogas energy is also calculated. The obtained results are compared with the relevant literature and calculations are made for the existing biogas potential. As a result of the research, it was calculated that the amount of manure that can be obtained from animal waste in Antalya province could be 3,821.86 million kg and the potential biogas energy could be 45.57 million MJ. It has been calculated that the total amount of biogas that can be obtained is equivalent to approximately 253.23 million kWh of electrical energy or 43.90 million m³ of natural gas energy. As a result, considering the energy need of Antalya province, it can be said that an economic gain can be achieved by utilizing animal wastes for energy production.

Keywords: Antalya, Animal waste, Biogas energy, Cattle, Sheep

Öz

Dünya nüfusunun artması gelecekte yeni enerji kaynaklarına olan talebi artıracaktır. Tarımsal faaliyet sonucu ortaya çıkan atıklar sürdürülebilir enerji kaynağı olarak değerlendirilebilir. Hayvançılık faaliyetleri sonucu ortaya çıkan hayvan gübresi uygunsuz yönetilirse birer enerji kaynağı olarak gösterilebilir. Bu amaçla tarım ve turizmin yoğun olduğu Antalya ili araştırılmasının amacı olarak seçilmiştir. Araştırma Türkiye İstatistik Kurumu’nun 2019 yılları verilerini dikkate alarak, süt, et, gübre miktarları ve potansiyel biyogaz enerjisi değerlendirilmiştir. Elde edilen sonuçlarla, sonucu ilgili literatür bilgileri ile kıyaslanarak muvevat biyogaz potansiyeli için hesaplanmalar yapılmıştır. Araştırma sonucunda, Antalya ilindeki hayvansal atıklardan elde edilebilecek gübre miktarının 3.821.86 milyon kg ve potansiyel biyogaz enerjisinin ise 45.57 milyon MJ olabileceği hesaplanmıştır. Toplam elde edilebilecek biyogaz miktarının yaklaşık 253.23 milyon kWh elektrik enerjisi ve 43.90 milyon m³ doğalgaz enerjine eşdeğer olduğu hesaplanmıştır. Sonuç olarak Antalya ilinin enerji ihtiyacını karşılamak için hayvansal atıklar enerji üretimi için değerlendirilmesi ile ekonomik bir kazanım sağlanabileceği söylenebilir.

Anahtar Kelimeler: Antalya, Hayvansal atık, Biyogaz enerjisi, Süt, Koyun

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1. Introduction

The rapid increase in the world population and the continuous decrease in the available energy resources require some measures to be taken in order to ensure that limited natural resources are sufficient for humanity. This process has made it necessary to restrict the use of natural resources and seek new resources instead of them (Nacar Koçer et al., 2006; Jiang et al., 2011).

In the 21st century, the need for energy is increasing day by day with the developments in people’s living standards. One of the most important indicators of developed countries is the amount of energy consumed per capita (Ulusoy et al., 2009; Ergüneş et al., 2009). The world population needs new and renewable energy sources to combat global warming, to close the energy gap and to solve environmental problems. Today, all countries are working to minimize these problems and turning towards renewable energy sources (Korkmaz et al., 2012). One of the energy resources within renewable energy sources is biogas. Biogas technology, which enables organic wastes that cause environmental and health problems to be made harmless through certain processes and converted into energy, has an important place in the renewable energy sector (Çağlayan and Koçer, 2014).

Animal and plant wastes that are not used in biogas production in our country are mostly either directly burned or given to agricultural land as fertilizer. However, it is more common to use waste in heat production by burning. In this way, the desired quality of heat cannot be produced, and it is not possible to use the wastes as fertilizers after heat generation (Koçer et al., 2006). Efficient use of energy in agriculture will minimize environmental problems and prevent the destruction of natural resources (Erdal et al., 2007; İnci et al., 2016).

