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Mersin İlinin Organik Atık Potansiyelinin Biyogaz Enerji Üretimine Etkisi

Araştırma Makalesi / Research Article

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ÖZ

Bu çalışmanın amacı; Mersin ilinde bitkisel, hayvansal, mutfak ve endüstriyel arıtma çamuru tesislerinden elde edilen organik atıkların mevcut durumu ve biyogaz enerji üretim potansiyelini belirlemek ve konuya ilişkin yerel ölçekte sürdürülebilir çözümler oluşturmaktır. Çalışmada hayvan ve bitkilere ait veriler Mersin İl Tarım ve Orman Müdürlüğünden, mutfak ve endüstriyel atıklara ilişkin veriler ise Mersin Büyükşehir Belediyesinden alınmıştır. Çalışma sonucunda, Mersin ilinde hayvansal, bitkisel, mutfak ve arıtma çamuru tesisinde üretilen günlük organik madde miktarının 16801.48 ton olduğu ve bu atıklardan üretilen biyogaz miktarının 557432.47 m³, metandan üretilen elektrik enerjisi ise 2619.93 MWh olarak elde edilebilecektir. Organik atıklardan üretilen elektrik miktarının %57'si hayvan gübresinden %33'ü arıtma çamurundan, %6'sı mutfak atıklarından ve %4'ü de tarımsal atıklarından elde edilebilecektir. Mersin ili için elektrik üretiminde hayvan gübresi ve arıtma çamurunun içerdiği organik madde bakımından önemli potansiyele sahip olduğu belirlenmiştir. Ayrıca, kurulacak biyogaz tesislerinin işletmelere ticari değer katkısı da sağlayabilecektir.

Anahtar Kelimeler: Biyogaz, enerji, organik atık, Mersin.

The Effect of Organic Waste Potential of Mersin Province on Biogas Energy Production

ABSTRACT

In this study is to determine the current status of organic wastes obtained from plant, animal, kitchen and industrial sewage sludge plants in Mersin province and to generate biogas energy production potential and to create sustainable solutions at the local level. Data on animals and plants were obtained from Mersin Provincial Directorate of Agriculture and Forestry and data on kitchen and industrial wastes were obtained from Mersin Metropolitan Municipality. As a result of this study, the daily organic matter produced in animal, vegetable, kitchen and sewage sludge plant in Mersin province is 16801.48 tons and the amount of biogas produced from these wastes is 557432.47 m³ and the electricity generated from methane is 2619.93 MWh. The amount of electricity produced from organic wastes; 57% can be obtained from animal manure, 33% from treatment sludge, 6% from kitchen waste and 4% from agricultural waste. In Mersin province, it has been determined that animal manure and sewage sludge have significant potential in terms of organic matter. In addition, the biogas facilities to be established will provide commercial value contribution to the enterprises.

Keywords: Biogas, energy, organic waste, Mersin.

1. INTRODUCTION

Nowadays, with the increase in population, energy needs to be produced in a level sufficient to meet basic human needs. The development of technology simplifies community life and increases average energy consumption. This situation leads to an increase in energy production and consumption in the world. In the near future, fossil energy resources, which are used extensively in meeting the energy requirements, will be unable to meet the needs of human beings and consequently, energy problems will be experienced. Excessive use of fossil fuels, which cover a large portion of our energy consumption, causes environmental pollution. Nowadays, the closure of the energy deficit, the solution of environmental problems, the struggle

against global warming and sustainable development necessitates the orientation to renewable energy resources[1]. However; The amount of wastes generated in direct proportion with the increasing world population and the need for energy are constantly increasing. Due to the negative environmental impact of the wastes generated, the necessity of disposal and the decrease in fossil energy sources and the increasing energy deficit increase the use of existing resources more efficiently and demand for renewable energy sources[2]. The industrialization process, which is one of the major factors in the growth of a developing and rapidly growing country, has gained momentum in recent years. With the increase in population, the countries' need for energy is increasing. In order to meet this need, electrical energy is produced by various methods. Conventional electric power generation systems; consumption of natural resources can lead to negative consequences that cannot

