The Effect of Organic Waste Potential of Mersin and Adana Provinces on Biogas Energy Production

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Abstract: In this study, the current state of organic wastes obtained from plant, animal, kitchen and industrial sewage sludge plants in Mersin and Adana provinces and biogas energy production potential were investigated. In this study, data on animals and plants were obtained from Adana and Mersin Provincial Directorate of Agriculture and data on kitchen and industrial wastes were obtained from Adana and Mersin Metropolitan Municipality. As a result of this study, the daily amount of organic matter produced in animal, vegetable, kitchen and sewage sludge plants in Mersin province is 16 801.48 tons and the amount of biogas produced from these wastes is 557 432.47 m^3 and the electricity generated from methane is 2 619.93 MWh. It has been identified. In Adana province, the daily organic matter produced in animal, vegetable, kitchen and sewage sludge plants is 24 517.35 tons and the amount of biogas produced from these wastes is 637 882.68 m^3 and the electricity generated from methane is 2 998.05 MWh. In Mersin, 33% of the electricity generated from organic wastes was obtained from treatment sludge, 57% from animal manure, 4% from agricultural waste and 6% from kitchen waste. In Adana, 39% of the electricity generated from organic wastes was obtained from treatment sludge, 36% from animal manure, 15% from agricultural wastes and 10% from kitchen wastes. Adana Province; In terms of organic matter produced in animal, vegetable, kitchen and sewage sludge plants, it is determined that it is approximately 19% more than Mersin province and it is about 7% more in terms of electrical energy produced from methane.

Keywords: Biogas, energy, organic waste, sewage sludge plants.

1. INTRODUCTION

The rapid growth in the world economy has led to huge increases in energy demand. However, with the limited amount of fossil fuel reserves such as oil, coal and natural gas, their damages to the environment made renewable energy resources compulsory [1,2]. When fossil fuels are burned, carbon dioxide, sulfur dioxide, nitrogen oxide, dust and soot emit into the atmosphere, pollute the environment and cause death, while carbon dioxide and similar greenhouse gases cause global climate change and threaten life in all countries of the world [3]. The limited availability of fossil fuel reserves in the world and their depletion in the near future accelerated the trend towards renewable energy sources [4]. The importance of strategies, plans and policies required for the proper and healthy utilization of renewable energy sources is increasing and reaching important dimensions [5]. As fossil energy sources such as oil and natural gas are decreasing day by day, price increases have led to an increase in the trend of renewable energy sources worldwide [6,7]. In Turkey, 86% of the energy needs are met from fossil sources and 73% is imported [8]. But Turkey is rich in renewable energy resources can not be adequately assessed [9,10]. Biogas energy is among the preferred alternative energy sources because it is environmentalist and cheaper than other energy sources. In rural areas, biogas is important due to its use as both energy source and fertilizer source [11]. While the highest incentives were given to biomass and solar energy with the regulations in the energy law; the lowest incentives were given to wind and hydroelectric energy [12]. Biomass sources can be used directly as fuels and are highly suitable and high potential products for biogas, biocarbon and biodiesel production [13]. Biogas formed as a result of fermentation of organic substances; is a colorless-odorless, flammable gas containing 55-75% CH_4, 24-44% CO_2 and low amounts of H_2S, N, CO[14,15,16]. Biogas is a gas formed by bacterial degradation of biomass under anaerobic conditions [17]. Various plant wastes, domestic wastes with organic content, domestic / urban and industrial treatment sludges and animal manure are the leading organic wastes used in biogas production [18]. Unlike other combustible gases (natural gas), biogas is obtained only from organic raw materials. Biomass of all types, including carbohydrates, proteins, fats, cellulose and hemicelluloses, can be used as substrates for biogas production [19]. As in natural gas, the main component of biogas is methane. Table **1** below shows the properties of biogas and some other gases. When the table is examined, it is seen that biogas is similar to other combustible gases [20].

The annual and total recoverable biomass energy potential of Turkey is estimated to be 17.2 and 32.6

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Table 1: Properties of Biogas and Other Gases

Fuel	Thermal value (kcal/kg)	Density	Air-Fuel ratio (kg/kg)	Ignition temperature (^{0}C)
LPG	10986,91	0,54 kg/ l	15,5	400
Natural gas	13733.64	0,83 kg/ Nm^3	17	600
Diesel	10150.95	0,85 kg/ l	14,5	220
Biogas (%60 CH_4, %40CO_2)	4299.23	1,2 kg/ Nm^3	10,2	650
Methane	11942.29	0,72 kg/ Nm^3	17,2	650
Butane	10891.37	2,70 kg/ Nm^3	15,6	365
Propane	11058.57	2,02 kg/ Nm^3	15,6	470
Benzine	10270.37	0,75 kg/ l	14,8	220