Biogas energy production among renewable energy sources in the direction of developing technology and increasing population needs can be applied in areas where animal breeding facilities are carried out. In case of animal wastes reaching underground and surface water resources for biogas production, water pollution will occur. Therefore, the properly storage of wastes on animal barns and transfer to biogas plants may remove the potential negative effects on water resources (Ertop et al., 2018a).

In a study carried out in the Euphrates basin (Adiyaman, Sanliurfa, Gaziantep and Kilis) 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 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 (Saltık et al., 2017).

Gases originating from organic matter, called biogas, can be obtained from many different sources. One of them is animal manure consisting of organic matter. For this reason, the potential of obtaining biogas energy from manure is quite high. Methane from manure is released during the anaerobic decay of organic matter. The higher the amount of animal manure, the higher the amount of organic matter in it and therefore the higher the methane emission (Ersoy, 2017). Animal manure is an important raw material for biogas production (Salihoğlu et al., 2019). As can be understood from literature researches, biogas, which has a great return potential especially for the national economy, has a very important place in terms of environmental sensitivity (Türe et al., 1994) and Demirbaş (2001) cited that Turkey 85% of the waste used in biogas production is expressed from animal manure. Biogas, a colorless and odorless gas, consists of 40-60% methane-weighted carbon dioxide, sulfur and nitrogen gas by fermenting organic wastes. (Kılıç, 2007; Yürek Erdoğlu, 2015).

In a study carried out Tigris basin (Diyarbakır, Mardin, Batman, Siirt and Sırnak). The potential pollution impacts of the cattle breeding enterprises in the research area on the Batman, Botan, Garzan and Tigris Rivers were examined. In this context, the borders of the research provinces and current water resources were drawn with ARCMAP 10.0 software by making geographical adjustments. It was found that the water resources, particularly in the villages of Batman and Diyarbakır provinces, faced a higher risk of contamination. Furthermore, attention was drawn to the issue of environmental pollution caused by animal manure, and the measures to be taken not to experience these and similar situations were mentioned. (Atılgan et al., 2016).

In our country, which has a significant number of animals, if the utilisable animal wastes are used for biogas production, it will be possible to contribute partially to both preventing environmental problems and reducing the problems related to energy consumption and energy use (Bramley et al., 2011; Polatcı et al., 2016).

The aim of this study is to determine the biogas production potential of the manure that can be obtained from these animals by using the cattle, ovine and poultry numbers of Antalya province and its districts and to draw them with the help of an ArcGIS map program.

2. Material and Method

The research covers the Antalya province and its districts located in the Mediterranean Region. The land border of Antalya, one of the most important cities in the Mediterranean Region, is the Taurus mountain range. Three sides of the province’s lands are surrounded by high mountains. The highest mountain is Beydağ (3085m) and Akdağ (3075m). All of these mountains are called the Southern Taurus Mountains. There are plains in the north of the coastline extending from Esen Stream in the west to Kaledron (Kaldiran) Stream in the east. The main rivers within the provincial borders are Alara Stream, Dimçay, Manavgat River, Köprüçay, Eşençay and Devrense Stream (Anonymous, 2020a).

In the study, taking into account the data of Turkey Statistical Institute (TUİK) in 2019, for cattle animal breeding the numbers of dairy and beef cattle; for ovine animal breeding the numbers of sheep and goats; For poultry, the numbers of laying hen, turkeys, geese and duck were evaluated. The numbers of all animals are compiled directly by the Ministry of Agriculture and Forestry (MAF) in the district detail through the Statistical Data Network (SDN) system. SDN is a data entry system established within MAF, and data are entered into this system electronically by responsible personnel in MAF provincial and district organizations. As a result of these data, the potential biogas amount that can be obtained for Antalya province and the equivalent levels of this biogas with other energy sources used were calculated. In determining the potential of manure and biogas that can be obtained from animals, manure production per unit animal, dry matter content, volatile dry matter content, values...
of the methane production rate of the manure and the usability of the manure values were calculated according to (Ekinci et al., 2010).

\[ AM \left( \frac{kg}{year} \right) = AN \times DMP \left( \frac{kg}{day} \right) \times 365 \ (day) \]