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be repaired from an environmental perspective. With the awareness of environmental protection, renewable energy sources gain great importance and develop rapidly. Although Turkey's potential of renewable energy sources at a level that can meet the entire energy needs of the country, and investments necessary information in this regard is quite insufficient. The search for renewable energy sources has increased significantly in recent years in order to meet the increasing energy demand. Biogas production from organic wastes is considered as an alternative source. The use of organic wastes in biogas production demonstrates effective waste management in both waste disposal and energy recovery from waste [3]. Evaluation of solid residues as biomass is only one of these methods. Countries with high agricultural potential create opportunities for biogas, biogas, biodiesel and bioethanol. The extremely limited reserves of energy resources have increased the demand for renewable energy sources for biogas production and biogas use. In most developed countries, biogas can be produced from organic wastes to meet various energy needs. Although fossil fuels are exhausted in the near future; Turkey has all extremely rich source of environmentally friendly biomass energy. Biogas production from biomass energy sources; It is a vital resource for sustainable agriculture and economic independence. Anaerobic treatment of the organic portion of domestic solid waste is particularly common in Europe in terms of renewable energy recovery and stabilization of waste. The treatment of the organic part of the solid waste by anaerobic biological methods is a very attractive treatment alternative. Significant advances in anaerobic reactor technology gained momentum after the 1950s [4]. An integrated (integrated) waste management is provided as a result of the combined treatment of the organic part of the domestic solid wastes and the different organic waste types in airless digesters [5]. Nowadays, due to the decrease in fossil fuels, it may cause an energy deficit and increase in energy prices in the near future. In addition, when environmental problems arising from plant and animal wastes are taken into consideration, it has been seen with the studies that it is of great importance to bring solutions to these problems in terms of sustainable development. Biomass energy conversion systems are one of the most environmentally acceptable solutions for agricultural and animal wastes. With these systems; organic wastes produce both organic and fertilizer with high energy and nutritional value [6,7,8]. Materials used in biogas production; all organic waste such as trees, corn, wheat crops, mosses, fruit and vegetable waste disposed from the houses are animal feces. The remaining liquid-solid fraction after biogas production is considered as fertilizer. The microbiological evaluation of wastes containing organic matter is important in terms of both preventing environmental pollution and producing clean energy [9]. The world average electricity consumption per capita in the entire 2376 kWh / year, while the average in Turkey 1281 kWh / year is around [10]. In Turkey, about 65 MTEP / year of organic waste

and 11.05 MTEP / year has the potential animal waste [11]. Only 60% of these wastes can be used for energy production. Turkey's annual energy consumption of the energy obtained from waste is known that this corresponds to about 22-27's% [11]. On average, 15% of the world's energy consumption is used in developing countries, and 43% of the energy consumption is obtained from biomass [11]. In developed and developing countries, industrial wastes, animal wastes and agricultural wastes are widely used as raw materials in renewable energy production. In particular, the production of electrical energy from biogas technology gas engines has expanded the use of this technology [12]. In a study on the availability of biogas energy in the Thrace Region, the data of State Institute of Statistics, Provincial Directorates of Agriculture and Meteorology Directorates were used. Using these data, the number and size of enterprises, number of animals, estimated annual fertilizer production amount, estimated annual biogas production amount with Energy values of Edirne, Kırklareli and Tekirdağ provinces were determined. [13]. In a study on the biogas potential and cost analysis of Elazığ province, Elazığ province was divided into 3 sub-regions and the number of animals and crop production in these regions were determined. Using these statistical data, the amount of wet and dry fertilizer that can be obtained, the amount of biogas production, the amount of energy that can be obtained and economic values have been determined [14]. In a study on the biomass potential of 15 provinces in the Eastern Anatolia Region, biomass formation, biomass sources and properties were revealed and the usability of biomass technology in this region and biomass potential and equivalent energy were estimated [15]. The annual and total recoverable biomass energy potential of Turkey is estimated to be 32.6 and 17.2 MTEP (Million Tons Equivalent Petroleum) respectively [16]. Animal, kitchen, agricultural and wastewater treatment sludge plant wastes of Ankara province were taken into consideration and biogas production amount was calculated from these wastes. As a result of the calculation, the theoretical biogas energy value that can be produced from organic wastes is 277 348 m³ / day animal wastes, 515 220 m³ / day wastewater treatment sludge, 38 493 m³ / day agricultural wastes; 160 380 m³ / day are kitchen wastes [17]. In a study conducted in Russia, the biogas potential of the produced wastes was studied. Annual waste, methane and fertilizer potential was calculated by calculating the agricultural industry wastes. In addition, the potential that can be obtained from municipal solid wastes, waste water sludge and garbage storage areas has been determined [18]. As of the end of 2006, it has a total generation capacity of 1100 MW in approximately 3500 biogas plants in Europe. Today, only about 4300 biogas plants are operated in Germany, Denmark and Austria [19]. The biogas potential of Bulgaria has been studied. For this purpose, existing biogas plants, biogas production opportunities and raw material opportunities were determined. After the country's raw material