MTEP (Million Tons Equivalent Petroleum) respectively [21]. In the world, especially in China, Germany, Netherlands, India, Japan, Finland, Malaysia, important studies on biogas production technology have been realized [22,23,24,25,26]. Some of the work done in this regard in recent years in Turkey can be summarized as follows. In the study conducted in 2014 for Tokat province, the biogas potential obtained from animal wastes was calculated as 301.434 m^3 / day and the amount of electric energy was 502.390 kWh / day [27]. In the study conducted to determine the biogas potential of Çanakkale, it was reported that a total of 96 934 753 m^3 of biogas can be obtained annually from bovine, ovine and poultry manure [28]. In the study conducted to determine the biogas potential of animal and some plant wastes in Kahramanmaraş province, the total annual biogas energy value was reported as 2 177 TJ [29]. Biogas potential of urban solid wastes is 4,850 million kWh / year and if energy plants are cultivated in 1% of processed agricultural areas, biogas potential will be 25.95 billion kWh / year; biogas potential of animal manure is reported to be 14.26 billion kWh / year [30]. Şenol et. al., 2017, taking into account kitchen wastes, animal wastes, agricultural wastes and wastewater treatment plant wastes of Ankara province, they calculated the amount of biogas production from these wastes[10]. As a result of the calculation, it is reported that the theoretical biogas energy value that can be produced from organic wastes is 277 348 m^3 from animal wastes, 515 220 m^3 from waste water treatment sludge, 38 493 m^3 from agricultural wastes and 160 380 m^3 from kitchen wastes. It is estimated that the amount of biogas energy from animal manure in the Thrace region is 2 427.81 TJ [1]. An exemplary biogas plant is shown in Figure **1**.

The aim of this study is to determine the current state of organic wastes to be obtained from plant, animal, kitchen and domestic / urban sewage sludge plants in Mersin and Adana Provinces and to determine sustainable potential on the local scale by determining the biogas energy production potential.

2. MATERIALS AND METHODS

Located between 39 ° 56'0.109 "north latitude and 32 ° 51'35.07" east longitude in the south of the Mediterranean, Mersin has a surface area of 15 853 km² and a population of 1 814 468 [31]. Adana province is located between 36 ° 30-38 ° 25 northern

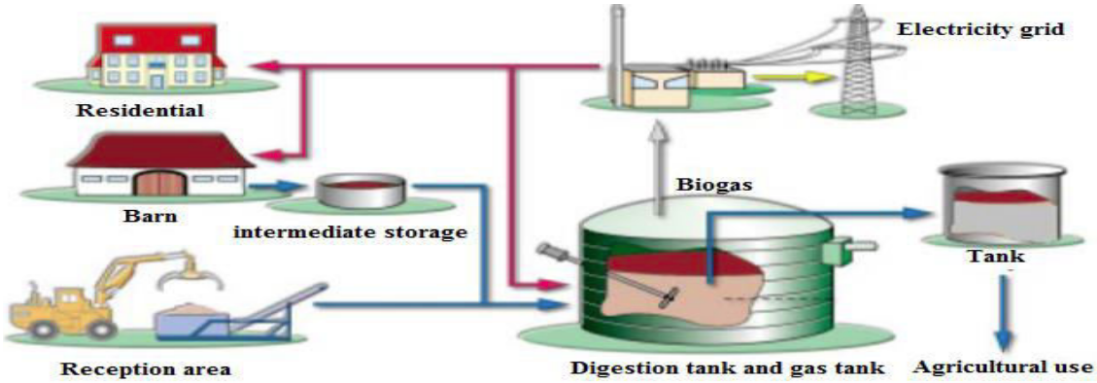

Figure 1: Example of a biogas plant.

Table 2: Number of Animals and Wet Fertilizer Production in Mersin and Adana Provinces

Species Animal	Mersin	Adana	Wet Manure production (Ton / year-animal)	Mersin	Adana
	Number of animals (pcs)			Wet Manure production (Ton / year)	
Bovine (cattle, adult)	115506	293873	3,6	415821,6	1057942,80
Ovine (sheep, goat)	1370420	950148	0,7	959294	665103,60
Poultry (chicken)	27413431	5276705	0,022	603095,5	116087,51
Total	28899357	6520726	-	1978211,1	1839133,91

latitudes and 34 ° 48-36 ° 41 east longitudes in the south of the Mediterranean Sea. Adana has a surface area of 14 125 km² and a population of 2 216 475[32]. In this study, data on animal and plants required for determination of biogas production potential from organic wastes were obtained from Adana and Mersin Provincial Directorate of Agriculture and Forestry and data on kitchen and industrial wastes were obtained from Adana and Mersin Metropolitan Municipalities.