Here:
- **AM**: Animal manure amount (kg/year)
- **AN**: Animal number
- **DMP**: Daily manure production per animal (kg/day-animal)

\[ BE(MJ) = AM \times DM(\%) \times VDM(\%) \times MPR(m^3CH_4/kg) \]

Here:
- **BE**: Amount of biogas energy available (MJ)

**DM**: Dry matter content (%)

**VDM**: Volatile Dry Matter content (%)

**MPR**: Methane Production Rate (m³ CH₄/kg)

It has been tried to compare the potential biogas that can be obtained in the research area with the other energy sources used today. (Zan Sancak et al., 2014), (Baran et al., 2017) and (Ertop et al., 2018b) stated that the amount of energy obtained from biogas is equivalent to 0.63 liters of gas oil, 3.47 kg of wood, 0.43 kg of butane gas, 4.7 kWh of electricity and 0.8 liters of gasoline. Deviren et al., (2017) stated that 1 m³ biogas can be generate energy from 0.62 m³ natural gas in return for thermal energy. These values have been taken into account when comparing the energy that can be obtained from annual biogas with other energy sources.

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### Table 1. The amount and properties of animal manure accepted for the biogas process (Ekinci et al., 2010)

| Type of animal | Manure production per animal (kg/animal-day) | DM (dry matter content) (%) | Specific methane production rate (m³ CH₄/kg VS) | VDM (Volatile dry matter content) (%) | The ratio of collectable animal manure |
|----------------|---------------------------------------------|-----------------------------|-----------------------------------------------|--------------------------------------|---------------------------------------|
| Dairy cattle   | 43.00                                        | 13.95                       | 0.18                                          | 83.36                                | 0.50                                  |
| Beef cattle    | 29.00                                        | 14.66                       | 0.33                                          | 84.65                                | 0.50                                  |
| Sheep          | 2.40                                         | 27.50                       | 0.30                                          | 83.63                                | 0.13                                  |
| Goats          | 2.05                                         | 31.71                       | 0.30                                          | 73.06                                | 0.13                                  |
| Laying hen     | 0.13                                         | 25.00                       | 0.35                                          | 75.00                                | 0.13                                  |
| Turkeys        | 0.38                                         | 25.53                       | 0.35                                          | 75.83                                | 0.26                                  |
| Duck and geese | 0.33                                         | 28.18                       | 0.35                                          | 61.28                                | 0.22                                  |

### 3. Results

It is known that the tourism potential of Antalya province is quite high. Tourism increases the meat and milk consumption of the region especially in the summer months. Therefore, it is known that the livestock potential of the region increases day by day. While the increase in the number of animals satisfies the producers, the negative environmental wastes that may arise make the authorities think. However, the use of these wastes as biogas energy will both turn into environmental benefits and provide income to producers as a gain. With this study, the animal husbandry data and literature information of the region were formulated and the biogas potential based on province and district was calculated, and potential biogas areas were shown on the map with the help of ArcGIS program.

The Mediterranean climate is dominant in the province of Antalya and its districts, and it is known that a large part of the research area has a hot climate seasonally. Therefore, it is anticipated that all biogas produced can be used as an energy source, as the biogas plants to be established may require no heating in many months of the year or very little heating in some months. The potential amount of manure and biogas amounts that can be obtained from dairy cattle in Antalya Province are given in Table 2.