opportunities were divided into 7 regions, biogas production potential was calculated by considering the literature values [20]. In countries such as Denmark, Germany and Sweden, more central and farm-type units have been established. There are many biogas plants in Latin America, India, China and Nepal with a volume of 3-10 m³[21-22]. In Greece, the waste potential, municipal waste, industrial waste and agricultural waste was tried to be determined.

Calculating agricultural wastes in tons, farm manure wastes in m³ / year, municipal and sewage wastes in tons, the country was divided into 10 regions and mapped the waste potential [23]. The biogas potential of the US state of Illinois was studied. Using the statistical data of the country, the main fields with energy production potential such as dairy and poultry holdings, garbage storage areas and related enterprises were determined. The estimated energy range and total energy potential that can be obtained from these areas have been determined [24]. An exemplary biogas plant is shown in Figure 1.

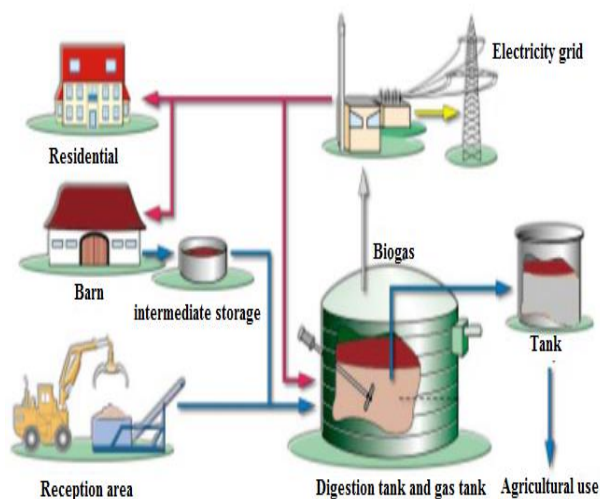


Figure 1. Example of a biogas plant

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 Province and to determine sustainable potential on the local scale by determining the biogas energy production potential.

2. MATERIAL and METHOD

Located between 39°56'0,109" north latitude and 32°51'35,07" east longitude in the south of the Mediterranean, Mersin Province has a surface area of 15 853 km² and a population of 1 814 468 [25].

There are Adana in the east of Mersin province, Antalya in the west, Niğde, Konya and Karaman provinces in the north and Mediterranean Sea in the south. Mersin province consists of a total of 13 districts (Akdeniz, Anamur, Aydıncık, Bozyazı, Çamlıyayla, Erdemli, Gülnar, Mezitli, Mut, Silifke, Tarsus, Toroslar and Yenişehir) (Figure 2) [26]. In order to determine biogas production potential of organic wastes of Mersin province, data on animals and plants were obtained from Forestry Directorate; data on kitchen and industrial wastes were obtained from Mersin Metropolitan Municipality.



Figure 2. Mersin province map

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, number of animals and amount of wet manure production are given in Table 1 [27,28].

Table 1. Number of animals and amount of wet manure produced in Mersin province

Species Animal	Number of animals (pcs)	Wet Manure production (Ton / year-animal)	Wet Manure production (Ton / year)
Bovine (cattle, adult)	115506	3,6	415821,6
Ovine (sheep, goat)	1370420	0,7	959294
Poultry (chicken)	27413431	0,022	603095,5
Total	28899357		1978211,1

The total number of animals (bovine, ovine and poultry) in Mersin province is 28899357 and the amount of wet manure produced from these animals is 1978211.1 tons. Total wet fertilizers produced; 48,49% of them are ovine, 30,49% of them are poultry and 21,02% of them are bovine.