2.1. Determination of Animal Wastes

Animal wastes are known as cattle, horses, sheep, goats, chickens, pigs and slaughterhouse wastes as well as wastes generated by processing animal products. In this study, only organic fertilizers produced from cattle, sheep, goats and chickens are considered. The amount of fertilizer produced daily varies according to the type of animals. Acceptance value of wet manure to be produced from animals in Mersin and Adana provinces, number of animals and amount of wet manure production are given in Table **2** [33].

The total number of animals (cattle, ovine and poultry) in Mersin is 28899357 and the amount of wet manure produced from these animals is 1978211.1 tons. 48.49% of total fertilizers produced are small ruminants, 30.49% are poultry and 21.02% are bovine animals. In Adana province, the total number of animals (bovine, ovine and poultry) is 6 520 726 and the amount of wet manure to be produced from these animals is 1 839 133,91 tons. 58% of the total age fertilizers produced are cattle, 36% sheep and 6% poultry.

2.2. Determination of Agricultural Waste Potential

Mersin province has a total agricultural production area of 3696380 da. 55% of this land is cultivated in fields, 36% in fruits and 9% in vegetables [34]. For this reason, in the study, common crops (corn, cotton, wheat, rye peanut, soybean, oat) crops were investigated in the determination of agricultural waste potential. In the study, plant organic wastes were calculated by multiplying the planting area of the cultivated plants and the amount of organic waste to be produced in the unit area (Table **3**). The spatial yield of the amount of organic waste was obtained from Mersin Provincial Directorate of Agriculture and Forestry [33]. Adana has an agricultural production area of 6 024 373 da. 83% of this land is cultivated in fields, 11.8% in fruits and 5.2% in vegetables. For this reason, in the study, common crops (corn, cotton, wheat, rye peanut, soybean, oat) crops were investigated in the determination of agricultural waste potential. In the study, plant organic wastes were calculated by multiplying the planting area of the cultivated plants

Table 3: Amount of Organic Waste Obtained According to The Plant Type Planted in Mersin and Adana Provinces

Plant	Mersin	Adana	Mersin	Adana	Mersin	Adana
	Sowing area (da)		Amount of organic waste (kg / ha)		Amount of organic waste (ton)	
Sunflower	22367	580227	227	276	5077,309	160142,652
Cotton	52216	317905	496	319	25899,136	101411,695
Soybean	84543	188354	347	340	29336,421	64040,360
Peanut	9824	236399	206	343	2023,744	81084,857
Wheat+Barley+Rye+Oats	978714	1828000	190	293	185955,660	535604,000
Corn plant	133069	931808	881	852	117233,789	793900,416
Total	1280733	4082693	-	-	365526,059	1736183,980

and the amount of organic waste to be produced in the unit area (Table **3**) [33].

As shown in the table, the amount of organic waste obtained in planting in 1 280 733 area in Mersin province is 365526,059 tons. 50.88% of the total organic wastes obtained were wheat + barley + rye + oats, 32.07% corn, 8.03% soy, 7.09% cotton, 0.55% peanut. and 1.39% consisted of sunflower plants. In Adana province, the amount of organic waste obtained in planting in 4 082 693 da area is 1 736 183.98 tons. 45.7% of the total organic wastes obtained were corn, 30.8% wheat + barley + rye + oats, 4.6% peanuts, 3.6% soybean, 5.8% cotton and 9.2% were sunflower plants.

2.3. Determination of Kitchen Waste

Today, almost all of the organic wastes that are consumed at home go to garbage. These wastes, which are thrown away in cities or rural areas, bring some problems such as footprint and formation of stench. However, the use of these organic wastes, which are dumped in the landfills, in proper gas collection, can contribute to both the environment and the household budget[35]. In the theoretical determination of the amount of kitchen waste, it is accepted that it produces 1 kg of waste per person per day and that 60% of the waste produced is organic waste [36]. Accordingly, since the population of Mersin is 1 814 468 according to the latest statistical data, the amount of organic waste produced from kitchen waste was calculated as 1 088.68 tons per day. Since the population of Adana is 2 216 475 according to the latest statistical data, the amount of organic waste produced from kitchen waste is calculated as 1 329.88 tons per day.