### Table 2. Manure and potential biogas energy amounts that can be obtained from dairy cattle

| District    | Animal numbers | Available manure amount (kg) | Available biogas energy amount (MJ) |
|-------------|----------------|------------------------------|-----------------------------------|
| Akseki      | 991            | 15553745                     | 162783,13                         |
| Akku        | 4342           | 68147690                     | 713223,37                         |
| Alanya      | 10058          | 157860310                    | 1652142,01                        |
| Demre       | 415            | 6513425                      | 68168,52                          |
| Döşemealtı | 12101          | 189925195                    | 1987728,22                        |
| Elmali      | 9766           | 153277370                    | 1604177,66                        |
| Finike      | 566            | 8883370                      | 92972,00                          |
| Gazipaşa    | 5419           | 85051205                     | 890132,98                         |
| Gündoğmuş    | 1006           | 15789170                     | 165247,05                         |
| İbradi      | 2514           | 39457230                     | 412953,37                         |
| Kaş         | 4208           | 66044560                     | 691212,33                         |
When Table 2 is examined, it is seen that the total potential amount of manure that can be obtained from dairy cattle is 647519845 kg per year and 19.79% of this manure is in Korkuteli district, followed by Manavgat district with 15.78%. Similarly, it has been determined that the total potential biogas energy that can be obtained from dairy cattle is 17242692.28 MJ per year, followed by Korkuteli district with 19.79% and the Manavgat district with 15.78%. As can be understood from all these data, Korkuteli district in the north of Antalya Province is one of the important districts of Antalya in terms of animal breeding. In the region, dairy cattle breeding is preferred because of the long production period and the variety of products. Enterprises on milk and dairy products operate in the organized industrial zone in the region (Anonymous, 2019a). 87008 cattle are grown in the fattening enterprises established to meet the beef needs of the region, and 66 enterprises throughout the province are producing (Anonymous, 2019b). Potential manure and biogas amounts that can be obtained from beef cattle in the research area are given in Table 3.

Table 3. Manure and potential biogas energy amounts that can be obtained from beef cattle

| District    | Animal numbers | Available manure amount (kg) | Available biogas energy amount (MJ) |
|-------------|----------------|------------------------------|-------------------------------------|
| Akseki      | 673            | 7123705,00                   | 145864,90                           |
| Aksu        | 3532           | 37386220,00                  | 765519,81                           |
| Alanya      | 6527           | 69088295,00                  | 1414651,13                          |
| Demre       | 248            | 2625080,00                   | 53751,11                            |
| Döşemealtı | 15094          | 159769990,00                 | 3271448,48                          |
| Elmalı      | 811            | 85854935,00                  | 1757964,66                          |
| Finike      | 360            | 3810600,00                   | 78025,80                            |
| Gazipaşa    | 2966           | 31395110,00                  | 642845,91                           |
| Gündoğmuş    | 713            | 7547105,00                   | 154534,44                           |
| İbradi      | 1695           | 17941575,00                  | 367371,48                           |
| Kaş         | 2344           | 24811240,00                  | 508034,66                           |
| Kemer       | 383            | 4054055,00                   | 83010,78                            |
| Kepez       | 4495           | 47579575,00                  | 974238,83                           |
| Konyaaltı   | 1076           | 11389460,00                  | 233210,45                           |
| Korkuteli   | 16801          | 177838585,00                 | 3641420,82                          |
| Kumluca     | 796            | 8425660,00                   | 172523,72                           |
| Manavgat    | 13095          | 138610575,00                 | 2838188,54                          |
| Muratpaşa   | 521            | 5514785,00                   | 112920,67                           |
| Serik       | 7578           | 80213130,00                  | 1642443,13                          |
| Total       | 87008          | 920979680,00                 | 18857969,34                          |

When Table 3 is examined, it is seen that the total amount of potential manure that can be obtained from beef cattle is 920979680 kg per year and 19.31% of this manure is in Korkuteli district and this is followed by the district of Döşemealtı with 17.34%. Similarly, it has been determined that the total potential biogas energy that can be obtained from beef cattle is 18857969,34 MJ per year and 19.31% is in Korkuteli district, followed by Döşemealtı district with 17.34%. Potential manure and biogas amounts that can be obtained from sheep in the research area are given in Table 4.
When Table 4 is examined, it is seen that the total amount of potential manure that can be obtained from sheep is 45,624,357.6 kg per year and 20.83% of this manure is in Manavgat district, followed by Korkuteli district with 19.28%. Similarly, it has been determined that the total potential biogas energy that can be obtained from sheep is 4,092,193.49 MJ per year, followed by Manavgat district with 20.83% and Korkuteli district with 19.28%. Potential manure amount and biogas quantities that can be obtained from laying hen in the research area are given in Table 6.