2.2. Determination of Agricultural Waste Potential

Located in the center of the fertile soil of Çukurova, Mersin has a total agricultural production area of 3696380 da. 55% of this production area is cultivated in

field, 36% in fruits and 9% in vegetables [29]. For this reason, in this study, the data of the commonly produced crops (corn, cotton, wheat rye peanut, soybean, oat etc.) were taken into consideration in determining the 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 2). The spatial yield of the amount of organic waste was obtained from Mersin Provincial Directorate of Agriculture and Forestry [28].

Table 2. Amount of organic waste obtained according to the plant type planted in Mersin province

Plant	Sowing area (da)	Amount of organic waste (kg / ha)	Amount of organic waste (ton)
Sunflower	22367	227	5077,309
Cotton	52216	496	25899,136
Soybean	84543	347	29336,421
Peanut	9824	206	2023,744
Wheat+Barley+Rye+Oats	978714	190	185955,660
Corn plant	133069	881	117233,789
Total	1 280 733		365526,059

As shown in the table, the amount of organic waste obtained from planting in 1 280 733 da area is 365526,059 tons. 50.88% of the total organic wastes obtained were wheat + barley + rye + oats, 32.07% corn, 8.03% soybean plant, 7.09% cotton, 0.55% peanuts and 1.39% sunflower plant constituted.

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 to the environment such as take up space and bad smells. However, the use of these organic wastes, which are disposed of in landfills, in proper production in gas production, can contribute to both the environment and the household budget [30].

In the theoretical determination of the amount of kitchen waste, it is accepted that 1 kg of waste is produced per person per day and that organic waste constitutes 60% of this waste [31]. 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.

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 / m³ [32]. A large part of the

sludge entering the decanter in the wastewater treatment plant is water and the amount of Dry Matter (ADM) is between 1-5% [33]. Municipal treatment plants generally convert 100 liters of sewage water into 1-2 liters of sludge. The remaining part formed by the removal of pollutants from the water is waste sludge. Unlike other organic wastes, these wastes are difficult and costly to be destroyed [34]. Studies have reported that the biogas yield per 1 tonne sludge is in the range of 10-30 m³. In the study, waste sludge (ADM) was calculated by taking 3% of the amount of water entering the daily wastewater treatment plant. In the study, capacities of wastewater treatment sludge facilities taken from Mersin Metropolitan Municipality are given in Table 3 [29]. The total amount of waste processed per day in the wastewater treatment plant is 309719 m³. The amount of sludge (ADM) produced by these plants can be calculated as 9291.6 m³ per day.

Table 3. Capacity of wastewater treatment plants in Mersin province

Wastewater Treatment Plant	Capacity (m ³ /day)
Karaduvar Wastewater Treatment Plant	189 523
Tarsus Wastewater Treatment Plant	61 272
Erdemli Wastewater Treatment Plant	21972
Kargıpınarı Wastewater Treatment Plant	6000
Atakent Wastewater Treatment Plant	6800
Silifke Wastewater Treatment Plant	21000
Narlıkuyu Package Wastewater Treatment Pl.	500
Bozyazı Wastewater Treatment Plant	2652
Total	309 719

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 province is given in Table 4. The electrical energy value to be produced from the biogas is taken as 4.7 kW / m³ (Since the energy value of the biogas in 65% methane content is approximately 22.4 MJ / m³, 1 m³ biogas is approximately equivalent to 4.7 kWh electrical energy) [35,36,37]

Table 4. Biogas yield values of some organic wastes

Organic matter	Biogas yield (m ³ / ton)	References
Bovine manure	33	[38,37]
Ovine manure	58	[27,37]
Poultry manure	78	[27,37,39]
Agriculturalwastes	20	[37,39]
Kitchen waste	30	[40,37]
Sewage sludge	20	[41,37]

2.5. Basic Parameter Acceptances

The energy production potential of animal feces was investigated in this study. Each type of feces has a changing energy potential depending on its physical and chemical properties. In the calculations, the assumptions regarding the solid and organic solids content and methane gas production potential depending on the types of animal wastes are summarized in Table 5., Table 6. and Table 7.

