Avrupa Bilim ve Teknoloji Dergisi
Özel Sayı 22, S. 263-272, Ocak 2021

Araştırma Makalesi

www.ejosat.com ISSN:2148-2683

European Journal of Science and Technology
Special Issue 22, pp. 263-272, January 2021

Research Article

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: Atılgan, A., Saltuk, B., Ertop, H., Aksoy, E., (2021). Determiınation 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 m^3 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

Hayvansal Atıkların Potansiyel Biyogaz Enerji Değerinin Belirlenmesi: Antalya Örneği

Öz

Dünya nüfusunun artması gelecekte yeni enerji kaynaklarına olan talebi artıracaktır. Tarımsal faaliyet sonucu ortaya çıkan atıklar sürdürülebilir enerji kaynağı olarak değerlendirilebilir. Hayvancılık faaliyetleri sonucu ortaya çıkan hayvan gübresi uygun yönetilirse birer enerji kaynağı olarak gösterilebilir. Bu amaçla tarımın ve turizmin yoğun olduğu Antalya ili araştırma alanı olarak seçilmiştir. Araştırmada Türkiye İstatistik Kurumu'nun 2019 yılları verileri dikkate alınarak, süt sığırı ve et sığırı varlığı büyükbaş; koyun ve keçi varlığı küçükbaş, yumurta tavuğu, hindi, kaz ve ördek varlığı ise kanatlı olarak değerlendirilmeye alınmıştır. Antalya ilinin 2019 yılına ait hayvan sayıları göz önüne alınarak gübre miktarları ile potansiyel biyogaz enerji değerleri hesaplanmıştır. Bu potansiyel enerjiden elde edilebilecek elektrik ve doğal gaz enerji miktarları da hesaplanmıştır. Elde edilen sonuçlar, konuyla ilgili literatür bilgileri ile kıyaslanarak mevcut biyogaz potansiyeli için hesaplamalar 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 enerjisine ya da 43.90 milyon m^3 doğalgaz enerjine eşdeğer olduğu hesaplanmıştır. Sonuç olarak Antalya ilinin enerji ihtiyacı göz önüne alındığında hayvansal atıkların enerji üretimi için değerlendirilmesi ile ekonomik bir kazanım sağlanabileceği söylenebilir.

Anahtar Kelimeler: Antalya, Hayvansal atık, Biyogaz enerjisi, Sığır, 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; Inci 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 (Saltuk 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; Yürük Erdoğmuş, 2015).

In a study carried out Tigris basin (Diyarbakir, Mardin, Batman, Siirt and Sirnak). 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 Diyarbakir 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. (Atilgan et al, 2016).

In our country, which has a significant number of animals, if the utilizable 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 Beydağı (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 Eşen Stream in the west to Kaledron (Kaldıran) 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 (TUIK) 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).

$$\boldsymbol{AM}\left(\frac{kg}{year}\right) = \boldsymbol{AN} * \boldsymbol{DMP}\left(\frac{kg}{day-animal}\right) * \mathbf{365}(day)$$

Here:

AM: Animal manure amount (kg/year)

AN: Animal number

DMP: Daily manure production per animal (kg/day-animal)

$$\boldsymbol{BE}(\boldsymbol{MJ}) = \boldsymbol{AM} * \boldsymbol{DM}(\%) * \boldsymbol{VDM}(\%) * \boldsymbol{MPR}(m^3 CH_4/kg)$$

Here:

BE: Amount of biogas energy available (MJ)

DM: Dry matter content (%)

VDM: Volatile Dry Matter content (%)

MPR: Methane Production Rate (m^3 CH_4/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 m^3 biogas can be generate energy from 0.62 m^3 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.

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 (m^3 CH_4/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
Aksu	4342	68147690	713223,37
Alanya	10058	157860310	1652142,01
Demre	415	6513425	68168,52
Döşemealtı	12101	189925195	1987728,22
Elmalı	9766	153277370	1604177,66
Finike	566	8883370	92972,00
Gazipaşa	5419	85051205	890132,98
Gündoğmuş	1006	15789170	165247,05
İbradı	2514	39457230	412953,37
Kaş	4208	66044560	691212,33

Kemer	677	10625515	111205,02
Kepez	4916	77156620	807509,46
Konyaaltı	1311	20576145	215346,81
Korkuteli	20772	326016540	3412039,55
Kumluca	1161	18221895	190707,58
Manavgat	16565	259987675	2720991,49
Muratpaşa	551	8647945	90508,08
Serik	7632	119784240	1253643,65
Total	104971	1647519845	17242692,28

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	8111	85854935,00	1757964,66
Finike	360	3810600,00	78025,80
Gazipaşa	2966	31395110,00	642845,91
Gündoğmuş	713	7547105,00	154534,44
İbradı	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.