When Table 5 is examined, it is seen that the total potential amount of manure that can be obtained from goats is 56,328,933.45 kg per year and 17.77% of this manure is in Manavgat district, followed by Korkuteli district with 14.52%. Potential manure amount and biogas quantities that can be obtained from laying hen in the research area are given in Table 6.
When Table 6 is examined, it is seen that the total potential manure amount that can be obtained from laying hens is 25350067,60 kg per year and 29,01% of this manure is in Korkuteli district, followed by Serik district with 12,23%. Similarly, it has been determined that the total potential biogas energy that can be obtained from laying hen is 216267,76 MJ per year and 29,01% of it is located in Korkuteli district, followed by Serik district with 12,23%. The potential amount of manure and biogas amounts that can be obtained from geese, turkeys and duck in the study area are given in Table 7.

When Table 6 is examined, it is seen that the total potential manure amount that can be obtained from laying hens is 25350067,60 kg per year and 29,01% of this manure is in Korkuteli district, followed by Serik district with 12,23%. Similarly, it has been determined that the total potential biogas energy that can be obtained from laying hen is 216267,76 MJ per year and 29,01% of it is located in Korkuteli district, followed by Serik district with 12,23%. The potential amount of manure and biogas amounts that can be obtained from geese, turkeys and duck in the study area are given in Table 7.

Table 7. Manure and potential biogas energy amounts that can be obtained from geese, turkeys and duck

| District | Type of animals | Animal Numbers | Available manure amount (kg) | Available biogas energy amount (MJ) |
|----------|----------------|----------------|-----------------------------|----------------------------------|
| Akseki   | Turkeys        | 180            | 24966,00                    | 439,83                           |
|          | Duck and Geese | 74             | 8913,30                     | 118,52                           |
| Aksu     | Turkeys        | 258            | 35784,60                    | 630,42                           |
|          | Duck and Geese | 251            | 30232,95                    | 402,00                           |
| Alanya   | Turkeys        | 190            | 26353,00                    | 464,26                           |
|          | Duck and Geese | 217            | 26137,65                    | 347,55                           |
| Demre    | Turkeys        | 28             | 3883,60                     | 68,42                            |
|          | Duck and Geese | -              | -                           | -                                |
| Döşemealtı | Turkeys     | -              | -                           | -                                |
|          | Duck and Geese | 320            | 38544,00                    | 512,52                           |
| Elmalı   | Turkeys        | 12500          | 1733750,00                  | 30543,57                         |
|          | Duck and Geese | 500            | 60225,00                    | 800,81                           |
| Finike   | Turkeys        | 730            | 101251,00                   | 1783,74                          |
|          | Duck and Geese | 520            | 62634,00                    | 832,84                           |
| Gazipaşa | Turkeys        | 315            | 43690,50                    | 769,70                           |
|          | Duck and Geese | 557            | 67090,65                    | 892,10                           |
| Gündoğmuş| Turkeys        | -              | -                           | -                                |
|          | Duck and Geese | -              | -                           | -                                |
| İbradi   | Turkeys        | -              | -                           | -                                |
|          | Duck and Geese | -              | -                           | -                                |
| Kaş      | Turkeys        | 319            | 44245,30                    | 779,47                           |
|          | Duck and Geese | 195            | 23487,75                    | 312,31                           |
| Kemer    | Turkeys        | 350            | 48545,00                    | 855,22                           |
When Table 7 is examined, it is seen that the total potential amount of manure that can be obtained from turkey, geese and duck is 4387949.70 kg per year and 40.88% of this manure is in Elmalı district, followed by Korkuteli district with 23.84%. Similarly, it has been determined that the total potential biogas energy that can be obtained from turkeys, geese and duck is 72360.34 MJ per year and 43.32% of it is located in Elmalı district, followed by Korkuteli district with 23.61%. The potential manure amount and biogas quantities that can be obtained based on the presence of cattle, ovine and poultry in Antalya province are given in Table 8.