2.4. Determination of Wastewater Treatment Sludge

Waste water; It consists of water contaminated by industrial, urban, agricultural and other uses and whose properties have been partially changed. Since wastewater treatment sludge contains high amounts of organic matter, nutrients and pathogenic bacteria, it is important to treat wastewater. Its thermal value depends on the type of sludge and the amount of organic matter it contains. The amount of gas per person in the domestic wastewater treatment plant varies between 15-22 liters / day. The methane percentage of the gas produced is 65% and the energy value is 22.4 MJ / m^3 [1]. A large part of the sludge entering the decanter in the waste water treatment plant is water and it is between 1-5% in Dry Matter Amount (KMM) [37]. Municipal treatment plants generally convert 100 liters of sewage water into 1-2 liters of sludge. The remaining part formed by removing contaminating substances from the water is waste

Table 4: Capacity of Wastewater Treatment Plants in Mersin and Adana Provinces

Wastewater Treatment Plant	Capacity (m^3 / day)
Karaduvar Wastewater Treatment Plant	189523
Tarsus Wastewater Treatment Plant	61272
Erdemli Wastewater Treatment Plant	21972
Kargıpınarı Wastewater Treatment Plant	6000
Atakent Wastewater Treatment Plant	6800
Silifke Wastewater Treatment Plant	21000
Narlıkuyu Package Wastewater Treatment Plant	500
Bozyazı Wastewater Treatment Plant	2652
Total	**309719**
Adana Seyhan Wastewater Treatment Plant	227346
Adana Yüreğir Wastewater Treatment Plant	128208
Adana Ceyhan Wastewater Treatment Plant	34896
Adana Karaisalı Wastewater Treatment Plant	2000
Adana Kozan Atık Wastewater Treatment Plant	22000
Adana Yumurtalık Package Waste Water Treatment Plant	900
Adana Tufanbeyli Wastewater Treatment Plant	1500
Total	**416850**

Table 5: Biogas Yield Values of Some Organic Wastes

Organic matter	Biogas yield (m^3 / ton)	References
Bovine manure	33	(Öztürk, 2008; Şenol *et al*., 2017) [41,10].
Ovine manure	58	(Ilgar, 2016; Şenol *et al*., 2017) [28,10].
Poultry manure	78	(Ilgar, 2016; Şenol *et al*., 2017; Aybek *et al*., 2015b) [28,10,29].
Agricultural wastes	20	(Şenol *et al*., 2017; Aybek *et al*., 2015b) [10,29].
Kitchen waste	30	(Anonymous, 2011a; Şenol *et al*., 2017) [42,10].
Sewage sludge	20	(Koçar *et al*., 2010; Şenol *et al*., 2017) [20,10].

sludge. Unlike other organic wastes, these wastes are difficult and expensive to be destroyed [38]. Studies have reported that the biogas yield per 1 tonne sludge varies between 10-30 m^3. In this study, waste sludge (KMM) was calculated by taking 3% of the amount of water entering the daily wastewater treatment plant. The wastewater treatment sludge from Mersin and Adana Metropolitan Municipalities is given in Table **4** [39]. Total amount of waste processed daily in Mersin Metropolitan Municipality waste water treatment sludge facilities is 309719 m^3. KMM (sludge) produced by these plants can be calculated as 9291.6 m^3 per day. In Adana Metropolitan Municipality waste water treatment sludge facilities, the total amount of waste processed per day is 416 850 m^3. KMM (sludge) produced by these plants can be calculated as 12 505.5 m^3 per day.

In this study, biogas yield value of wastes used in the calculation of biogas potential of organic wastes to be produced from animal, plant, kitchen and wastewater treatment plant for Mersin and Adana provinces is given in Table **5**. The electrical energy value to be produced from biogas is taken as 4.7 kW / m^3 (Since the energy value of biogas in 65% methane content is approximately 22.4 MJ / m^3, 1 m^3 biogas is approximately equivalent to 4.7 kWh) [10,39-41].

3. RESULTS AND DISCUSSIONS

The amount of biogas production obtained from organic wastes of Mersin and Adana provinces and the change in the electricity production potentials to be produced from methane gas are given in Table **6** and Figure **2**.

As shown in the Table **5**, the total amount of organic waste of Mersin province is calculated as 16801.48 tons per day. 55% of the calculated value consists of sewage sludge, 32% animal manure, approximately 7% kitchen wastes and 6% agricultural wastes. In the study, 557432.47 m3 of biogas and 2619.93 MWh of electricity were generated from 16801.48 tons of organic waste per day. 57% of the total amount of electricity generated daily from organic wastes was obtained from animal manure, 33% from sludge, 6% from kitchen wastes and 4% from agricultural wastes. In other words, animal manure and wastewater sludge facilities accounted for about 90% of the total amount of electricity generated. Since sewage sludge and manure have high organic potential, these wastes seem to have a significant impact on electricity generation. It is seen that the amount of collected organic waste produced in the water treatment sludge facility in Mersin is about 2-9 times higher than the

Table 6: Electricity Potential That Can be Produced From Biogas and Methane Produced Due to Organic Wastes of Mersin and Adana Provinces