Table 4. Manure and potential biogas energy amounts that can be obtained from sheep

District	Animal numbers	Available manure amount (kg)	Available biogas energy amount (MJ)
Akseki	2384	2088384	18731,38
Aksu	23013	20159388	180815,95
Alanya	21923	19204548	172251,69
Demre	3257	2853132	25590,65
Döşemealtı	26517	23228892	208347,31
Elmalı	76780	67259280	603269,84
Finike	3490	3057240	27421,36
Gazipaşa	11450	10030200	89964,05
Gündoğmuş	6412	5616912	50379,87
İbradı	4445	3893820	34924,91
Kaş	27890	24431640	219135,14
Kemer	2790	2444040	21921,37
Kepez	16344	14317344	128416,80
Konyaaltı	8608	7540608	67634,11
Korkuteli	103270	90464520	811405,00
Kumluca	5502	4819752	43229,89
Manavgat	108510	95054760	852576,32
Muratpaşa	3496	3062496	27468,50
Serik	64745	56716620	508709,37
Total	520826	456243576	4092193,49

When Table 4 is examined, it is seen that the total amount of potential manure that can be obtained from sheep is 456243576 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 4092193,49 MJ per year, followed by Manavgat district with 20,83% and Korkuteli district with 19,28%. Potential manure and biogas amounts that can be obtained from goats in the research area are given in Table 5.

Table 5. Manure and potential biogas energy amounts that can be obtained from goats

District	Animal numbers	Available manure amount (kg)	Available biogas energy amount (MJ)
Akseki	33473	25046172,25	226298,61
Aksu	7442	5568476,50	50312,62
Alanya	37565	28108011,25	253963,11
Demre	27895	20872433,75	188587,81
Döşemealtı	39692	29699539,00	268342,97
Elmalı	108223	80977859,75	731655,79
Finike	25685	19218801,25	173646,81
Gazipaşa	30955	23162078,75	209275,34
Gündoğmuş	28343	21207649,75	191616,57
İbradı	15923	11914384,75	107649,53
Kaş	66750	49945687,50	451272,13
Kemer	6680	4998310,00	45161,02
Kepez	16600	12420950,00	112226,48
Konyaaltı	17811	13327080,75	120413,60
Korkuteli	109280	81768760,00	738801,77
Kumluca	21285	15926501,25	143900,03
Manavgat	133800	100115850,00	904572,45
Muratpaşa	1979	1480786,75	13379,29
Serik	23428	17530001,00	158388,07
Total	752809	563289334,25	5089463,98

When Table 5 is examined, it is seen that the total potential amount of manure that can be obtained from goats is 563289334,25 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.

Table 6. Manure and potential biogas energy amounts that can be obtained from laying hen

District	Animal numbers	Available manure amount (kg)	Available biogas energy amount (MJ)
Akseki	3400	161330,00	1376,35
Aksu	16025	760386,25	6487,05
Alanya	32050	1520772,50	12974,09
Demre	9943	471795,35	4025,00
Döşemealtı	39000	1850550,00	15787,50
Elmalı	18000	854100,00	7286,54
Finike	11550	548047,50	4675,53
Gazipaşa	52600	2495870,00	21292,89
Gündoğmuş	5450	258602,50	2206,20
İbradı	779	36963,55	315,35
Kaş	27600	1309620,00	11172,70
Kemer	20500	972725,00	8298,56
Kepez	8900	422305,00	3602,79
Konyaaltı	15000	711750,00	6072,12
Korkuteli	155000	7354750,00	62745,21
Kumluca	4255	201899,75	1722,46
Manavgat	48000	2277600,00	19430,78
Muratpaşa	895	42467,75	362,30
Serik	65301	3098532,45	26434,35
Total	534248	25350067,60	216267,76

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	-	-	-
İbradı	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