Table 8. Potential manure and biogas amount that can be obtained in Antalya province

| District   | Cattle | Manure amount (kg) | Available biogas energy amount (MJ) | Manure amount (kg) | Available biogas energy amount (MJ) |
|------------|--------|--------------------|--------------------------------------|--------------------|--------------------------------------|
| Akseki     | Cattle | 226774450          | 308648.03                            | 27134556.25        | 245029.99                            |
| Aksu       | Cattle | 105533910          | 1478743.18                           | 25727864.50        | 231128.57                            |
| Alanya     | Cattle | 226948605          | 3066793.14                           | 47312559.25        | 426214.80                            |
| Demre      | Cattle | 9138505            | 121919.63                            | 23725565.75        | 214178.46                            |
| Döşemealtı | Cattle | 349695185          | 5259176.70                           | 52928431.00        | 476690.28                            |
| Kemer      | Cattle | 14679570           | 194215.80                            | 7442350.00         | 670407.27                            |
| Kepez      | Cattle | 124736195          | 1781748.29                           | 7467688.75         | 680328.28                            |
| Konyaaltı  | Cattle | 31965605           | 448557.26                            | 20867688.00        | 188047.71                            |
| Korkuteli  | Cattle | 503855125          | 7053460.37                           | 172233280.00       | 1550206.77                           |
| Kumlucu    | Cattle | 26647555           | 363231.30                            | 20746253.25        | 187129.92                            |
| Manavgat   | Cattle | 398598250          | 5559180.03                           | 195170610.00       | 1757148.77                           |
| Muratpaşa  | Cattle | 14162730           | 203428.75                            | 4543282.75         | 40847.79                             |
| Serik      | Cattle | 199997370          | 2896086.78                           | 7424662.00         | 667097.44                            |
When table 8 is examined, it is seen that the total amount of potential manure that can be obtained in Antalya province is 3821867452.35 kg per year and 17.91% of this manure is in Korkuteli district, followed by Manavgat district with 15.60%. Similarly, it has been determined that the total potential biogas energy that can be obtained in Antalya is 45570947.23 MJ per year and 19.05% of it is located in Korkuteli district, followed by Manavgat district with 16.10%. The equivalent of the potential annual biogas energy of Antalya in the our energy resources we use is given in Table 9.

Table 9. Equivalence of biogas that can be produced in Antalya province in other energies