Table 5. Acceptance of solid(S) and volatile solids(VS) value of animal wastes

Waste Type	Solid %	Volatile S. %	Reference
Bovine (cattle, adult)	19	90	Laboratory Analysis
Ovine (sheep, goat)	28	80	Laboratory Analysis
Poultry (chicken)	44	89	Laboratory Analysis

Table 6. Unit methane gas potential value acceptance of animal wastes

Waste Type	Unit Methane Potential (m ³ CH ₄ / ton VS)	Reference
Bovine (cattle, adult)	220	Lab. Analysis
Ovine (sheep, goat)	200	Lab. Analysis
Poultry (chicken)	256	Lab. Analysis

Table 7. Unit methane gas potential value acceptance of agricultural wastes

Waste Type	Unit Methane Potential (m ³ CH ₄ / ton VS)	Reference
Wheat	295,2	Laboratory Analysis
Corn plant	250,9	Laboratory Analysis
Barley	351,9	Laboratory Analysis
Rye	273,6	Laboratory Analysis
Oat	290,5	Laboratory Analysis

3. RESULTS AND DISCUSSIONS

The amount of biogas production obtained from organic wastes of Mersin province and the amount of electricity production potential to be produced from methane gas are given in Table 8 and Figure 3. The amount of biogas production obtained from organic wastes of Mersin province and the percentage ratio of electricity production potential to be produced from methane gas are given in Figure 4.

As shown in Table 8 and Figure 4, 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 a total of 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%

Table 8. Electricity potential that can be produced from biogas and methane produced due to organic wastes of Mersin Province

Organic waste	Amount of organic waste (ton / day)	Amount of biogas (m ³ / day)	Electricity production(Methane) (MWh /day)
Animal fertilizers	5419,76	318911,27	1498,88
Agriculturalwastes	1001,44	20028,8	94,14
Sewage sludge	9291,6	185832	873,41
Kitchen waste	1088,68	32660,4	153,5
Total	16801,48	557432,47	2619,93

from kitchen wastes and 4% from agricultural wastes. In other words, approximately 90% of the total amount of electricity generated is obtained from animal manure and wastewater sludge plants. Since sewage sludge and animal manure have high organic potential, these wastes seem to have a significant impact on electricity generation. It is seen that the amount of organic waste produced in the water treatment sludge facility in Mersin Province is about 2-9 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 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. Therefore, it has been confirmed that the high organic matter content of animal wastes is effective in increasing biogas production and production efficiency of the Plant. Nowadays, especially with the increasing environmental risks of organic wastes and their economic and social effects added, the management of these wastes gains importance day by day. Therefore, in the evaluation of these wastes having such high energy potential; duty areas of municipalities are becoming more and more important. The reason that the amount of biogas produced in the plant is lower than the theoretically calculated biogas production may be due to the chemical composition of the sludge, the process difference or the inability to use it effectively