	Duck and Geese	525	63236,25	840,85
Kepez	Turkeys	340	47158,00	830,78
	Duck and Geese	430	51793,50	688,69
Konyaaltı	Turkeys	250	34675,00	610,87
	Duck and Geese	540	65043,00	864,87
Korkuteli	Turkeys	5300	735110,00	12950,47
	Duck and Geese	2580	310761,00	4132,16
Kumluca	Turkeys	201	27878,70	491,14
	Duck and Geese	152	18308,40	243,45
Manavgat	Turkeys	275	38142,50	671,96
	Duck and Geese	440	52998,00	704,71
Muratpaşa	Turkeys	50	6935,00	122,17
	Duck and Geese	391	47095,95	626,23
Serik	Turkeys	2102	291547,40	5136,21
	Duck and Geese	1806	217532,70	2892,51
Total	Turkeys	23388	3243915,60	57148,23
	Duck and Geese	9498	1144034,10	15212,11
	Turkeys, Duck and Geese	32886	4387949,70	72360,34

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**		**Ovine**	
	Manure amount (kg)	**Available biogas energy amount (MJ)**	**Manure amount (kg)**	**Available biogas energy amount (MJ)**
Akseki	226774450	308648,03	27134556,25	245029,99
Aksu	105533910	1478743,18	25727864,50	231128,57
Alanya	226948605	3066793,14	47312559,25	426214,80
Demre	9138505	121919,63	23725565,75	214178,46
Döşemealtı	349695185	5259176,70	52928431,00	476690,28
Elmalı	239132305	3362142,32	148237139,80	1334925,63
Finike	12693970	170997,80	22276041,25	201068,17
Gazipaşa	116446315	1532978,89	33192278,75	299239,39
Gündoğmuş	23336275	319781,49	26824561,75	241996,44
İbradı	57398805	780324,85	15808204,75	142574,44
Kaş	90855800	1199246,99	74377327,50	670407,27
Kemer	14679570	194215,80	7442350,00	67082,39
Kepez	124736195	1781748,29	26738294,00	240643,28
Konyaaltı	31965605	448557,26	20867688,75	188047,71
Korkuteli	503855125	7053460,37	172233280,00	1550206,77
Kumluca	26647555	363231,30	20746253,25	187129,92
Manavgat	398598250	5559180,03	195170610,00	1757148,77
Muratpaşa	14162730	203428,75	4543282,75	40847,79
Serik	199997370	2896086,78	74246621,00	667097,44

District	Poultry		Total (Cattle+ Ovine+Poultry)	
	Manure amount (kg)	Available biogas energy amount (MJ)	Manure amount (kg)	Available biogas energy amount (MJ)
Akseki	195209,30	1934,70	254104215,55	555612,72
Aksu	826403,55	7519,47	132088178,05	1717391,22
Alanya	1573263,15	13785,90	275834427,40	3506793,84
Demre	475678,95	4093,42	33339749,70	340191,51
Döşemealtı	1889094,00	16300,02	404512710,00	5752167,00
Elmalı	2648075,00	38630,92	390017519,80	4735698,87
Finike	711932,50	7292,11	35681943,75	379358,08
Gazipaşa	2606651,15	22954,69	152245244,90	1855172,97
Gündoğmuş	258602,50	2206,20	50419439,25	563984,13
İbradı	36963,55	315,35	73243973,30	923214,64
Kaş	1377353,05	12264,48	166610480,55	1881918,74
Kemer	1084506,25	9994,63	23206426,25	271292,82
Kepez	521256,50	5122,26	151995745,50	2027513,83
Konyaaltı	811468,00	7547,86	53644761,75	644152,83
Korkuteli	8400621,00	79827,84	684489026,00	8683494,98
Kumluca	248086,85	2457,05	47641895,10	552818,27
Manavgat	2368740,50	20807,45	596137600,50	7337136,25
Muratpaşa	96498,70	1110,70	18802511,45	245387,24
Serik	3607612,55	34463,07	277851603,55	3597647,29

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 (m^3)
Akseki	350036,01	1927976,14	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	2473431,81	4601733,60	27035184,90	3566343,54
Elmalı	2983490,29	16432875,08	2036350,51	3788559,10	22257784,69	2936133,30
Finike	238995,59	1316372,54	163123,97	303486,46	1782982,98	235202,01
Gazipaşa	1168758,97	6437450,21	797724,38	1484138,38	8719312,96	1150207,24
Gündoğmuş	35530,82	195701,51	24251,20	45118,50	265071,21	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	11663389,62
Kemer	170914,48	941386,09	116655,91	217034,26	1275076,25	168201,55
Kepez	1277333,71	7035472,99	871830,95	1622011,06	9529315,00	1257058,57
Konyaaltı	405816,28	2235210,32	276985,72	515322,26	3027518,30	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	1546988,33	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.