| District   | Gas oil (L) | Wood (kg) | LPG (kg) | Gasoline (L) | Electricity (KWh) | Natural gas (m³) |
|------------|-------------|-----------|----------|---------------|-------------------|-----------------|
| Akseki     | 350036,01   | 1927967,14| 238913,47| 444490,18     | 2611379,78        | 344479,89       |
| Aksu       | 1081956,47  | 5959347,53| 738478,22| 1373912,98     | 8071738,73        | 1064782,56      |
| Alanya     | 2209280,12  | 12168574,62| 1507921,35| 2805435,07    | 16481931,05       | 2174212,18      |
| Demre      | 214320,65   | 1180464,54| 146282,35| 272153,21     | 1598900,10        | 210918,74       |
| Döşemealtı| 3623865,21  | 19960019,49| 247341,81| 4601733,60     | 27035184,90       | 2936133,30      |
| Elmalı     | 2983490,29  | 16432875,08| 2036350,51| 3788559,10    | 22257784,69       | 2936133,30      |
| Finike     | 238995,59   | 1316372,54| 163123,97| 303486,46      | 1782982,98        | 1125202,91      |
| Gazipaşa   | 1168758,97  | 6437450,21| 797724,38| 1483138,38     | 7813912,96        | 2174212,18      |
| Gündoğmuş  | 35530,82    | 195701,51  | 24251,20  | 45118,50       | 260507,12         | 349670,17       |
| İbradı     | 5816295,22  | 32035784,80| 3969852,30| 7385771,71     | 43391408,81       | 5723973,08      |
| Kaş        | 1185608,81  | 6530258,03| 809225,06| 1505534,99     | 8845018,08        | 1163389,62      |
| Kemer      | 170914,48   | 941386,09  | 116655,91| 217034,26      | 12707675,26       | 168201,55       |
| Kepez      | 1277333,71  | 7035472,99| 871830,95| 1622010,06     | 9529315,00        | 1257058,57      |
| Konyaaltu  | 405816,28   | 2235210,32| 276985,72| 515322,06      | 30275183,30       | 399374,75       |
| Korkuteli  | 5470601,84  | 30131727,58| 3733902,84| 6946795,98    | 40812426,41       | 5383766,89      |
| Kumluca    | 348275,51   | 1918279,40| 237711,86| 442254,62      | 2598245,87        | 342747,33       |
| Manavgat   | 4622395,84  | 25459862,79| 3154968,59| 5869709,00    | 34484540,38       | 4549024,48      |
| Muratpaşa  | 154593,96   | 851493,72  | 105516,51| 196309,79      | 1153320,03        | 152140,09       |
| Serik      | 2266517,79  | 12483836,10| 1549883,38| 2878117,83     | 16908942,26       | 2230541,32      |
| Total      | 33944366,75 | 186963416,89| 23168377,31| 43103957,78 | 253235751,98      | 43902167,31     |
When Table 9 is examined, it is seen that the amount of biogas that can be obtained per year is equivalent to approximately 253,2 million kWh of electrical energy. According to TEDAŞ (Turkey’s electricity distribution corporation) electricity pricing for October 2019, the residential consumption price of electricity in kWh is 0.366 TL (Anonymous, 2020b). It has been determined that a total of 253235751.98 kWh of electrical energy can be obtained from biogas in Antalya. It has been calculated that the annual economic gain of electrical energy production from biogas to Antalya is 92684285.22 TL. According to the data of 2019, an energy consumption of 8574815390 kWh was realized in Antalya (Anonymous, 2020c). Considering the electricity production potential, it has been determined that Antalya province can meet 2.95% of the electricity consumed by its own resources. By the end of 2019, the average unleaded gasoline price in Antalya is 7.19 (TL/L) (Anonymous, 2020d). Considering the equivalent value of the energy that can be obtained in Antalya province with gasoline energy, an economic gain of 309917456.44 TL can be obtained. The natural gas consumption amount in 2019 in Antalya was 740020000 m$^3$ (Anonymous, 2020e). However, it can be thought that a heat energy equivalent to 43902167.31 m$^3$ natural gas can be obtained in Antalya and 5.93 % of the natural gas consumption of the province can be provided by its own resources.

Conclusions

It is thought that determining the potential amount of biogas energy that can be obtained from cattle, ovine and poultry animal wastes of Antalya province can provide convenience for energy investments that can be planned in districts. The amount of biogas energy that can be obtained from total animal manure has been determined as 45570947.23 MJ per year. It has been concluded that the highest production amount of biogas energy is in Korkuteli district with an annual potential of 8683494.98 MJ and the lowest biogas energy production potential is in Muratpaşa district with 245387.24 MJ. In addition, the energy equivalent values have been found by comparing the biogas energy that can be obtained with other energy sources used as energy sources today. It has been concluded that 16481931.05 kWh of electricity can be obtained in Alanya and 22257784.69 kWh in Elmali from biogas energy that can be obtained from total animal manure, similarly, equivalent energy can be obtained in 2805435.07 L gasoline Alanya and 3788559.10 L gasoline in Elmali. When the total number of animals in Antalya is examined, priority should be given to these districts in a biogas plant project that can be built, since the animal presence of Korkuteli and Manavgat is higher than other districts. As a result, it can be said that an economic gain can be achieved by utilizing the animal wastes that will arise in Antalya province for energy production.
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