Organic waste	Mersin	Adana	Mersin	Adana	Mersin	Adana
	Amount of organic waste (ton / day)		Amount of biogas (m^3 / day)		Electricity production (Methane) (MWh / day)	
Animal fertilizers	5419,76	5038,72	318911,27	226145,06	1498,88	1062,88
Agricultural wastes	1001,44	4756,66	20028,80	95133,37	94,14	447,13
Sewage sludge	9291,6	12505,50	185832	250110,00	873,41	1175,52
Kitchen waste	1088,68	2216,47	32660,40	66494,25	153,50	312,52
Total	16801,48	24517,35	557432,47	637882,68	2619,93	2998,05

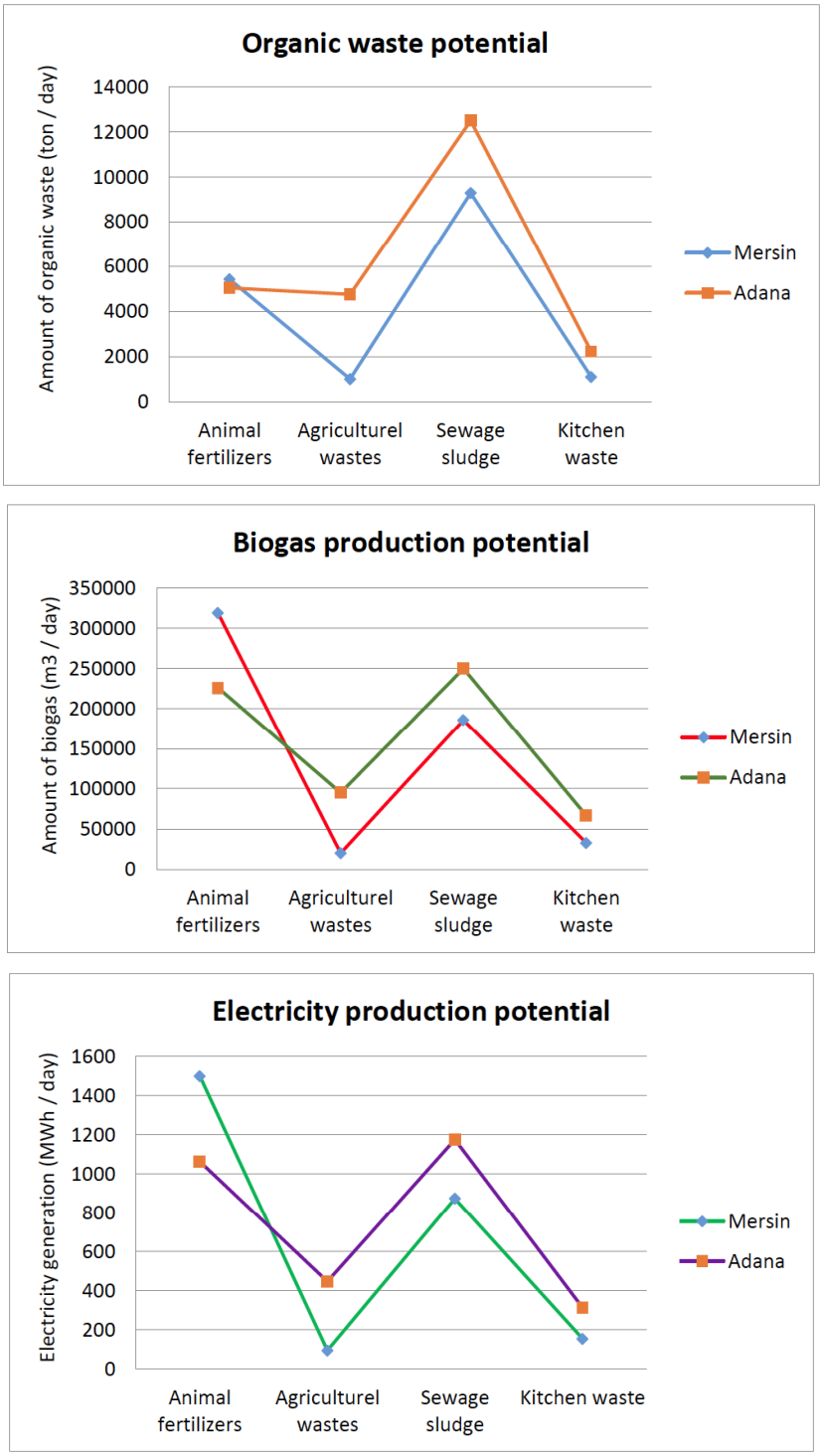

Figure 2: Electricity generation from biogas and methane in Mersin and Adana provinces.