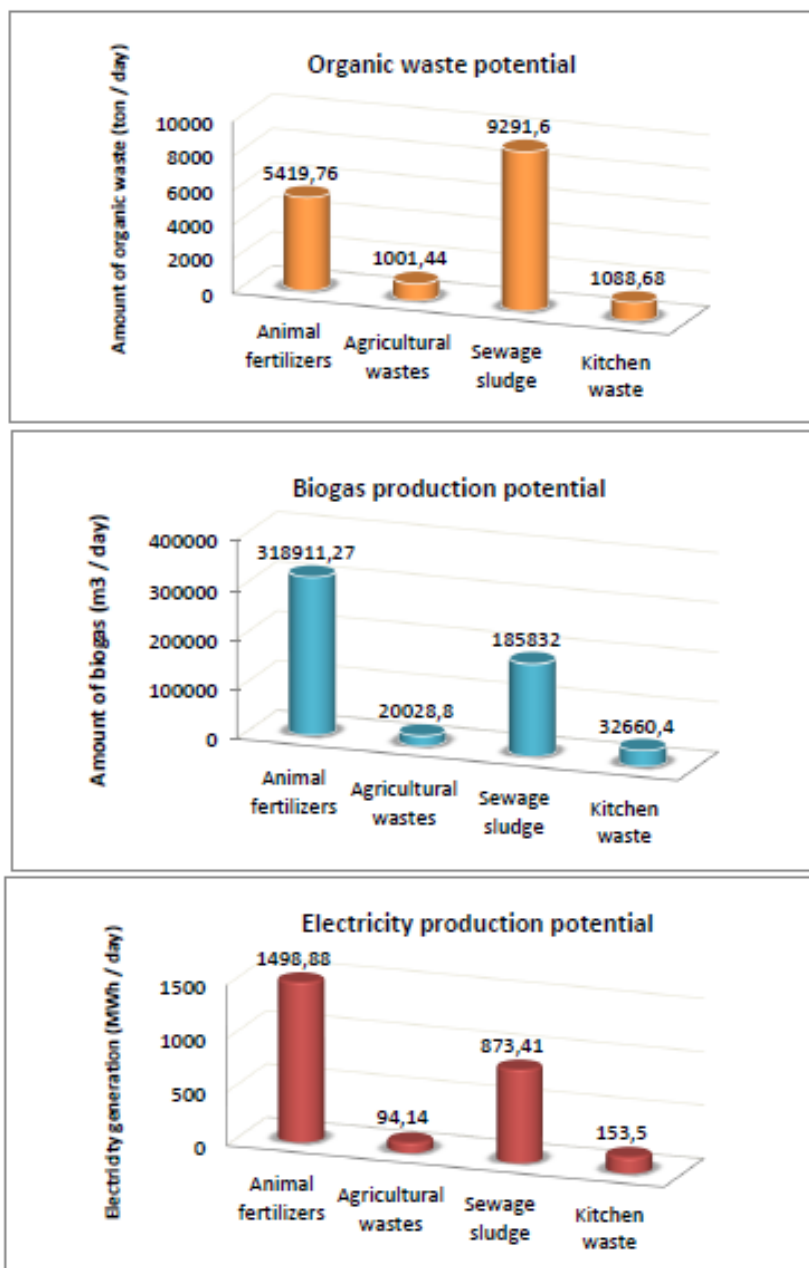


Figure 3. Electricity production amounts from organic waste, biogas and methane in Mersin