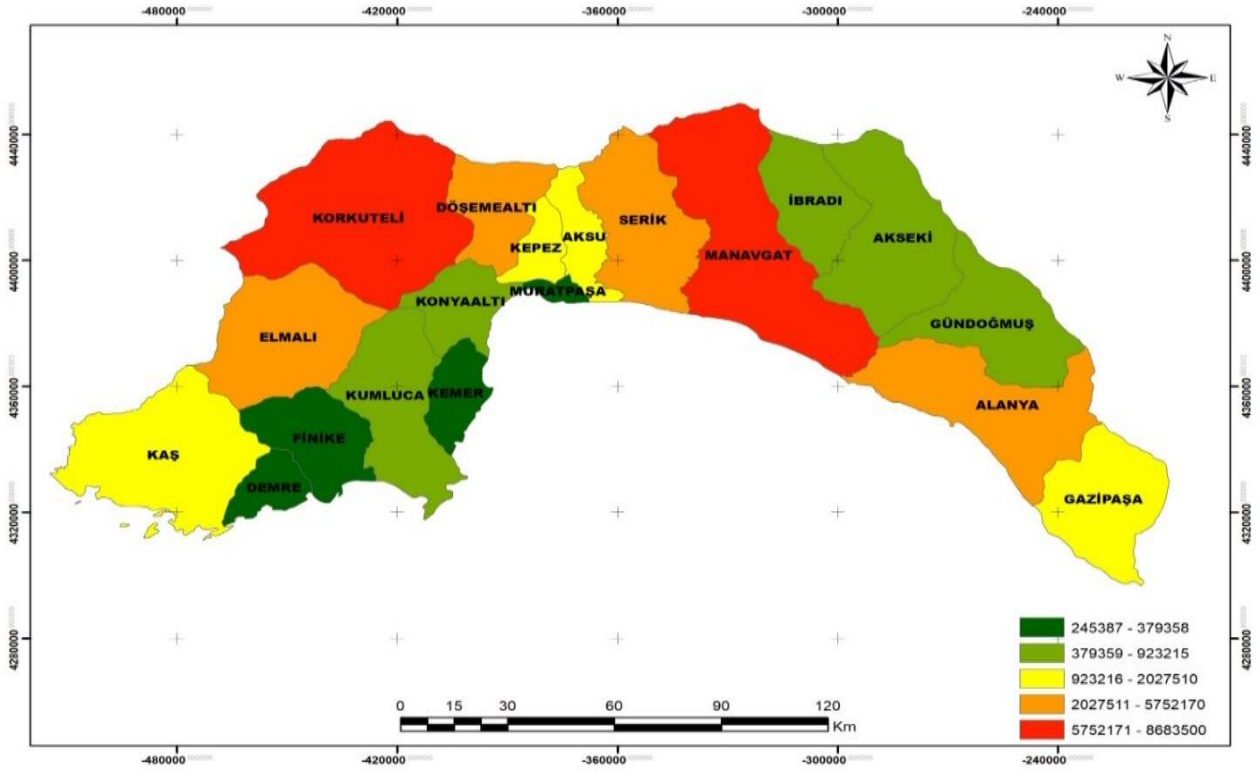

Figure 1. Biogas energy levels that can be obtained from animal waste in Antalya province

When Figure 1 is examined; It is seen that the districts of Manavgat and Korkuteli have the highest energy level and the districts with the lowest energy level are Demre, Kemer, Finike and Muratpaşa. The high energy levels of Manavgat and Korkuteli districts can be explained by the intense animal husbandry activities in rural areas. Due to the geographical location of the town of Manavgat, tourism activities are intense, however, its high energy value can be explained by the intense animal husbandry activities in its rural areas. The high energy level of Korkuteli district can be explained as its geographical location and climatic conditions have more favorable conditions for animal husbandry than other districts. The fact that the tourism activities and greenhouse cultivation of Demre, Kemer and Finike districts are at the forefront may explain the low energy levels in these districts. The reason for the low energy level of the Muratpaşa district can be shown because of the limited livestock activities since Antalya is the central district.

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 Elmalı 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 Elmalı. 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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