other wastes. This shows how important the municipal sewage sludge plant is for electricity generation. In addition, although the amount of organic waste from the wastewater sludge plant is about 1.71 times the amount of organic matter of animal manure; in terms of the amount of biogas produced, it is about 1.71 times the amount of biogas obtained from wastewater treatment sludge of animal manure. As can be seen in Table **5**, the amount of organic waste of Adana province; daily total was calculated as 24 517.35 tons. Of this value, 51% consists of sewage sludge, 21% animal manure, 19% agricultural waste and 9% kitchen waste. In the study, 637 882.68 m3 of biogas and 2 998.05 MWh of electricity were obtained from 24 517.35 tons of organic waste per day. 39% of the total amount of electricity generated daily from organic wastes was obtained from sewage sludge, 36% from animal manure, 15% from agricultural wastes and 10%

from kitchen wastes. In other words, bovine and wastewater sludge facilities accounted for 75% of the total amount of electricity generated. Since sewage sludge and manure have high organic potential, these wastes seem to have a significant impact on electricity generation. It is observed that the amount of collected organic waste produced in the water treatment sludge plant in Adana province is 2.5-5 times higher than the other wastes. This shows how important the municipal sewage sludge plant is for electricity generation. In addition, although the amount of organic matter of animal manure was 40% lower than the wastewater sludge plant, the amount of biogas produced was the same in these two wastes. Therefore, it is confirmed that the high organic matter content of animal wastes is effective in increasing biogas production and production efficiency of the plant. Nowadays, the management of these wastes has become increasingly important and even more complicated, especially with the increasing environmental risks of organic wastes and their economic and social effects. Therefore, it shows the importance of the functional characteristics of municipalities in the evaluation of these wastes having such high energy potential.

4. CONCLUSION AND SUGGESTIONS

The rapid increase in demand for energy has led to the need to find new energy sources. Biogas has an important place among renewable energy sources due to its potential and social and economic benefits. The results obtained from the study conducted to determine the current state of organic wastes to be obtained from plant, animal, kitchen and industrial sewage sludge plants in Mersin and Adana provinces and their effect on biogas energy production can be summarized as follows; The daily amount of organic matter produced in animal, vegetable, kitchen and sewage sludge facilities in Mersin is 16801.48 tons, the amount of biogas produced from these wastes is 557432.47 m3 and the electricity generated from methane is determined as 2619.93 MWh. In Adana province, the daily amount of organic matter produced in animal, vegetable, kitchen and sewage sludge plants is 24 517.35 tons, the amount of biogas produced from these wastes is 637 882.68 m^3 and the electricity generated from methane is determined as 2 998.05 MWh. In Mersin, 55% of the organic matter wastes obtained from wastes are treated sludge, 32% are animal manure, 7% are kitchen wastes and 6% are agricultural wastes. The amount of electricity generated from these organic wastes is 57% of the generated electricity from animal manure, 33% from sludge, 6% from kitchen waste and 4% from agricultural waste. In Adana, on the other hand, 51% of the organic matter wastes obtained from wastes are treated sludge, 21% are animal manure, 19% are agricultural and 9% are kitchen wastes. The amount of electricity generated from these organic wastes is 39% of the generated electricity from sludge, 36% from animal manure, 15% from agricultural waste and 10% from kitchen waste. In Mersin and Adana provinces, it has been determined that animal manure and sewage sludge have significant potential in terms of organic matter in electricity generation. In addition to protecting the environment, electricity and heat are obtained; will contribute to the region economically and will reveal new research topics. Thus, maximum benefits can be obtained in terms of economic, social and environmental-public health. With the rapid increase in population and industrialization in Mersin and Adana provinces, it brought many environmental problems, but also caused the region's need for energy. To meet this need, the use of biogas to be produced from sewage sludge, animal manure and plant wastes within the boundaries of the Region will provide positive gains in terms of decreasing the need for traditional electric power generation systems and protecting natural resources and the environment. Mixing and processing of wastes with low organic content such as domestic, industrial and plant residues in animal manure and waste sludge having high organic potential can be considered to be effective in increasing the utilization capacity of the treatment plant by increasing the utilization capacity of the treatment plant. Today, biogas technology is an important factor for renewable energy production, enabling organic wastes to be harmless and causing energy problems to be used in energy generation. In order to utilize this biogas potential determined in Mersin and Adana provinces as soon as possible, alternative projects suitable for the region should be produced. In the projects to be carried out, it may be effective to provide the producers with technical information about the gains of the biogas plant and to provide incentives for the installation of the plant. In addition, since the installation of the biogas plant constitutes an important investment cost, in case the problems of the breeders are overcome, energy recovery and reduction of environmental risks will result in significant technological gains to the industry and the regional industry.