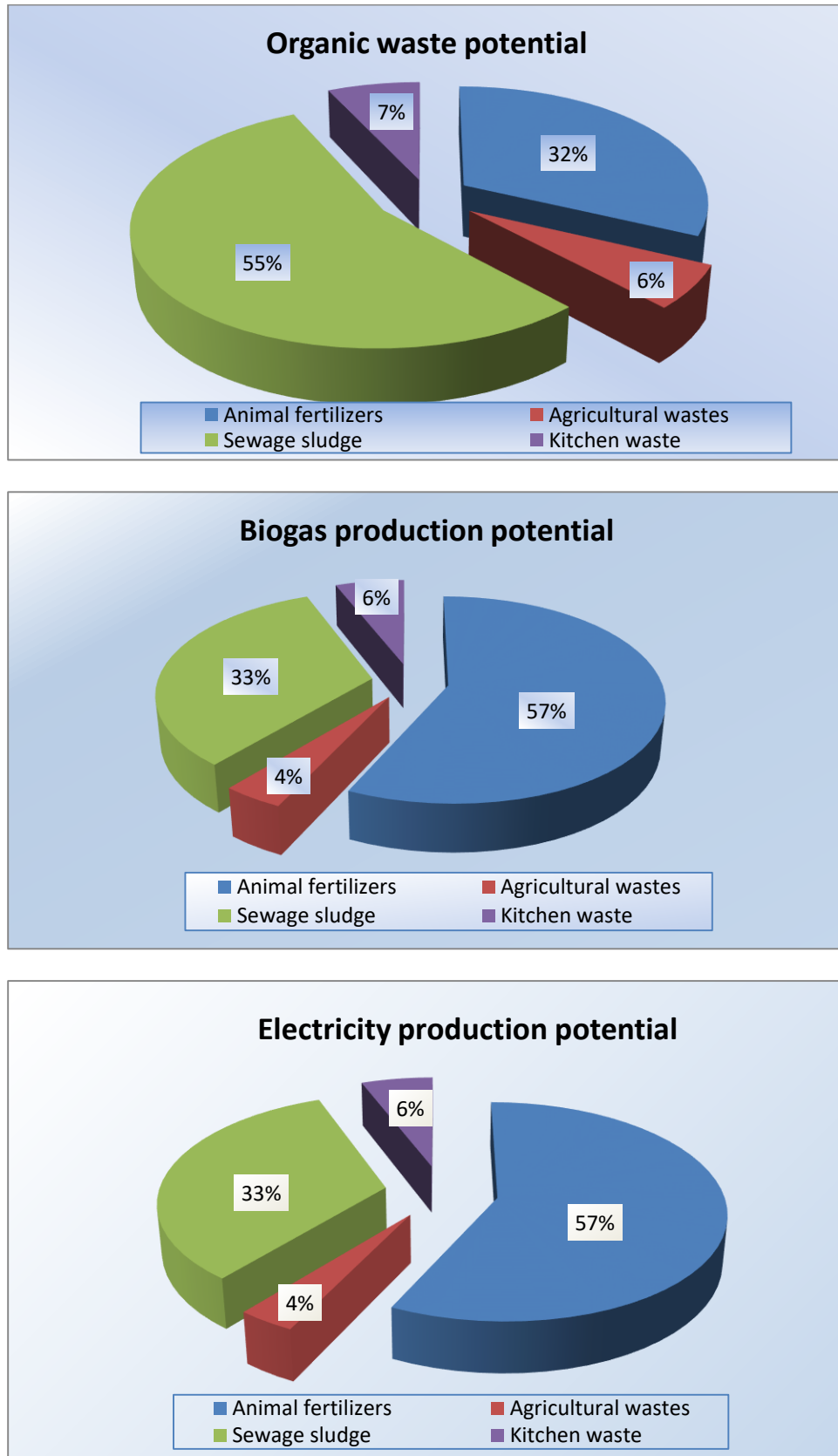


Figure 4. Electricity generation rates of organic waste, biogas and methane in Mersin

4. CONCLUSIONS AND RECOMMENDATIONS

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, social and economic benefits. The results of 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 province and its effect on biogas energy production can be summarized as follows; Produced in animal, vegetable, kitchen and sewage sludge facility in Mersin province; The amount of organic matter per day is 16801.48 tons and the amount of biogas produced from these wastes is determined as 557432.47 m³ and the electricity generated from methane is 2619.93 MWh. 55% of the organic matter wastes obtained from the wastes are treatment 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 electricity produced was obtained from animal manure, 33% from sludge, 6% from kitchen wastes and 4% from agricultural wastes. In the electricity generation for Mersin province; It has been determined that animal manure and sewage sludge have significant potential in terms of organic matter. 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. The rapid increase in population and industrialization in Mersin province causes many environmental problems. This has caused the region's need for energy to increase. 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 environment. Animal manure and waste sludge with high organic potential; mixing and treating wastes of low organic content in the region, such as domestic, industrial and plant residues; With the contribution it provides to waste management, it can be considered that it can contribute to the more effective operation of the treatment plant by increasing the utilization capacity of the treatment plant. Today, biogas technology is an important factor for renewable energy production, which enables organic wastes, which cause environmental problems and threaten human health, to make them harmless and to be used in energy generation. In order to evaluate this biogas potential for Mersin province 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, if these problems are overcome by the producers, energy

recovery and environmental risks will be reduced and the sector and the regional industry will be able to make significant technological gains. In addition, it contributes to sustainable development, greenhouse gas reduction and environmental protection through the use of renewable energy sources by providing economic contribution to regional agriculture and animal husbandry. While minimizing the environmental impact of animal wastes with the applied technologies; it is possible to obtain energy and to benefit from the fertilizer properties of animal wastes.

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