REFERENCES

[1] Köse, T. E. (2017): Determination and Digital Mapping of Biogas Energy Potential of Animal Manures in Thrace Region. Pamukkale University Journal of Engineering Sciences 23(6), 762-772. https://doi.org/10.5505/pajes.2016.33600

[2] Afacan, T. (2007): "Energy Security, Energy Agriculture, Biofuels in terms of Global Warming Biodiesel, Biogas, Bioethanol", 4th New and Renewable Energy Resources Symposium, TMMOB Chamber of Mechanical Engineers, Kayseri Branch, 23-24 November 2007, Kayseri, pp. 93-99.

[3] Akınerdem, F.(2007): "Energy Agriculture; Energy Plants Potential"Energy Security, Energy Agriculture, International Symposium on Biofuels in Terms of Global Warming, 6April2007,Accessed:18.11.2007;http://www.albiyobir.org.tr/files/img_etk/fikret_akinerdem.pdf

[4] Alternatürk (2007): Turkey Biofuels Report, Accessed: 18/11/2007; http://www.alternaturk.org/biyoetanol_rapor.php

[5] Ar, F., (2007): "Biofuels", Central Anatolia Energy Forum, April 14, 2007, Aksaray, Access :11.11.2007; http://www.emo.org.tr/resimler/ekler/65eb348fb03103d_ek.pdf

[6] Abdeshahian, P., Lim, J.S., Ho, W.S., Hashim, H., Lee, C.T. (2016): Potential of biogas production from farm animal waste in Malaysi, Renewable and Sustainable Energy Reviews, 60, 714–723. https://doi.org/10.1016/j.rser.2016.01.117

[7] Seyhan, A. K., Badem, A. (2018): Investigation of Biogas Potential of Animal Wastes in Erzincan Province, APJES 6-1 25-35. https://doi.org/10.21541/apjes.334256

[8] Anonymous (2017a): "Renewable Energy Project". World Wildlife Foundation, Turkey.

[9] Kumar, A., Kumar k, Kaushik Ashwanic, Sharma Ashwani S., Mishra, S. (2009): Renewable energy in India: Current status and future potentials, Renewable and Sustainable Energy Reviews 14 pp. 2434–2442. https://doi.org/10.1016/j.rser.2010.04.003

[10] Şenol, H., Elibol, E. A., Açıkel, Ü., Şenol, M. (2017): Main Organic Waste Sources of Biogas Production in Ankara, BEU Journal of Science, 6 (2), 15-28. https://doi.org/10.17798/bitlisfen.339261

[11] Eryilmaz, T., Yesilyurt, M.K., Gokdogan, O., Yumak, B.(2015): Determination of Biogas Potential From Animal Waste in Turkey: A Case Study for Yozgat Province. European Journal of Science and Technology, 2(4), 106-111.

[12] Anonymous (2017b): "Renewable Energy Report", Çukurova Development Agency, Turkey.

[13] ADSYB (2011): Aydın Province Biogas Potential Feasibility Report. Aydın: Cattle Breeders Association of Aydın Province - South Aegean Development Agency.

[14] Ardıç, İ., Taner, F. (2014): Biogas production from biomass I. Fundamentals of anaerobic treatment. http://www.emo.org.tr/ekler/14101ec47c52b48_ek.pdf (Accessed:03.12. 2018)

[15] Yenilmez, F. (2015): Biogas Production from Poultry Wastes, Fırat University Journal of Health Sciences Veterinary, 29(3).205–212, http://veteriner.fusabil.org/text.php3?id=1063 (Accessed:15.12.2018).

[16] Aybek, A., Üçok, S., İspir, S., Bilgili, M. E. (2015a): Turkey cereal straw and animal manure can be used in determining the energy potential of biogas and waste creation of digital maps, Tekirdağ Agriculture Faculty Journal, 12 (3), 109-120.

[17] Thamsiriroj, T., Murphy, J. D.(2013): Fundamental science and engineering of the anaerobic digestion process for biogas production 104. https://doi.org/10.1533/9780857097415.1.104

[18] Nacar, K.N, Öner, C., Sugözü, İ.(2006): "Livestock and Biogas Production Potential in Turkey". Eastern Anatolia Studies, 17-20.

[19] Weiland, P.(2010): "Biogas production: Current state and perspectives," Applied Microbiology and Biotechnology, vol. 85, no. 4, pp. 849–860. https://doi.org/10.1007/s00253-009-2246-7

[20] Koçar, G., Eryaşar, A., Ersöz, Ö., Arıcı, Ş., Durmuş, A. (2010): Biogas Technologies, Ege University Press, Izmir

[21] Öztürk, M., Yüksel, Y. E. (2016): Energy structure of Turkey for sustainable development, Renewable and Sustainable Energy Reviews, 53, 1259–1272. https://doi.org/10.1016/j.rser.2015.09.087

[22] Qi,X., Zhang, S., Wang, Y., Weng, R.(2005): Advantageous of the ıntegrated pig biogas- vegetable green house system in North China. Ecological Engineering, 34(3), 175-185. https://doi.org/10.1016/j.ecoleng.2004.11.001

[23] Rao, P.V., Banal, S.S., Dey, R., Mutmuri, S.(2010): Biogas generation potential by anaerobic digestion for sustainable energy development in India. Renewable and Sustainable Energy Reviews, 14(7), 2086-2094. https://doi.org/10.1016/j.rser.2010.03.031

[24] White, A.J., Kirk, D.W., Graydon, J.W.(2011): Analysis of small scale biogas utilization systems on ontario cattle farm. Renewable Energy, 36(3), 1019-1025. https://doi.org/10.1016/j.renene.2010.08.034

[25] Luostarinen, S.(2013): Energy Potential of Manure in The Baltic Sea Region: Biogas Potential & İncentives and Barriers for ımplementation. Knowledge Report: Baltic Forum for Innovative Technologies for Sustainable Manure Management.

[26] Afazeli, H., Jafari, A., Rafiee, S., Nosrati, M. (2014): An investigation of biogas production potential from livestock and slaughterhouse wastes. Renew Sustain Energy Reviews, 34, 380-386. https://doi.org/10.1016/j.rser.2014.03.016

[27] Avan, H.(2014): Evaluation of Biogas Production Potential of Animal Wastes in Tokat by Using Geographical Information Systems (GIS). Master Thesis, University of Eyup, Turkey.

[28] Ilgar, R.(2012): A Study on the Determination of Çanakkale Biogas Potential According to Animal Presence, Doğu Geography Journal, 21 (35), 89-106. https://doi.org/10.17295/dcd.08733

[29] Aybek, A., Üçok, S., Bilgili, M.E., Ali, İspir, M. (2015b): Determination of Biogas Energy Potential of Some Agricultural Wastes in Kahramanmaraş Province. UU Journal of the Faculty of Agriculture, 29 (2), 25-37.

[30] Özcan, M., Öztürk, S., Yıldırım, M.(2011): "Determining the potential of biogas by Turkey's Different Types of Resources". IV. Energy Efficiency and Quality Symposium, Kocaeli.

[31] GDM (2018): Republic of Turkey Ministry of Agriculture, Forestry General Directorate of Meteorology. https://www.mgm.gov.tr/?il=Mersin

[32] Anonymous(2018): https://www.gezilecekyerler.biz/aydinlik-nerede-hangi-sehirde/

[33] MAF (2018): Republic Of Turkey Ministry Of Agriculture And Forestry. Mersin Directorate Of Provincial Agriculture And Forestry. https://mersin.tarimorman.gov.tr/#

[34] TSI (2018): Turkey Statistical Institute of the Republic of Turkey. Statistics by Subject, Agriculture.http://www.tuik.gov.tr/UstMenu.do?metod=kategorist (Erişim: 27.02 2019).

[35] Dağ, Ö.(2014): Biogas Production Project for Domestic Wastes, http://ozgurdag4941.blogspot.com.tr/2014/12/ev-atiklarindan-biyogaz-uretim-projesi.html?m=1 (Accessed : 01.02.2019).

[36] Anonymous (2011b): Environment and urban ministry. 2011. Report on the Technical-Economic Principles of the Suluova Biogas Plant, Turkish-German Biogas Project, Ankara.

[37] Anonymous(2017c): Biogas Production from Sewage Sludge and Energy Saving.; https://www.yenienerji.info/proje/aritma-camurundan-biyogaz-uretimi-ve-enerji-tasarrufu. (Accessed: 05.01.2019)

[38] Yiğit, K.S., Gündüz, M., Şerit, G., Yeğin, M., Saraç, M., Bayram, İ., Bostan, Ü., Pir, H. (2011): Biogas Production and Energy Savings From Waste Water Treatment Sludge, Kocaeli and IZAYDAS ISU study report, Turkey.

[39] Acaroğlu, M.(2007): Alternative Energy Sources. Nobel Publication No: 1253, 609 p, Ankara.

[40] Kaya, D.(2010): Evaluation of the Use of Domestic Sewage Sludge in Biogas Production, ICCI - International Energy and Environment Fair and Conference.

[41] Öztürk, H. H. (2008): Renewable Energy Resources and Usage. Technical Publishing, 367p, Ankara.

[42] Anonymous (2011a): South Aegean Development Agency. Ege South Aegean Renewable Energy Working Report ". Pamukkale, Denizli, Turkey

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